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FINAL REMEDIAL INVESTIGATION WORK PLAN/TIER II SAMPLING AND ANALYSIS PLAN
FORMER NAS SOUTH WEYMOUTH MA
11/03/2015
RESOLUTION CONSULTANTS

FINAL
REMEDIAL INVESTIGATION WORK PLAN/ TIER II SAMPLING AND ANALYSIS PLAN

HANGAR 1
FORMER NAVAL AIR STATION SOUTH WEYMOUTH
WEYMOUTH, MASSACHUSETTS 02190

Version: 1

Prepared For:

Department of the Navy
Naval Facilities Engineering Command, Mid-Atlantic
9742 Maryland Ave.
Norfolk, Virginia 23511-3095

November 3, 2015

SAP Worksheet #1: Title and Approval Page

Final

REMEDIAL INVESTIGATION WORK PLAN/TIER II SAMPLING AND ANALYSIS PLAN

November 3, 2015

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Former Naval Air Station South Weymouth
Weymouth, Massachusetts

Prepared for:
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Naval Facilities Engineering Command, Mid-Atlantic
9742 Maryland Ave.
Norfolk, VA 23511-3095

Prepared by:
Resolution Consultants
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Prepared under:
Contract Number N62470-11-D-8013

CTO WE27

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Ken Bowers/Chemist, QA Manager — Date
US Navy

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Brian Helland, Navy RPM — Date
US Navy

SAP Worksheet #1: Title and Approval Page

Draft

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November 2014

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Review Signature: _____

Michelle Snyder, Project Manager — Date
Resolution Consultants

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Ken Bowers/Chemist, QA Manager — Date
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List of Acronyms and Abbreviations

µg/L	Microgram per liter
AFFF	Aqueous film forming foam
APD	Aquifer Protection District
AST	Aboveground storage tank
bgs	Below ground surface
CAS	Chemical Abstract Services
CSM	Conceptual site model
CTE	central tendency exposure
DO	Dissolved Oxygen
DoD	Department of Defense
DQO	Data Quality Objective
DVA	Data Validation Assistant
eQAPP	Electronic Quality Assurance Project Plan
EPD	Effective predictive domain
ESD	Explanation of Significant Differences
FTL	Field Team Leader
GC/MS	Gas chromatograph/mass spectrometer
GPS	Global positioning system
HDPE	High-density polyethylene
HQ	Hazard Quotient
HSO	Health and Safety Officer
K_{ow}	Octanol-water partition coefficients
LC/MS/MS	High performance liquid chromatography tandem mass spectrometer
LCS	Laboratory control sample
LOQ	Limit of quantitation
MassDEP	Massachusetts Department of Environmental Protection
mg/kg	Milligrams per kilogram
MPC	Measurement performance criteria
MS/MSD	Matrix spike/matrix spike duplicate

NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
Navy	U. S. Department of the Navy
NFA	No Further Action
NIRIS	Naval Installation Restoration Information Solution
ORP	Oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response
PAL	Project action level
PFC	Perfluorinated compound
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PHA	Provisional health advisory
PM	Project Manager
POC	Point of Contact
PSQ	Principal Study Question
QA	Quality assurance
QAO	Quality Assurance Officer
QC	Quality control
QSM	Quality systems manual
RI	Remedial investigation
RME	Reasonable maximum exposure
ROD	Record of Decision
RPD	Relative percent difference
RPM	Remedial Project Manager
RSL	Regional Screening Level
SAP	Sampling and analysis plan
SOP	Standard operating procedure
SSO	Site Safety Officer
STTDC	South Shore Tri-Town Development Corporation
TBD	To be determined
TOM	Task Order Manager
UFP-QAPP	Uniform Federal Policy-Quality Assurance Project Plan
U.S. EPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

This document presents the Remedial Investigation Work Plan and Tier II Sampling and Analysis Plan for perfluorinated compounds at the Hangar 1 site, of the Former Naval Air Station South Weymouth, Weymouth, Massachusetts.

This document was prepared by Resolution Consultants for the U.S. Department of the Navy (Navy) and the Naval Facilities Engineering Command Atlantic, under the Comprehensive Long-Term Environmental Action, Navy Contract No. N62470-11-D-8013, Contract Task Order WE27.

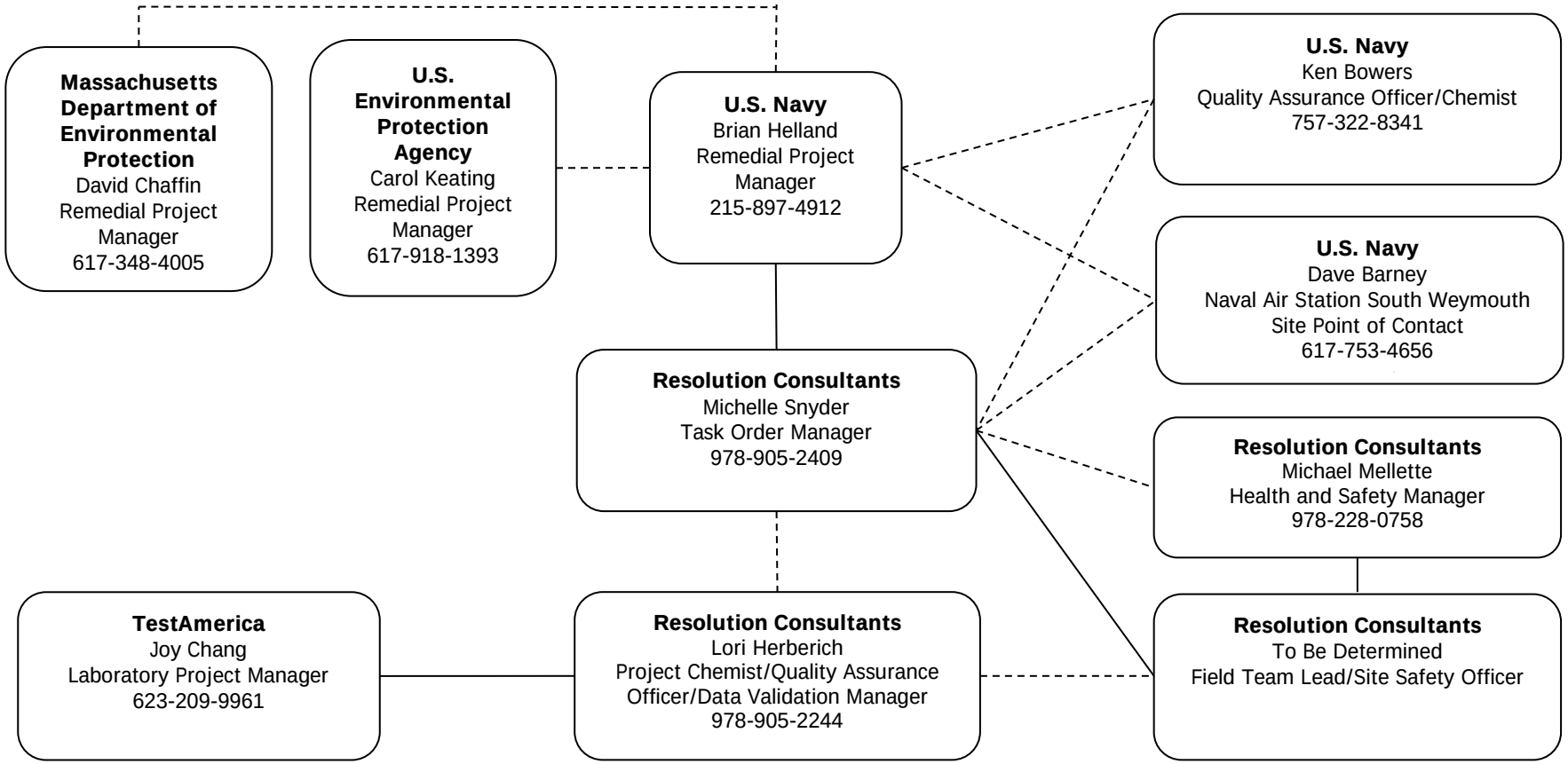
This Work Plan outlines the organization, objectives, planned activities, and data review/reporting procedures associated with the Remedial Investigation at Hangar 1. Protocols for sample collection, handling, and storage, chain-of-custody, laboratory and field analyses, data validation, and reporting are also addressed herein. This Work Plan was generated for, and complies with, applicable Navy, United States Environmental Protection Agency (U.S. EPA) Region 1, and Massachusetts Department of Environmental Protection (MassDEP) requirements, regulations, guidance, and technical standards, as appropriate. Field activities conducted under this Work Plan will be conducted in accordance with Resolution Consultants Standard Operating Procedures and a Site-Specific Health and Safety Plan. This includes satisfying environmental requirements as set by the Department of Defense and U.S. EPA Interagency Data Quality Task Force regarding federal facilities, as specified in the Uniform Federal Policy Quality Assurance Project Plan guidance (U.S. EPA 2005) and the Navy's Sampling and Analysis guidance.

In 2010, the U.S. EPA and the MassDEP requested that additional environmental data be collected to investigate the potential presence of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) in groundwater at Hangar 1. Sampling confirmed the presence of PFOS and PFOA at concentrations exceeding the U.S. EPA provisional health advisory guidance values in both the Aquifer Protection District (APD) and non-APD portions of the site. An Explanation of Significant Differences (ESD) was issued for Hangar 1 to address the presence of PFOS and PFOA in groundwater outside of the APD. The ESD added an institutional control remedy prohibiting the use of groundwater as drinking water in the non-APD portion of Hangar 1.

Additional soil data are required from the saturated zone in the vicinity of the former Aqueous Film Forming Foam (AFFF) above-ground storage tanks, former subsurface floor drain system, and the former Crash Truck Garage to determine if these media are functioning as continuing sources of PFOS and PFOA. Additional groundwater data is required to determine the horizontal and vertical extent of PFOS and PFOA in groundwater at the Hangar 1 site and to identify potential risks to human receptors.

SAP Worksheet #5: Project Organizational Chart

Lines of Authority ———— Lines of Communication - - - - - - - -



SAP Worksheet #6: Communication Pathways

The communication pathways for the SAP are shown below.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Regulatory Agency Interface	U.S. EPA RPM MassDEP RPM Navy RPM	Carol Keating David Chaffin Brian Helland	617-918-1393 617-348-4005 215-897-4912	The Navy RPM will contact the regulatory agency via phone and/or email within 24 hours of recognizing the issue whenever issues arise.
Field Progress Reports	Resolution Consultants FTL Resolution Consultants TOM	TBD Michelle Snyder	TBD 978-905-2409	The Resolution Consultants FTL will contact the Resolution Consultants TOM on a daily basis via phone, and every one-to-two days will summarize progress via email.
Gaining Site Access	Resolution Consultants TOM Resolution Consultants FTL Navy RPM NAS South Weymouth POC	Michelle Snyder TBD Brian Helland Dave Barney	978-905-2409 TBD 215-897-4912 617-753-4656	The Resolution Consultants TOM or FTL will notify the Navy RPM and NAS South Weymouth POC via email or verbally of planned sampling event 2 weeks prior to mobilizing to the site.
Obtaining Utility Clearances for Intrusive Activities	Resolution Consultants FTL NAS South Weymouth POC	TBD Dave Barney	TBD 617-753-4656	The Resolution Consultants FTL will coordinate verbally or via email with the NAS South Weymouth POC at least 2 weeks in advance of accessing the site to initiate the utility clearance process for all intrusive sampling locations.
Stop Work Due to Safety Issues	Resolution Consultants TOM Resolution Consultants FTL/SSO Resolution Consultants HSO Navy RPM NAS South Weymouth POC	Michelle Snyder TBD Michael Mellette Brian Helland Dave Barney	978-905-2409 TBD 978-228-0758 215-897-4912 617-753-4656	Any field team member who observes an unsafe situation has the authority to stop work. If Resolution Consultants is the responsible party for a stop work command, the Resolution Consultants SSO will inform onsite personnel, subcontractor(s), TOM, HSO, and the NAS South Weymouth POC within 1 hour (verbally or by email). The HSO will notify the Navy RPM within 24 of notification from the SSO. If a subcontractor is the responsible party, the subcontractor PM must verbally inform the Resolution Consultants SSO within 15 minutes, and the Resolution Consultants SSO will then follow the procedure listed above.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
SAP Changes prior to Field/ Laboratory work	Resolution Consultants TOM Resolution Consultants FTL Resolution Consultants QAO/Chemist Navy RPM U.S. EPA RPM MassDEP RPM	Michelle Snyder TBD Lori Herberich Brian Helland Carol Keating David Chaffin	978-905-2409 TBD 978-905-2244 215-897-4912 617-918-1393 617-348-4005	The Resolution Consultants FTL will verbally inform the TOM upon realizing a need for a SAP modification. The FTL or TOM will document the proposed changes via a SAP modification form within 5 days and send it to the project QAO/chemist. The project QAO/chemist will assess whether: a) The modification has the potential to affect the project's ability to achieve DQOs, b) The modification requires a change in field or laboratory methods, which may affect project schedule or cost, or c) The modification does not affect DQOs, schedule, or cost, and is for documentation purposes only. SAP modifications potentially affecting DQOs will be submitted to the Navy RPM, U.S. EPA RPM, and MassDEP RPM for review and consideration, and may require SAP amendments and approval. Modifications in laboratory/field methods, project schedule or cost will be submitted to the Navy for review and consideration. Minor modifications not affecting DQOs, schedule, or cost will be documented in the project file.
SAP Changes in the Field	Resolution Consultants TOM Resolution Consultants FTL Navy RPM U.S. EPA RPM MassDEP RPM	Michelle Snyder TBD Brian Helland Carol Keating David Chaffin	978-905-2409 TBD 215-897-4912 617-918-1393 617-348-4005	The Resolution Consultants FTL will inform the TOM verbally within same day of the need for a SAP change in the field. The TOM will inform the Navy RPM by email within 24 hours; the TOM sends a concurrence letter to the Navy RPM, if warranted, within 7 calendar days and the Navy RPM signs the letter within 5 business days of receipt Scope change is to be implemented before work is executed. Changes must be documented on the SAP modification form (within 2 business days) or SAP amendment (within timeframe agreed to by Resolution Consultants TOM, Navy RPM, U.S. EPA RPM, and MassDEP RPM). The Navy will notify U.S. EPA and MassDEP of any significant SAP field changes within 5 business days. Any change of the approved SAP affecting the scope or implementation of the sampling program will be made only upon authorization of the Navy RPM and regulatory agencies.
Field Corrective Actions	Resolution Consultants TOM Resolution Consultants FTL Navy RPM	Michelle Snyder TBD Brian Helland	978-905-2409 TBD 215-897-4912	The Resolution Consultants FTL will inform the TOM verbally within same day of field corrective actions. The Resolution Consultants TOM will then notify the Navy RPM (verbally or by email) within one business day.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Recommendations to stop work and initiate work upon corrective action	Resolution Consultants FTL/SSO Resolution Consultants TOM Resolution Consultants QAO/Chemist Navy RPM	TBD Michelle Snyder Lori Herberich Brian Helland	TBD 978-905-2409 978-905-2244 215-897-4912	Responsible party verbally informs the Resolution Consultants TOM, FTL, and subcontractors within 1 hour of recommendation to stop work and within 24 hours of recommendation to restart work. Responsible party follows verbal notification with an email to the Resolution Consultants TOM, Navy RPM, U.S. EPA RPM, and MassDEP RPM, within 24 hours.
Sample Receipt and Laboratory Quality Variances	Resolution Consultants TOM Resolution Consultants FTL TestAmerica PM	Michelle Snyder TBD Joy Chang	978-905-2409 TBD 623-209-9961	The analytical laboratory PM will notify verbally or by email the Resolution Consultants FTL immediately upon receipt of any chain-of-custody/sample receipt variances for clarification or direction from the FTL. The Resolution Consultants FTL will notify verbally or by email the Resolution Consultants TOM within one business day, if corrective action is required. The Resolution Consultants TOM will notify verbally or by email the analytical laboratory PM and the Resolution Consultants FTL within 1 business day of any required corrective action.
Analytical Corrective Actions	TestAmerica PM Resolution Consultants Project Chemist	Joy Chang Lori Herberich	623-209-9961 978-905-2244	The analytical laboratory PM shall notify the Resolution Consultants Project Chemist of any analytical data anomaly within one business day of discovery. After the analytical laboratory receives guidance from the Resolution Consultants Project Chemist, the laboratory shall initiate any corrective action to prevent further anomalies.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Analytical Data Quality Issues	TestAmerica PM Resolution Consultants QAO/Chemist Resolution Consultants TOM Navy RPM	Joy Chang Lori Herberich Michelle Snyder Brian Helland	623-209-9961 978-905-2244 978-905-2409 215-897-4912	The analytical laboratory PM will notify verbally or by email the Resolution Consultants Project Chemist within one business day of discovering an issue related to analytical laboratory data. The Resolution Consultants Project Chemist will notify the Resolution Consultants TOM within one business day. The Resolution Consultants Project Chemist will notify the Resolution Consultants TOM verbally or by email within 48 hours of validation completion that a non-routine and significant analytical laboratory quality deficiency has been detected that could affect this project and/or other projects. The Resolution Consultants TOM will then verbally advise the Navy RPM within 24 hours of notification from the Project Chemist. The Navy RPM will take corrective action appropriate for the identified deficiency. If lack of significant data quality or non-useable data is at issue, the Navy QAO/Chemist will be contacted to ensure the issues do not have the potential to impact other Navy projects.
Reporting Data Validation Issues/Data Validation Corrective Actions	Resolution Consultants QAO Resolution Consultants TOM	Lori Herberich Michelle Snyder	978-905-2244 978-905-2409	The Resolution Consultants Project Chemist or Data Validator will perform validation as specified in Worksheets #34, #35, and #36, and will contact the analytical laboratory as soon as possible if issues are found that require corrective action. If the Resolution Consultants Project Chemist or Data Validator identifies non-usable data during the data validation process that requires corrective action, the Resolution Consultants TOM will coordinate with the Project Chemist to take corrective action appropriate for the identified deficiency to ensure project objectives are met. Corrective action may include resampling and/or reanalyzing the affected samples, as determined by the TOM.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Notification of Non-Usable Data	TestAmerica PM Resolution Consultants Project Chemist Resolution Consultants TOM Navy RPM U.S. EPA RPM MassDEP RPM	Joy Chang Lori Herberich Michelle Snyder Brian Helland Carol Keating David Chaffin	623-209-9961 978-905-2244 978-905-2409 215-897-4912 617-918-1393 617-348-4005	If the analytical laboratory determines that any data they have generated is non-usable, the analytical laboratory PM will notify verbally or by email the Resolution Consultants Project Chemist within 1 business day of when the issue is discovered. The Resolution Consultants Project Chemist will notify the TOM verbally or by email within 1 business day of the need for corrective action, if the non-usable data is a significant issue (i.e., critical sample data). Corrective action may include resampling and/or reanalyzing the affected samples. If a Resolution Consultants Project Chemist or Data Validator identifies non-usable data during the data validation process, the TOM will be notified verbally or via email within 48 hours of validation completion that a non-routine and significant analytical laboratory quality deficiency has resulted in non-usable data. The Resolution Consultants TOM will take corrective action appropriate for the identified deficiency to ensure the project objectives are met. The TOM will notify the Navy RPM verbally or by email of any problems discovered regarding analytical laboratory results or of analyses that could significantly affect the usability of that data or of project failures that impact the ability to complete the scope of work. The Navy RPM may, at his discretion, contact the Navy QAO/Chemist for assistance in problem resolution. Such notification will be made within one business day of when the issue is discovered. The Navy RPM will notify U.S. EPA RPM and MassDEP RPM when any significant corrective action is taken.

Notes:

DQO	=	Data quality objective
FTL	=	Field Team Lead
HSO	=	Health and Safety Officer
MassDEP	=	Massachusetts Department of Environmental Protection
NAS	=	Naval Air Station
POC	=	Point of Contact
PM	=	Project Manager
QAO	=	Quality Assurance Officer
RPM	=	Remedial Project Manager
SAP	=	Sampling and Analysis Plan
SSO	=	Site Safety Officer
TBD	=	To be determined
TOM	=	Task Order Manager
U.S. EPA	=	United States Environmental Protection Agency

SAP Worksheet #9: Project Planning Session Participants Sheet

Project Name: PFOS and PFOA Remedial Investigation Work Plan	**Site Name:** Hangar 1
Projected Date(s) of Sampling: Fall 2015	**Site Location:** Former NAS South Weymouth, Weymouth, Massachusetts
Project Manager:	Michelle Snyder
Date of Session:	14 October 2014
Scoping Session Purpose:	Discuss framework of the Tier II SAP/Remedial Investigation Work Plan

Name	Title	Affiliation	Phone #	Email Address
Brian Helland	Remedial Project Manager	Naval Facilities Engineering Command, Mid-Atlantic	215-897-4912	Brian.Helland@navy.mil
David Barney	NAS South Weymouth POC	Naval Facilities Engineering Command, Mid-Atlantic	617-753-4656	David.a.Barney@navy.mil
Michelle Snyder	Task Order Manager	Resolution Consultants	978-902-2409	Michelle.Snyder@aecom.com
Julie Kabel	Risk Assessor	Resolution Consultants	603-263-2145	Julie.Kabel@aecom.com
Thomas Deck	Environmental Scientist	Resolution Consultants	904-301-4515	TDeck@ensafe.com

Notes:

PFOS = Perfluorooctane sulfonate
PFOA = Perfluorooctanoic acid
NAS = Naval Air Station
SAP = Sampling and Analysis Plan
POC = Point of contact

Comments/Decisions:

- Navy and Resolution Consultants discussed the scope of the Remedial Investigation (RI) at Hangar 1.
- Navy requested that the perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) plume lines from the recent long-term monitoring be added to Figure 17-1.
- Navy requested discussion of exposure scenarios is included in Worksheet #10.3.5.

Consensus Decisions:

- Resolution Consultants will write a Tier II Sampling and Analysis Plan (SAP)/RI Work Plan.
- Additional overburden and bedrock wells will be installed to determine the extent of PFOS and PFOA at Hangar 1. Note: During the October 8, 2015 Project Manager meeting, it was agreed that the RI would be conducted in phased approach, beginning with installation and sampling of overburden wells. Following review of laboratory results, additional overburden and/or bedrock well locations will be identified and installed, as necessary.
- Leaching potential of PFOS and PFOA in soil will be evaluated.

SAP Worksheet #10: Conceptual Site Model

10.1 Introduction

This worksheet presents general background information and the current Conceptual Site Model (CSM) for the Hangar 1 site. The CSM describes potential contamination routes and possible exposure pathways, and serves as the basis for developing the sampling and analysis program.

10.2 Site Description

Former Naval Air Station (NAS) South Weymouth is located approximately 15 miles southeast of Boston, Massachusetts and is situated in Norfolk and Plymouth counties. Portions of the Base are located in the towns of Weymouth, Abington, and Rockland. Former NAS South Weymouth was developed during the 1940s for blimp aircraft used to patrol the North Atlantic during World War II. The facility was closed at the end of the war and was reopened in 1953 as a Naval Air Station for aviation training. Former NAS South Weymouth was in continuous use from that time until it was operationally closed on 30 September 1996, and was administratively closed on 30 September 1997.

Hangar 1 (**Figure 10-1**) is located at the intersection of Shea Memorial Drive and Cummings Road. The new Bill Delahunt Parkway runs through the southeastern portion of the Hangar 1 site. Hangar 1 was built in 1966 on the site of a former World War II-era dirigible hangar originally constructed in 1942. The combined size of the Hangar 1 area is approximately 165,290 square feet; the main bay of the hangar was approximately 68,800 square feet. The primary use of Hangar 1 was for storage and maintenance of aircraft, including activities such as metal working, engine work, painting, arming, washing, hydraulic system repair, welding, parachute packing, photo development, training, and plating and anodizing (Tetra Tech 2010).

Aqueous film forming foam (AFFF) containing perfluorinated compounds (PFCs) was stored in Hangar 1 (North Lean-To) in two above-ground storage tanks (ASTs) as shown on **Figure 10-2**. Releases of AFFF occurred in the area of the AFFF ASTs, the pump room, and the AFFF distribution system (Tetra Tech 2011). AFFF was also stored in 55-gallon drums in the Crash Truck Garage in the South Lean-To, attached to Hangar 1 (**Figure 10-2**).

Hangar 1 and its Lean-Tos were demolished in February 2012, but its concrete floor and the surrounding apron are still present. The Hangar 1 site is now the entrance for the Bill Delahunt Parkway, which acts as the main entryway from the east side of former NAS South Weymouth. The area surrounding the former location of Hangar 1 is paved. No surface water bodies are located within 1,500 feet of the site. Only sparse vegetation exists on the site (Foster Wheeler Environmental 2001).

10.3 Site History

Hangar 1 was initially investigated along with the floor drainage system located within the hangar. Subsequent to completion of the No Further Action (NFA) Record of Decision (ROD) in 2010 and the commencement of the perfluorinated compounds (PFC) investigation, the site was divided into two parcels, the Hangar 1 Aquifer Protection District (APD) parcel and the Hangar 1 Non-APD parcel. A site chronology is included in **Table 10-1**.

Table 10-1
Chronology of Site Events

Event	Date
Hangar 1 and Lean-Tos re-constructed (originally constructed in 1942)	1966
Naval Air Station South Weymouth is placed on the National Priority List	May 1994
Phase I Environmental Baseline Survey	1995
Hydrostatic Testing of Floor Drain System	1998
Removal Action Report for Building 1	March 1999
Time Critical Removal Action for Building 1	January 2001
Removal Action Report for Floor Drain System Removal	January 2001
Removal Action Report for Floor Drain System Soil Remediation	February 2001
Phase II Environmental Baseline Survey Field Report	December 2004
Streamlined Human Health Risk Assessment	December 2009
Proposed Plan	March 2010
Record of Decision signed, No Further Action	July 2010
Perfluorinated Compound Investigation 2010 through 2012	April 2010 — February 2012
Explanation of Significant Differences, 2011 (Groundwater use restriction)	December 2011
Hangar 1 and Lean-Tos demolished	February 2012
Annual Land Use Control Inspection — 2012	December 2012
Annual Land Use Control Inspection — 2013	December 2013

The division of Hangar 1 into two separate parcels was conceptualized as a means to facilitate land transfer discussions between the Navy, EPA, MassDEP, South Shore Tri-Town Development Corporation (SSTTDC) and their master developer. An Explanation of Significant Differences (ESD) with public comment signed by Navy and EPA was issued for Hangar 1 to address the presence of PFOS and PFOA in groundwater outside of the APD at concentrations exceeding the Provisional Health Advisory (PHA). The ESD added an institutional control remedy and a deed restriction was placed on the property prohibiting the use of groundwater as a source of drinking water in a 22-acre area of Hangar 1 (outside the APD) as presented in **Figure 10-1** (Tetra Tech 2011). This remedy was protective of human health and the environment and the 22-acre parcel was determined to be suitable to transfer. The portion of Hangar 1 area within the APD was not part of the ESD and will be the subject of a future decision document.

The ROD (U.S. Navy 2010) for Hangar 1 specified a NFA decision for soils and groundwater based on the Navy's investigations and removal actions at the site. The streamlined human health risk assessment performed at the completion of the removal actions concluded that exposure to the soils and groundwater at the site did not pose an unacceptable risk to human health or the environment.

In 2010, the United States Environmental Protection Agency (U.S. EPA) and the Massachusetts Department of Environmental Protection (MassDEP) requested that additional environmental data be collected to investigate the potential presence of PFCs in groundwater. PFCs are components of AFFF, which was used, released, and/or spilled in areas of NAS South Weymouth, specifically in and around Hangar 1. PFCs are stable and bioaccumulative compounds classified by the Department of Defense (DoD) as emerging contaminants. Two PFCs, PFOS and PFOA, are considered marker compounds that serve to indicate the presence of other PFCs. PFOS and PFOA are the only PFCs with U.S. EPA PHA values available for comparison.

During 2010-2011, a *Phase II Environmental Baseline Survey* (Tetra Tech, August, 2012) was conducted to assess the presence/absence of PFOS and PFOA at NAS South Weymouth, specifically at Hangar 1. PFOS and PFOA were detected above PHA values at four of the six wells sampled at Hangar 1 during the 2011 groundwater sampling event. The highest concentrations of PFOS and PFOA were identified near Hangar 1 and decreased downgradient of the hangar. This spatial distribution pattern is consistent with Hangar 1 being a source of these chemicals in groundwater. Soil borings were advanced adjacent to groundwater sample locations and at target locations associated with the AFFF ASTs, AFFF distribution system, floor drain system, two former exterior oil-water separator locations, and the former Crash Truck Garage. The highest concentrations of PFOS and PFOA were detected in the vicinity of the former Crash Truck Garage (South Lean-To) and the former AFFF ASTs (North Lean-To) just above the water table. Based on the current land use, there are no identified human or ecological receptors potentially impacted by the presence of PFOS and PFOA in soil or in groundwater. However, future use of the site may include development at or near Hangar 1.

An ESD was issued for Hangar 1 to address the presence of PFOS and PFOA in groundwater outside of the APD at concentrations exceeding the PHA. The ESD added an institutional control remedy to the 2010 ROD and a deed restriction was placed on the property prohibiting the use of groundwater as a source of drinking water in a 22-acre area of Hangar 1 (outside the APD) as presented in **Figure 10-1** (Tetra Tech 2011). This remedy was deemed protective of human health and the environment, and the 22-acre parcel was determined to be suitable to transfer. The portion of Hangar 1 area within the APD was not part of the ESD and will be the subject of a future decision document.

10.4 Conceptual Site Model

This section provides the CSM for Hangar 1, which describes potential sources of contamination, nature and extent of contamination, fate and transport mechanisms, and receptor and land uses. A graphical representation of the CSM is provided as **Figure 10-3**.

10.4.1 Site Geology/Hydrogeology

The soils at former NAS South Weymouth are typical of the glacial outwash region and vary from rock outcroppings and sandy loam to highly organic soils. Soils are primarily sand and gravel mixed with silt, clay, and organic matter. The dominant soil is classified as Made Land and occurs on and around the runways (Stone and Webster 1996).

Three general geologic units have been identified at Hangar 1: fill (artificially placed), native overburden, and bedrock. Sandy fill material was observed in areas throughout the site, with a thickness ranging from 0 to approximately 16 feet below ground surface (bgs). The bedrock at the site is mapped as Dedham Granite (Zen, et al. 1983). Bedrock was not encountered at the deepest overburden monitoring well at the site, H1-MW-2D, which was installed to a depth of 33 feet bgs.

As of April 2014, the measured depths to groundwater at Hangar 1 range from approximately 7 to 13 feet bgs and groundwater flow has both a southeasterly and southwesterly component.

There is a medium yield aquifer beneath a portion of Hangar 1 as shown on **Figure 10-1**, which is designated by MassDEP as a Potential Drinking Water Source Area. This aquifer is designated as an APD in the SSTTDC Zoning (now Southfield Redevelopment Authority) and Land Use By-Laws for former NAS South Weymouth (SSTTDC 2005). There are high yield aquifers located to the east and west of the Site. Although the high yield aquifers are also considered Potential Drinking Water Source Areas, they are outside the extent of this investigation and not suspected to be impacted by historic site activities.

10.4.2 Potential Sources

AFFF was primarily stored in two 10,000 gallon ASTs at the North Lean-To of Hangar 1. A subsurface piping system beneath the concrete slab of Hangar 1 transported AFFF to six above-slab distribution points within Hangar 1. A spill of 5,000 to 10,000 gallons of AFFF occurred on October 21, 1987, inside Hangar 1. The spill was captured by the Hangar 1 floor drain system and contained in the western exterior oil-water separator, which flows to the sanitary sewer (**Figure 10-2**). This spill was managed in accordance with the Spill Prevention, Control, and Countermeasure Plan. Several inadvertent releases of AFFF from the two AFFF ASTs in the North Lean-To were also reported. Inadvertent

releases were also reported from the fire hose nozzles and piping from the ASTs and pump room. It is possible that inadvertent releases of AFFF within Hangar 1 would have been directed to the floor drain system. A hydraulic test was completed on the Hangar 1 floor drain system and the results indicated that the integrity of the floor drain system was compromised (Foster Wheeler 1999). It is also possible that inadvertent releases of AFFF from either within Hangar 1, or on the tarmac surrounding Hangar 1, may have been directed to the exterior trench drains located adjacent to the east and west hangar doors, which were connected to the storm water drainage system.

The two AFFF ASTs were drained in January 1997. All floor and trench drains, piping inside and outside Hangar 1, and the east and west oil-water separators were removed prior to 2004 (Tetra Tech 2009). As part of floor and trench drain and associated piping removal activities approximately 105 tons of contaminated soil was excavated and transported off-site for disposal. The soil excavation work was completed in response to contaminants identified at Hangar 1 prior to the discovery of PFOS and PFOA in 2010 at Hangar 1. It is likely that the historical excavation efforts to address other contaminants likely also removed some PFOS and PFOA in soil located in the vicinity of the comprised floor drain system. Prior investigations conducted after excavation activities were completed have identified the highest PFOS/PFOA concentrations in soil just above the water table in the vicinity of the former ASTs and the former Crash Truck Garage.

AFFF is widely used for firefighting by the military and municipal fire departments. The fluorinated compounds found in AFFF are also used in herbicides, insecticides, cosmetics, greases, lubricants, and adhesives. They are now considered to be ubiquitous in the environment.

10.4.3 Nature and Extent

In soil, the maximum PFOS and PHOA concentrations were observed just above the water table in the area of the former Crash Truck Garage (South Lean-To). Additionally, elevated PFOS and PFOA concentrations were reported in the vicinity of the former AFFF ASTs (North Lean-To).

In overburden groundwater, there are two diffuse co-mingled dissolve-phase PFOS and PFOA plumes at the Hangar 1 site. The distribution of reported concentrations in overburden groundwater is indicative of lateral stability of the central portions/cores of the comingled PFOS and PFOA plumes (e.g., where the impact exceeds screening criteria, there has been little-to-no change over time in the lateral extent of the footprint of the identified plumes). A reduction in the magnitude of PFOS and PFOA concentrations was reported in the overburden aquifer at Hangar 1 following the 2014 sampling event, when compared to historical PFOS and PFOA concentrations (Resolution Consultants 2014). However, during the 2014 investigation both PFOS and PFOA were reported at concentrations above

PHAs at several monitoring well locations. The distribution of groundwater PFOAS and PFOA impacts are presented on **Figure 10-2**. Additional investigation of overburden groundwater impacts, via an expanded monitoring well network, is required to adequately characterize the co-mingled PFOS and PFOA plumes at Hangar 1.

Currently, there are no bedrock monitoring wells located at the Hangar 1 site. Recently, monitoring well H1-MW-2D has been represented as a location screened within bedrock; however, review of the boring log indicates that bedrock was not encountered at this location during drilling and therefore, is considered screened in the overburden. Based on the boring log for H1-MW-2D, bedrock could be as deep as 33+ feet bgs. Based on the physical properties of PFOS and PFOA, these compounds are considered likely to migrate vertically through the saturated zone and at Hangar 1, potentially enter bedrock via fractures. Due to the lack of bedrock groundwater quality data available, combined with the known physical properties of PFOS and PFOA, additional investigation of the bedrock aquifer at the Hangar 1 site may be required to evaluate potential PFOS and PFOA impacts, pending review of deep overburden groundwater data.

10.4.4 Fate and Transport Mechanisms

PFOS and PFOA are highly soluble with a high affinity for aqueous transport; in general unlikely to volatilize, and do not readily sorb to soil (Agency for Toxic Substances and Disease Registry 2009). However, residual PFOS and PFOA may leach from soil and abandoned infrastructure (concrete foundations) to groundwater.

Groundwater at Hangar 1 is present in both the overburden and bedrock aquifers. Surface releases from Hangar 1 are expected to have primarily impacted the overburden aquifer. However, PFOS and PFOA could potentially migrate between aquifers by natural hydraulic interconnectivity.

10.4.5 Receptors and Land Use

The Hangar 1 property is currently vacant land covered by pavement and concrete; as a result, only sparse vegetation exists on the site. Currently there are no identified human or ecological receptors that may be exposed to PFOS and PFOA in groundwater. However, future use of the site may include development at or near the identified areas of concern. No drinking water supply wells are located at Hangar 1 but the APD is considered a Potential Drinking Water Source Area. Additionally, use of groundwater for irrigation is possible in the future. In accordance with the Hangar 1 Decision Document for the Non-APD area, land-use controls have been implemented to restrict use of groundwater. Additional investigation is required to determine if groundwater within either the APD or non-APD poses unacceptable risks to potential future site receptors. Potential human receptors that

may be exposed to groundwater in the future are listed below, along with the associated potentially complete exposure pathways. These receptors and pathways will be evaluated in a human health risk assessment, conducted as part of the RI, if concentrations of PFOS and PFOA in groundwater are detected above screening levels (referred to as Project Action Levels [PALs] in this SAP), defined in **Section 11.3**. The human health risk assessment will evaluate the following pathways for a reasonable maximum exposure (RME) scenario. A central tendency exposure (CTE) scenario will also be evaluated only if the RME scenario identifies unacceptable potential risk/hazard.

- Hypothetical Future Construction/Utility Worker — Exposure to groundwater in an excavation trench through incidental ingestion
- Hypothetical Future Onsite Worker — Exposure to groundwater through ingestion of drinking water
- Hypothetical Future Onsite Residents (Adult and Child) — Exposure to groundwater through ingestion of drinking water

The numerical exposure assumptions that will be used to evaluate the above receptors are presented in **Table 10-2** through **Table 10-4**.

Table 10-2
Summary of Exposure Assumptions — Current/Future Construction/Utility Worker
Remedial Investigation Work Plan
Aquifer Protection District at Hangar 1
Former Naval Air Station South Weymouth

Parameter		Current/Future Construction/Utility Worker			
		Reasonable Maximum Exposure		Central Tendency Exposure	
Parameters Used in the Groundwater Contact Pathway					
	Exposure Frequency (days/year)	250	(b)	130	(f)
	Exposure Duration (yr)	1	(c)	0.5	(c)
	Water Ingestion Rate (l/day)	0.005	(d)	0	(a)
	Body Weight (kg)	80	(e)	80	(e)

Notes:
(a) Assumes construction workers obtain their drinking water offsite and that incidental ingestion to groundwater is trivial.
(b) Exposure frequency is equivalent to 5 days per week for the exposure duration.
(c) Construction activities are assumed to occur within a 1 year period (for RME scenario) and for a 6 month period (for CTE scenario) based on professional judgment.
(d) Based on professional judgment and U.S. EPA, 1989, Risk Assessment Guidance for Superfund, Volume I. Value is one-tenth of that assumed to occur during a swimming event via incidental ingestion. Assumes drinking water is obtained offsite.
(e) U.S. EPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. 6 February 2014.
(f) Exposure frequency is equivalent to 5 days per week for exposure duration (26 weeks).

Table 10-3
Summary of Exposure Assumptions — Future Onsite Worker
Remedial Investigation Work Plan
Aquifer Protection District at Hangar 1
Former Naval Air Station South Weymouth

Parameter		Future Onsite Worker			
		Reasonable Maximum Exposure		Central Tendency Exposure	
Parameters Used in the Groundwater Ingestion Pathway					
	Exposure Frequency (days/year)	250	(a)	219	(c)
	Exposure Duration (yr)	25	(a)(b)	7	(e)
	Water Ingestion Rate (l/day)	1	(a)	0.7	(f)
	Body Weight (kg)	80	(d)	80	(d)

Notes:
U.S. EPA, 1997. U.S. EPA Exposure Factors Handbook. Volume I. August 1997.
U.S. EPA, 2004. Risk Assessment Guidance for Superfund, Supplemental Guidance for Dermal Risk Assessment. July 2004.
(a) U.S. EPA, 1991. Standard Default Exposure Factors.
(b) U.S. EPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December, 2002.
(c) U.S. EPA, 2004. Exhibit 3-5, recommended value.
(d) U.S. EPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. 6 February 2014.
(e) U.S. EPA, 1997. Recommended value for median occupational tenure, average of values for men and women (Table 15-158).
(f) One-half of the recommended mean value for the ingestion of drinking water for the associated age range (U.S. EPA, 1997, Table 3-30), assuming workers get one-half of their daily drinking water at work.

Table 10-4
Summary of Exposure Assumptions — Hypothetical Future Onsite Resident
Remedial Investigation Work Plan
Aquifer Protection District at Hangar 1
Former Naval Air Station South Weymouth

Parameter	Reasonable Maximum Exposure				Central Tendency Exposure			
	Young Child (0 to 6 yrs)		Adult		Young Child (0 to 6 yrs)		Adult	
Parameters Used in the Groundwater Contact Pathway								
Exposure Frequency (days/year)	350	(a)	350	(a)	234	(e)	234	(e)
Exposure Duration (yr)	6	(a)	20	(b)	6	(a)	19	(f)
Water Ingestion Rate (l/day)	0.78	(b)	2.5	(b)	0.6	(d)	1.4	(d)
Body Weight (kg)	15	(c)	80	(b)	15	(c)	80	(b)
Parameters Used in the Showering/Bathing Pathway								
Exposure Frequency (days/year)	350	(a)	350	(a)	234	(e)	234	(e)
Exposure Duration (yr)	6	(a)	20	(b)	6	(a)	19	(f)
Body Weight (kg)	15	(c)	80	(b)	15	(c)	80	(b)

Notes:
U.S. EPA, 1991. Standard Default Exposure Factors.
U.S. EPA, 1993. U.S. EPA Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Preliminary Review Draft. 5 May 5 1993.
U.S. EPA, 1997. Exposure Factors Handbook. Volume I. August 1997.
(a) U.S. EPA, 1991.
(b) U.S. EPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. 6 February 2014.

(c) U.S. EPA, 1997. Recommended mean body weights. Weighted average of associated age ranges (Tables 7-1, 7-3).
(d) U.S. EPA, 1997. Recommended mean value for the ingestion of drinking water for the associated age range (Table 3-30).
(e) Value recommended by U.S. EPA (1993) for CTE scenario.
(f) For the CTE the children exposure remains 6 years, but the adult is reduced to 19 years based on a total residence time of 25 years (U.S. EPA, 1997, Table 15-174).

Dermal contact with PFOS and PFOA in groundwater is not proposed for evaluation due to the lack of chemical-specific information relative to these compounds to calculate their absorption from water through the skin. U.S. EPA's RAGS Part E Dermal Risk Assessment Guidance (U.S. EPA 2004) states: "The dermal risk guidance uses a mathematical model to predict absorption and risk from exposures to water. Contaminants for which there are sufficient data to predict dermal absorption with acceptable confidence are said to be within the model's effective predictive domain (EPD). Although the methodology can be used to predict dermal exposures and risk to contaminants in water outside the EPD, there appears to be greater uncertainty for these contaminants. OSWER [Office of Solid Waste and Emergency Response] and the workgroup, which developed this guidance, do not recommend that the model be used to quantify exposure and risk to contaminants in water that are outside the EPD in the "body" of the risk assessment. Rather, it is recommended that such information be presented in the discussion of uncertainty in the risk assessment." In addition, U.S. EPA's online calculator to calculate a tap water Regional Screening Level (RSL) for PFOS and PFOA (U.S. EPA 2015) indicates that the values are "outside of the EPD."

This specifically relates to the dermal pathway only and it suggests that the U.S. EPA does not advocate evaluating the dermal exposure to groundwater pathway for these compounds. Typically, compounds with very large and very small octanol-water partition coefficients (K_{ow}) (which is used to estimate dermal permeability) are "outside" of the EPD and therefore are not recommended to be quantitatively assessed.

A review of available literature related to the dermal absorption of PFOS and PFOA will be performed as part of the risk assessment to determine if the evaluation of the dermal contact pathway for PFCs is considered appropriate. If deemed appropriate, dermal contact pathways for PFOS and PFOA associated with groundwater exposure will be evaluated in the human health risk assessment. If not deemed appropriate, the dermal pathways will not be quantitatively evaluated and a qualitative discussion will be provided in the uncertainty assessment.

Use of groundwater for irrigation purposes is possible in the future. However, all of the exposure scenarios listed above are protective of a groundwater irrigation exposure pathway (i.e., the potential risks posed by the above scenarios would be higher than the potential risks posed by an irrigation

scenario given that the scenario involves only intermittent, low frequency contact with groundwater). Therefore, the irrigation exposure pathway will not be included in the human health risk assessment.

If PFOS and PFOA in groundwater or soil are detected above PALs, the human health risk assessment will be conducted in accordance with Navy Human Health Risk Assessment Guidance (Department of Navy 2008) U.S. EPA Risk Assessment Guidance for Superfund (U.S. EPA 1989) and other related guidance. The RI report will include a literature review and evaluation of detected PFOS and PFOA concentrations and potential ecological pathways relative to ecological receptors. The review will evaluate the literature concerning effects of PFOS and PFOA on aquatic organisms and compare the detected concentrations with such literature findings.

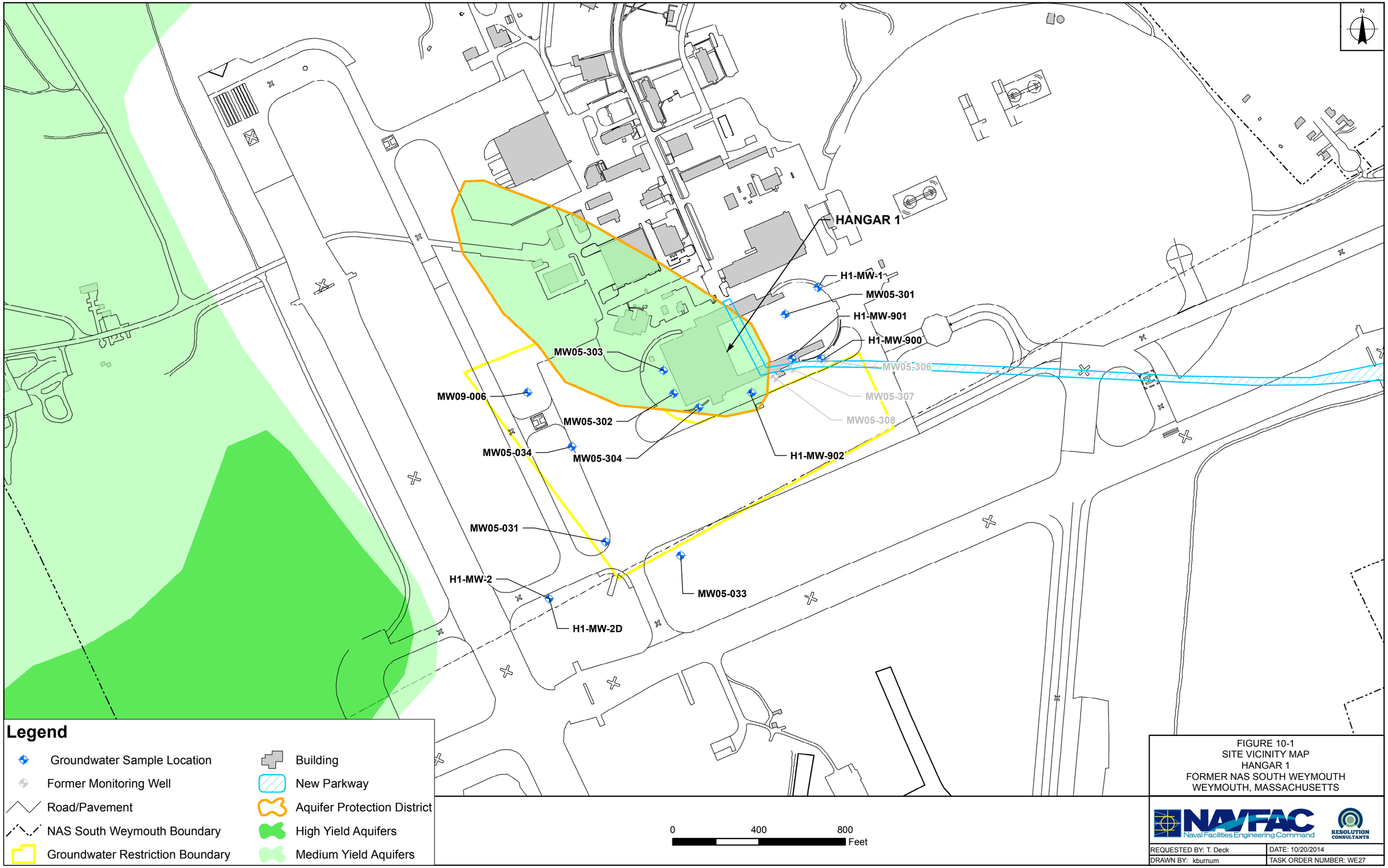


FIGURE 10-1
SITE VICINITY MAP
HANGAR 1
FORMER NAS SOUTH WEYMOUTH
WEYMOUTH, MASSACHUSETTS

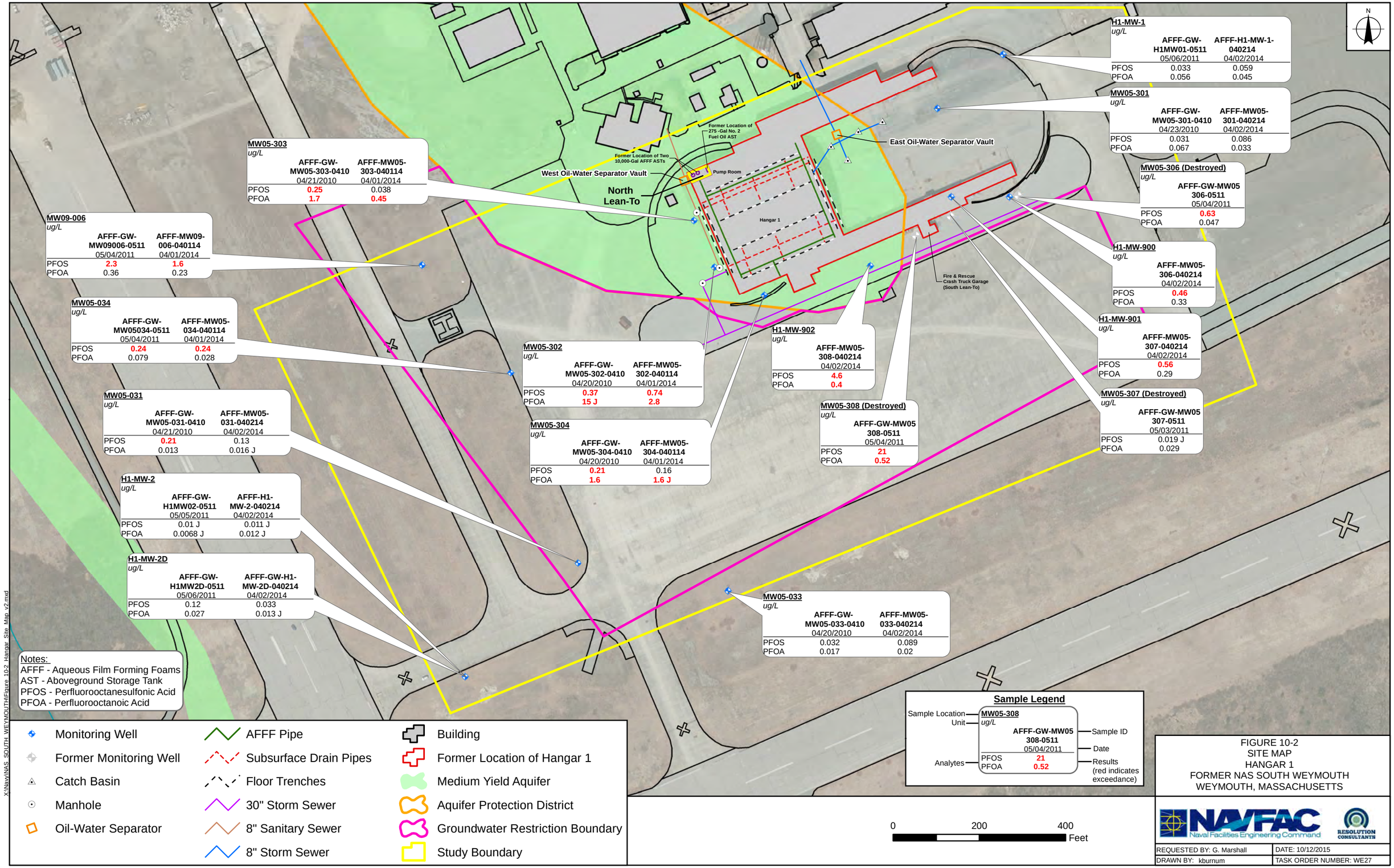


FIGURE 10-2
SITE MAP
HANGAR 1
FORMER NAS SOUTH WEYMOUTH
WEYMOUTH, MASSACHUSETTS

NAVFAC Naval Facilities Engineering Command
RESOLUTION CONSULTANTS

REQUESTED BY: G. Marshall	DATE: 10/12/2015
DRAWN BY: kburnum	TASK ORDER NUMBER: WE27

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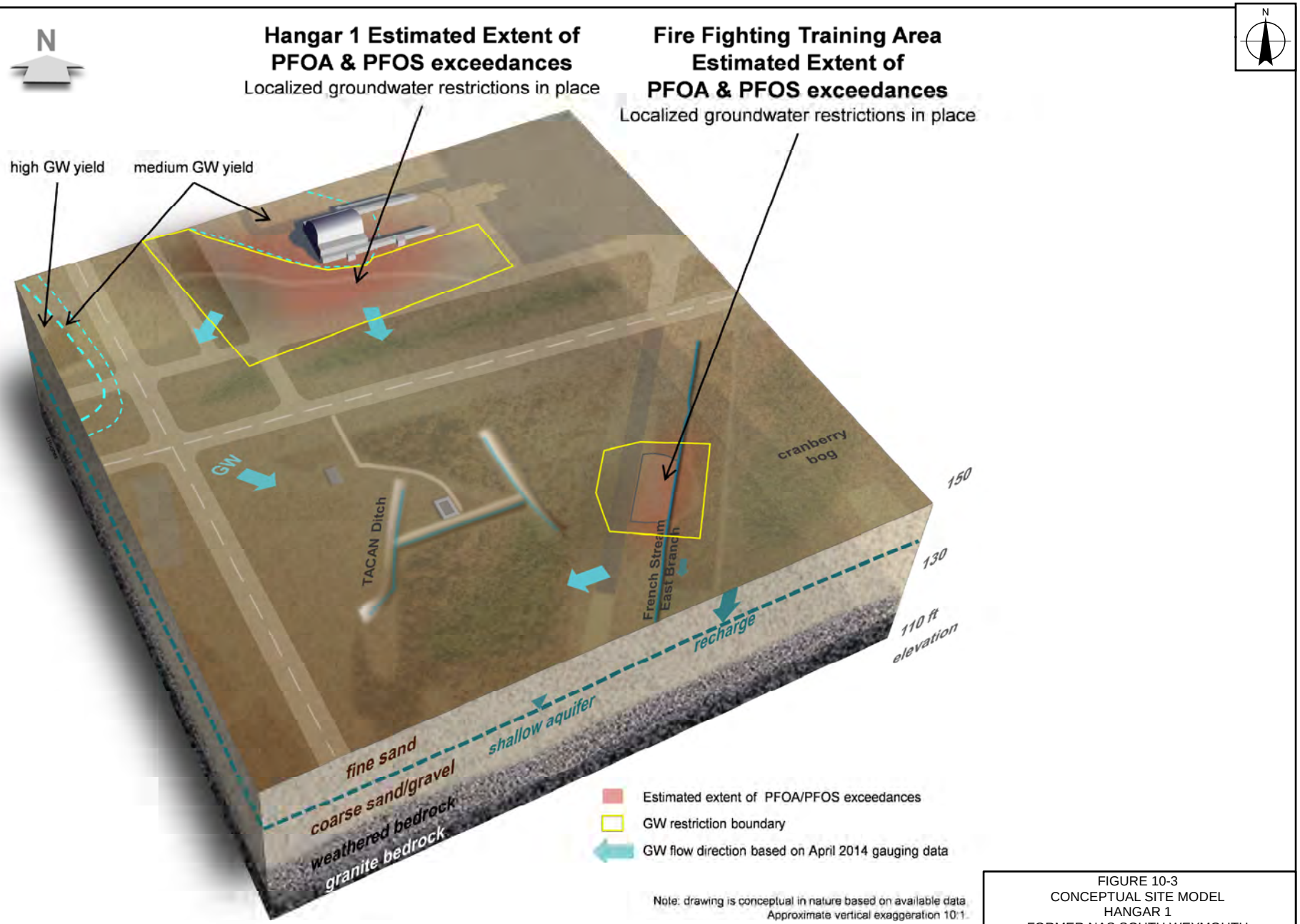

FIGURE 10-3
CONCEPTUAL SITE MODEL
HANGAR 1
FORMER NAS SOUTH WEYMOUTH
WEYMOUTH, MASSACHUSETTS

NAVFAC Naval Facilities Engineering Command
RESOLUTION CONSULTANTS

REQUESTED BY: T. Deck	DATE: 10/7/2015
DRAWN BY: kburnum	TASK ORDER NUMBER: WE27

Service Layer Credits: Larry Hughes

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SAP Worksheet #11: Data Quality Objectives/Systematic Planning Process Statements

The planned RI at former NAS South Weymouth is designed to determine the extent of PFOS and PFOA at the Hangar 1 site. Data quality objectives (DQOs) were developed for this investigation based on the Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G4, EPA/240/B-6/001) (U.S. EPA, February, 2006) and are presented below.

11.1 Problem Statement

In 2010, the U.S. EPA and the MassDEP requested that additional environmental data be collected to investigate the potential presence of PFOS and PFOA in groundwater at Hangar 1. Sampling confirmed the presence of PFOS and PFOA in both the APD and non-APD portions of the site. An ESD was issued for Hangar 1 to address the presence of PFOS and PFOA in groundwater outside of the APD at concentrations exceeding PHAs. Data is required to determine the extent of PFOS and PFOA in groundwater within both the APD and non-APD portions of the site and to identify potential risks to human receptors. Additionally, characterization of the leaching potential of soil from within the saturated zone in the vicinity of the former AFFF ASTs, the floor drain system, the exterior drain trenches, the former western oil-water separator, and the former Crash Truck Garage are required to determine if soil is functioning as a continuing source of PFOS and PFOA.

11.2 Goals of the Study

Based on the project objectives outlined above, the principal study questions (PSQs) developed to define decision statements and to ultimately resolve the problem are as follows:

- PSQ1: What is the extent of PFOS and PFOA concentrations in groundwater in the overburden and bedrock aquifer within both the APD and non-APD portions of the Hangar 1 site?
- PSQ2: Is there unacceptable potential risk to human receptors posed by exposure to groundwater?
- PSQ3: Are there any continued sources (soil) located under the Hangar 1 site impacting groundwater?

To meet the goals of the RI, phased intrusive investigation activities are required at the site. The first phase will consist of advancing a total of 34 soil borings, 31 completed as overburden monitoring wells, and collection of 24 total soil samples from a select subset of the 34 soil boring locations. Pending review of overburden groundwater and soil analytical data, a second phase of additional overburden or bedrock monitoring wells will be installed at the site, as necessary. The purpose of the

monitoring wells is to allow for assessment of the extent of dissolved-phase PFC impacts, and the purpose of the soil samples is to assess the magnitude of PFCs in saturated soils at previously identified areas where releases of AFFF are known or suspected to have occurred at Hangar 1.

The intent is that the activities outlined in this SAP will provide sufficient data to meet the PSQs. Following evaluation of the data collected during performance of this RI, additional mobilization(s) would be conducted as needed to resolve the PSQs identified above, using the Decision Rules identified in Section 11.5.

11.3 Information Inputs to Resolve the Problem

Data that are required to resolve the problems described in Section 11.1 are as follows:

- Chemical Data: Groundwater collected from new and existing overburden monitoring wells will be analyzed for PFOS and PFOA. If overburden data indicates the potential for bedrock impacts exists, then bedrock wells will be installed and sampled for PFOS and PFOA. Soil collected from the saturated zone in the vicinity of the former AFFF ASTs, the floor drain system, the exterior drain trenches, and the former Crash Truck Garage will be analyzed for PFOS and PFOA.

- Field Measurements: During groundwater sampling, field parameters (temperature, dissolved oxygen [DO], pH, specific conductance, oxidation-reduction potential [ORP], and turbidity) will be collected to determine when purge stabilization is complete.

- Groundwater Level Measurements: Synoptic water level measurements will be collected from existing and new site monitoring wells during this investigation to provide information regarding groundwater elevations and flow gradients. Every effort will be made to measure synoptic water levels during a period of time without a significant rain event. This data will be used to refine the CSM.

- Project Action Levels: Groundwater and Soil: PALs that are protective of a residential drinking water pathway were calculated for PFOS and PFOA using the U.S. EPA RSL Calculator (June 2015) as presented below and in Worksheet 15:

  Groundwater:

  — PFOS: 0.16 micrograms per liter (µg/L)
  — PFOA: 0.4 µg/L

Soil:

— PFOS: 0.023 milligram per kilogram (mg/kg)
— PFOA: 0.0213 mg/kg

Concentrations above PALs do not necessarily indicate the presence of unacceptable risk/hazard, but instead, indicate that further evaluation is necessary to quantify the level of potential risk/hazard to make a determination. Currently, toxicity values for PFOS and PFOA are not published in U.S. EPA's Integrated Risk Information System (U.S. EPA's Tier 1 source of toxicity values). Therefore, toxicity values used in the RSL calculator are Tier 3 source toxicity values obtained from U.S. EPA's Short-term PHA Memo (U.S. EPA 2009). If updated toxicity values for PFOS and PFOA are published before the risk assessment is conducted, the PALs will be revised based on the updated toxicity values as appropriate. In addition, a target hazard quotient (HQ) of 0.1 was used for calculation of the PALs for PFOS and PFOA, which is considered highly conservative. Please note that a target HQ of 0.3 could be used to derive PFOS and PFOA screening levels and still be protective of a cumulative noncancer target hazard index of 1 for the site. If the screening levels are exceeded, the site-specific information based on number of compounds acting on the same target organs and site-specific target HQ levels will be incorporated into a further evaluation of potential risk.

The laboratory selected for the current work is expected to achieve limits of quantitation (LOQs) that are low enough to measure constituent concentrations less than the PALs identified in Worksheet #15.

11.4 Define the Study Boundaries

The study boundary incorporates portions of both the APD and non-APD portions of the Hangar 1 site, and will include the locations of all existing and proposed monitoring well locations. The study boundary is depicted on **Figure 10-2**.

11.5 Analytic Approach

Decisions regarding future, next steps will be made by the Navy, in consultation with MassDEP and EPA, as required by CERCLA and in accordance with the November 1999, South Weymouth Federal Facilities Agreement. The following decision rules quantify the planned analytical approach for the Hangar 1 study.

Decision Rule #1: Extent of Contamination

If analytical results from the initial overburden phase of the investigation indicate that sufficient data was collected to characterize the extent of PFOS and PFOA in groundwater at Hangar 1, then additional characterization data will not be collected and the Navy will prepare an RI report documenting investigation findings. If the extent of PFOS and PFOA in groundwater at Hangar 1 is not resolved, then further data will be collected during a second phase mobilization.

Decision Rule #2: Risk Assessment

If soil or groundwater concentrations of either PFOS or PFOA exceed the respective PAL, the site risk assessor will evaluate the potential risk to human health, as applicable. If it is concluded that soil or groundwater may pose an unacceptable risk to human health, response actions will be presented and evaluated in a feasibility study. If no unacceptable potential risk to human receptors is identified, then no further action will be recommended.

The RI report will include a literature review and evaluation of detected PFOS and PFOA concentrations and potential ecological pathways relative to ecological receptors. If it is concluded that soil or groundwater may pose an unacceptable risk to ecological receptors, response actions will be presented and evaluated in a feasibility study. If no unacceptable potential risk to ecological receptors is identified, then no further action will be recommended for soil or groundwater.

Decision Rule #3: Continued Sources

If soil concentrations exceed either PFOS and/or PFOA PALs, then the data will be further assessed to gauge the magnitude of ongoing source contributions to groundwater and the need for additional actions (which may include, but is not limited to an updated decision document, Land Use Controls, source removal, or remedial design). If soil concentrations do not exceed PALs then no further action will be recommended for soil.

11.6 Performance Criteria

The objective of this section is to complete the following:

- Identify potential sources of study error (i.e., field error, analytical error)
- Establish and identify the methods used to reduce potential sources of error
- Determine how decision errors will be managed during the project
- Establish goals for laboratory and field completeness

Sources of Error — Sources may be divided into two main categories: sampling errors and measurement errors. A sampling error occurs when the sampling design, planning, and implementation do not provide for a representative range of heterogeneity at the site. A measurement error occurs because of performance variance from laboratory instrumentation, analytical methods, and operator error. The U.S. EPA identifies the combination of all these errors as a "total study error" (U.S. EPA 2006). One objective of the investigation is to reduce the total study error so that decision makers can be confident that the data collected accurately represent the chemical characteristics of the site. Comparability of data within the investigation will be maximized by using standard methods for sampling and analysis, reporting data, and data validation.

Managing Decision Error — The investigation will utilize decision-error minimization techniques in sampling design, sampling methodologies, and laboratory measurement of constituents of potential concern. Possible decision errors will be minimized during the field investigation by using the following methods:

- Use standard field sampling methodologies (as discussed in Worksheets #14 and #21). Due to the nature of PFOS and PFOA, special care must be taken to avoid cross contamination. Specific precautions for soil and groundwater sample collection are provided in Worksheet #14.

- Use applicable analytical methods and standard operating procedures (SOPs) for sample analysis by a competent analytical laboratory having state appropriate National Environmental Laboratory Accreditation Program accreditation, and be accredited through the DoD Environmental Laboratory Accreditation Program.

- Confirm analytical data to identify and control potential laboratory error and sampling error by using matrix spikes, blanks, and duplicate samples.

Decision errors associated with judgmental sampling are based on sample design and measurement errors. Assuming that the best possible professional judgment was used to develop the judgmental sampling plan (i.e., position sampling locations), the most important decision errors will be associated with field and laboratory techniques involved in the collection and analysis of the data.

Completeness – Field completeness is a measure of the amount of valid samples obtained during all sampling for the project. A field completeness goal of greater than 90 percent will be used for the soil and groundwater sampling.

Laboratory completeness is a measure of the amount of valid measurements obtained from all the measurements taken in the project. A laboratory completeness goal of greater than 95 percent will be used for the analytical data.

Field Data Logs— Sample information will be transcribed into a field logbook, tablet computer, and/or onto field datasheets.

Analytical Laboratory Sample Management — The sample matrix, number of samples, and number and type of laboratory quality assurance (QA)/quality control (QC) samples are summarized in combined Worksheets #18, 19, 20, and 30. Also included in this combined Worksheet are details on the analytical group, sample volumes, sample container specifications, preservation requirements, and maximum holding times.

The laboratory will provide electronic data deliverable files, portable document format files of the data deliverables for all project data, and a hard copy of data deliverables for all results. Designated samples will be used to obtain necessary subsamples for laboratory QC measurements (i.e., analytical sample duplicate and sample matrix spike/matrix spike duplicate [MS/MSD]). Tasks will be completed using the laboratory SOPs. Resolution Consultants will provide data validation services and verify and evaluate the usability of the data as described in Worksheets #34 through #36.

Portable document format copies of all analytical data packages will be stored on CD-ROM, archived in the Naval Facilities Engineering Command (NAVFAC) Southeast Administrative Record, and electronic results will be uploaded onto the Naval Installation Restoration Information Solution (NIRIS) system. All other data generated in the field and reports generated for the project will be stored as computer readable data files by Resolution Consultants and transferred to NAVFAC at the close of the project.

11.7 Sampling Design

The sampling design was developed using a biased sampling approach (based on prior field events) to optimize resources and generate data to satisfy the DQOs. Sample locations have been placed in areas that have been impacted by historical operations, and areas intended to delineate PFOS and PFOA in groundwater. The critical objective is to obtain a quality dataset. The sampling design, rationale, and locations are summarized in Worksheet #17 and combined Worksheets #18, 19, 20, and 30. These worksheets identify where groundwater and soil samples will be collected, and the analyses to be conducted for each sample.

The RI intrusive investigation activities will be implemented in a phased approach. The first phase will include the installation of monitoring wells to characterize the overburden aquifer. Pending review of the initial groundwater analytical data, and with regulatory input and approval, a second phase of drilling will occur, if necessary, that could include either additional overburden or bedrock monitoring well locations. The specifics of the second mobilization will be addressed in a SAP modification form and provided to the Navy, U.S. EPA, and MassDEP for review.

This investigation is scheduled to be initiated in fall of 2015.

SAP Worksheet #12: Field Quality Control Samples

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria
Equipment Rinsate Blank	PFOS and PFOA	One per 20 samples per matrix per sampling equipment	Accuracy/Bias/ Contamination	No analytes > ½ LOQ
Field Duplicate	PFOS and PFOA	One per 10 field samples	Precision	RPD ≤ 30 if both results are ≥2 x LOQ
Matrix Spike/Matrix Spike Duplicate	PFOS and PFOA	One pair per 20 field samples	Accuracy/Bias/ Precision	Percent recoveries — Laboratory limits (See Worksheet #28) RPD ≤30
Cooler Temperature Indicator	PFOS and PFOA	One per cooler	Representativeness	Temperature ≤ 6 degrees Celsius.

Notes:

PFOS	=	Perfluorooctane sulfonate
PFOA	=	Perfluorooctanoic acid
LOQ	=	Limit of quantitation
RPD	=	Relative percent difference
QC	=	Quality Control

SAP Worksheet #14: Field Project Tasks

It is anticipated that two phases of field activities will be completed during the RI. Under the initial phase, a total of 34 soil borings will be advanced within the study boundary, 31 of which will be completed as groundwater monitoring wells. Twelve of the soil borings have been identified for collection of soil samples for the purpose of evaluating PFOS and PFOA in soil within the saturated zone beneath areas of known or suspected AFFF releases at Hangar 1. The 31 new groundwater monitoring wells will consist of 14 shallow overburden and 17 deep overburden wells. Following review of the overburden groundwater data, and with regulatory input, a second phase of monitoring wells will be installed, if necessary, consisting of either overburden or bedrock wells, as necessary. The additional wells, combined with the existing monitoring well network, will allow for an assessment of the horizontal and vertical extent of dissolved-phase PFOS and PFOA concentrations within the project study boundary.

The following project tasks are summarized below:

- Field Tasks
- Analytical Tasks
- Data Management and Review
- Report Preparation

Field Tasks

The following subsections present field tasks that will be completed as part of the soil and groundwater investigation at Hangar 1.

Mobilization/Demobilization — Mobilization includes procurement of field equipment and supplies; a site walkover; mobilization of field staff, equipment, and supplies to the site, and; site set-up. The Resolution Consultants Task Order Manager (TOM) notifies the Navy Remedial Project Manager and Site Point of Contact two weeks prior to mobilizing to the site.

A field team orientation meeting will be conducted prior to starting the investigation to familiarize the team personnel with the site-specific health and safety requirements, the objectives and scope of the field activities, and chain-of-command. This meeting will be attended by the field staff and conducted by the Field Team Leader (FTL). The Project Chemist (or designee) will also participate in the orientation meeting to discuss sample requirements, methods, and quality objectives.

Demobilization includes removing field equipment and supplies from the site, returning rented equipment, managing investigation-derived waste, performing general site cleanup, organizing and finalizing field paperwork, and entering field records/data into the database.

Field Instrument Calibration — Field instruments will be used to measure for pH, specific conductivity, turbidity, temperature, DO, and ORP in groundwater. Field instruments will be operated and calibrated in accordance with Resolution Consultants SOP 3-24.

Utility Clearance **—** Utility clearance will be performed using Resolution Consultants SOP 3-01. The Resolution Consultants FTL will coordinate verbally or via email with the Site Point of Contact at least two weeks in advance of site access to initiate the utility clearance process for all intrusive sampling locations. The Resolution Consultants FTL will coordinate with the Site Point of Contact to document the utility clearance process and obtain approval for conducting intrusive activities. Prior to mechanical drilling, Resolution Consultants field personnel will hand auger or vacuum-clear to a depth of approximately 48 inches. In the event an unidentified underground utility is encountered, the proposed boring will be offset accordingly.

Soil Sampling **—** Of the 34 soil borings to be advanced during the initial phase, 12 will be utilized for the collection of subsurface soil samples to be submitted for laboratory analysis. Two subsurface soil samples will be collected from each of the 12 soil borings. The subsurface soil samples will be collected from within the saturated zone, with one sample obtained from the two-foot interval immediately below the interpreted top of the groundwater table, and the second collected from the two-foot interval just above bedrock. The purpose of the saturated zone soil samples is to assess if PFOS or PFOA have accumulated in this area from historical AFFF releases, and thereby acting as a potential ongoing source for dissolved-phase contamination. Previous investigation activities have occurred to assess soils in the unsaturated zone. Soil samples will be collected utilizing a 24 inch split-spoon sampler advanced ahead of 4.25 inch hollow-stem augers in accordance with Resolution Consultants SOP 3-21 and SOP 3-33. Each soil boring designated for soil sampling will be advanced to bedrock and continuous soil sampling will occur such that the interpreted groundwater table location can be identified, and to allow for the classification of soil to bedrock.

All soil samples shall be classified following Resolution Consultants SOP 3-16. Soil sample collection and handling will be in accordance with Resolution Consultants SOP 3-03, SOP 3-04, and SOP 3-21, and as described in Worksheet #21. A soil boring log will be prepared for each boring with soil

descriptions and all relevant information, observations, and field screening results. Sample depths will be included on each log. After sampling, the three boreholes not slated to be completed as monitoring wells will be backfilled to within 6 inches of grade using soil cuttings removed from the borehole and subsidized with bentonite grout, as necessary.

Soil samples will be analyzed for PFOS and PFOA by TestAmerica. Worksheet #17 provides sampling design and rationale. The combined Worksheets #18, 19, 20, and 30 provides sample identifications, necessary sample volume and preservative requirements, and hold time limitations. Soil samples will be packaged and shipped according to Resolution Consultants SOP 3-04, and to accommodate the required hold times. All sample shipments to a designated laboratory will contain appropriate chain-of-custody forms.

Monitoring Well Installation and Development — During the initial overburden investigation phase, a total of 31 overburden monitoring wells will be installed at the site. Each monitoring well will be constructed of 2 inch diameter, schedule 40, polyvinyl chloride well screen and solid riser pipe. Monitoring wells will be finished flush to grade with road boxes set in concrete or with a locking standpipe. Of the 31 wells to be initially installed, 14 will be set as shallow overburden and screened across the inferred groundwater table. The remaining 17 overburden wells will be set on top of the competent bedrock / overburden interface. Bedrock is anticipated to range from 20 to 40 feet bgs. At locations where overburden couplets are located, the deep overburden well will be installed first such that appropriate screen intervals can be selected for both the deep and shallow overburden well. It is anticipated that monitoring wells will be constructed with a 10-foot well screen; however, final well construction details will be made in the field based on site conditions. Well screens will be set such that the bottom of the screened interval of shallow overburden wells do not overlap the top of the screened interval of deep overburden wells. If bedrock is found less than 20 feet bgs. at any couplet location, then shorter well screens will be installed. No well screens will be longer than 10 feet.

Following review of the analytical data from the initial overburden investigation phase, a second phase of drilling may be required to install additional overburden or bedrock monitoring wells at the Hangar 1 site. The location of additional monitoring wells will be based on the review of data from the initial phase. For the bedrock monitoring well locations, following contact with bedrock via the drilling method described above, borings will be advanced via bedrock coring techniques. Bedrock wells will be advanced at least 12 feet into competent bedrock, with a 10 foot screened interval installed at the base of the boring. The final bedrock boring depth and screened interval will be determined in the field, with an emphasis placed on screening across significant bedrock fractures. A grout seal will be

placed above the bedrock screened interval to prevent connectivity between the overburden and bedrock aquifers. All soil borings will be installed by a Massachusetts licensed, well drilling contractor in accordance with local and state regulations. Resolution Consultants field personnel will conduct field activities associated with the well installation process in accordance with Resolution Consultants SOP 3-12.

Surveying — New overburden and bedrock groundwater wells and soil sample locations will be surveyed, in accordance with SOP 3-07 for land surveying, by a Massachusetts licensed surveyor.

Monitoring Well Development — All new monitoring wells will be developed following Resolution Consultants SOP 3-13, prior to groundwater sampling activities (discussed below). Additionally, if during the groundwater sampling event any existing monitoring wells appear to be performing inadequately, as deemed by the FTL, than the existing monitoring well will be re-developed (if required) in accordance with Resolution Consultants SOP 3-13.

Extended Purge — Several existing monitoring wells within the Hangar 1 study area may have dedicated tubing or other equipment installed. If dedicated equipment is found installed at any well designated for sampling, the following steps will be taken:

- Dedicated equipment will be removed
- Three well volumes will be purged to evacuate any potential PFOS or PFOA related to cross-contamination from the dedicated equipment
- Following extended purge, groundwater will be allowed to recharge to its pre-purge elevation
- Monitoring wells will be sampled as described below

Groundwater Quality Monitoring and Sample Collection — Groundwater samples will be collected from existing and new overburden and bedrock wells no sooner than one week following development. The monitoring wells will be gauged and sampled in accordance with Resolution Consultants SOP 3-14 and U.S. EPA Region 1 Low-Stress (Low-Flow) SOP EQASOP-GW001 (U.S. EPA 2010). The field team will be equipped with both a peristaltic and submersible pump. A submersible pump may be required depending on the depth of the well and the depth to water. No Teflon bladders or tubing will be used during sampling activities. Groundwater levels will be measured in each well prior to sampling. Groundwater will be measured in the field for pH, specific conductivity, turbidity, temperature, DO, and ORP to determine purge stabilization.

Groundwater samples will be analyzed for PFOS and PFOA by TestAmerica. Worksheet #17 provides sampling design and rationale. The combined Worksheets #18, 19, 20, and 30 provide sample identifications, necessary sample volume and preservative requirements, and hold time limitations. Groundwater samples will be packaged and shipped according to Resolution Consultants SOP 3-04, and to accommodate the required hold times. All sample shipments to a designated laboratory will contain appropriate chain-of-custody forms.

Field Precautions to Minimize Cross-Contamination by PFOS and PFOA — In addition to the decontamination procedures described in Resolution Consultants SOP 3-06, the following measures will be taken during the sampling process to avoid sample cross-contamination during PFOS and PFOA sample collection:

- **Products containing Teflon will not be used during sample handling or during mobilization/demobilization.** High density polyethylene tubing will be used.
- Sample personnel should wear only old, well-laundered (at least six washings since purchase) clothing.
- Nitrile gloves must be worn at all times while collecting and handling samples.
- **Sample personnel should not wear water resistant clothing prior to or during sample collection. Tyvek suits or clothes containing Gore-Tex must not be worn during sample handling.**
- Sample personnel should not use Post-it Notes, plastic clipboards/binders, or waterproof field books at any time during sample handling, or mobilization/demobilization.
- Many food and snack products are packaged in wrappers treated with PFCs. Therefore, hands will be thoroughly washed after handling fast food, carry-out food, or snacks.
- **Pre-wrapped food or snacks (like candy bars, microwave popcorn, etc.) must not be in the possession of the sampling personnel during sampling.**
- Blue ice must not be used to cool samples or be used in sample coolers.
- No cosmetics, moisturizers, hand cream, or other related products should be used as part of personal cleaning/showering routine on the morning of sampling.

Equipment Decontamination — To the maximum extent possible, Resolution Consultants will utilize dedicated and disposable sampling equipment to avoid the potential for cross contamination of samples due to inadequate decontamination processes. The dedicated/disposable sampling equipment will include disposable polyethylene tubing, disposable gloves, and laboratory-supplied sample bottles.

Non-disposable or non-dedicated sampling equipment (e.g., peristaltic pumps, submersible pumps with Teflon-free bladders, water level indicators, water quality meters, etc.) will be decontaminated prior to sampling and between samples. Cleaning of equipment is performed to prevent cross-contamination between samples and to maintain a clean working environment for all personnel. Decontamination will generally consist of a water rinse station to remove gross contamination (if needed), followed by a non-phosphate detergent (e.g., Liquinox) water rinse, and a rinse with de-ionized water (provided by the laboratory). If smaller equipment is to be stored or transported, it will be wrapped in aluminum foil after air-drying. **If recycled paper towels are used then the water level measurements will be collected after completion of groundwater sampling to avoid potential contamination from materials containing PFOS and PFOA.**

Field Documentation — Field documentation will be performed during this investigation in accordance with Resolution Consultants SOP 3-02. Sample collection information will be recorded in bound field notebooks, tablet computers, or specific field forms.

A summary of field activities will be properly recorded in a bound logbook with consecutively numbered pages that cannot be removed. Logbooks will be assigned to field personnel and stored in a secured area when not in use. All entries will be written in indelible ink, and no erasures will be made. If an incorrect entry is made, striking a single line through the incorrect information will make the correction; and the person making the correction will initial and date the change. Sampling forms and other field forms will also be used to document field activities.

Field Quality Control Tasks — Field QC samples will be collected as part of this investigation, including field duplicates, MS/MSDs, field blanks, and equipment rinsate blanks (if sampling tools are decontaminated in the field). Worksheet #12 and combined Worksheets #18, 19, 20, and 30 present a summary of field QC samples.

Global Positioning System Locating — A hand-held Global Positioning System (GPS) unit capable of sub-meter accuracy (i.e., Trimble GeoXM or Trimble GeoHX) will be used to locate sampling points in accordance with SOP 3-07. To ground-truth the sample locations with Site features, GPS coordinates will also be collected from several definable Site features and used to establish sample locations

relative to these features. GPS data collected during the survey will be stored in the GPS unit and downloaded to a computer daily or as soon as possible after acquisition. Data will also be manually entered into a field log as it is collected. Once downloaded from the GPS unit, the data will then be uploaded for processing by Resolution Consultants' Geographic Information System personnel. To ensure sub-meter accuracy, a minimum of six satellites is desired for each position. If GPS accuracy is not sub-meter, data will not be collected until more satellites become available and the accuracy criteria are met. In locations where the overhead canopy interferes with satellite lines-of-sight and GPS accuracy cannot be reasonably established, an alternative positioning technique will be employed (e.g., compass and tape measure, fiducials, or total station) to ensure that sample locations can be re-acquired at a later date, if necessary.

Investigation-Derived Waste Management — Investigation-derived waste, consisting of water generated during decontamination processes and soil waste that cannot be returned to the boreholes will be collected in properly labeled 55-gallon drums, sampled for waste characterization, and temporarily staged in Building 41 for subsequent offsite disposal in accordance with SOP 3-05. An Off Site Rule Compliance Request Form will be submitted to U.S. EPA to obtain facility-specific approval to dispose of the materials. Disposable personal protective equipment and disposable sampling equipment/materials (spent tubing, etc.) will be disposed of as general refuse at the approved disposal location on the former NAS Weymouth property.

Analytical Tasks

Chemical analyses will be performed by TestAmerica in Denver, Colorado, a DoD Environmental Laboratory Accreditation Program accredited laboratory. A copy of the laboratory accreditation certificate may be found in Appendix B. Chemical analyses will be performed in accordance with the analytical methods identified in Worksheet #23 and combined Worksheets #18, 19, 20, and 30. TestAmerica will provide fully validatable chemical data packages, which will include summary forms containing all quality control information and raw data.

Data Management and Review

The principal data generated for this project will be from laboratory analytical data. The field forms, chain-of-custody, air bills, and logbooks will be placed in the project files after completion of the field program. The field logbooks for this project will be used only for this site, and will also be categorized and maintained in the project files after the completion of the field program. All project records will be maintained in a secure location.

Data Tracking — The Resolution Consultants TOM, or designee, is responsible for the overall tracking and control of data generated for the project. Data is tracked from generation to archiving in the project-specific files. The Project Chemist, or designee, is responsible for tracking the samples collected and shipped to the contracted laboratory. Upon receipt of the data packages from the analytical laboratory, the Project Chemist will oversee the data validation effort, which includes verifying that the data packages are complete and that results for all samples have been delivered by the analytical laboratory.

Resolution Consultants shall submit all Administrative Record Files, Site Files, and Post Decision Files in accordance with the specifications defined in the NAVFAC Environmental Restoration Recordkeeping Manual (NAVFAC 2009). Additionally, Resolution Consultants will update the project related documents, data, and maps in NIRIS. Project related spatial data including maps, models, and associated collected or created data will also be uploaded into NIRIS.

Data Storage, Archiving, and Retrieval — After the data is validated, the data packages are entered into the Resolution Consultants file system and archived in secure files. The field records including field logbooks, sample logs, chain-of-custody records, and field calibration logs will be submitted by the Resolution Consultants FTL to be entered into the file system before archiving in secure project files. Project files will be kept in a secured, limited access area. At the completion of the Navy contract, files will be shipped to the Federal Records Center for storage where the files will remain until 50 years after the last decision document for former NAS South Weymouth.

Data Security — Access to Resolution Consultants project files is restricted to designated personnel only. The Resolution Consultants data manager maintains the electronic data files, and access to the data files is restricted to qualified personnel only. File and data backup procedures are routinely performed.

Electronic Data — Laboratory data, provided in electronic format, will be verified for accuracy prior to use and during the data validation process. After data is validated, the electronic data results will be uploaded into the Resolution Consultants database for use in data evaluation and subsequent report preparation. The project database will be on a password protected secure network and access to changing data files will be restricted to qualified personnel. The Resolution Consultants TOM (or designee) is responsible for the overall tracking and control of data generated for the project. All final electronic data and administrative records will be compiled uploaded into NIRIS for final repository.

Data Review and Validation — Following receipt of analytical laboratory results, Resolution Consultants will verify data completeness as specified on Worksheet #34. To ensure that the analytical results meet the project quality objectives, the laboratory data will undergo verification and validation as cited in Worksheets #34 through #36 and described below.

Prior to data validation, electronic laboratory data will be verified for accuracy against the hardcopy laboratory report and the electronic Quality Assurance Project Plan (eQAPP) will be established using the project-specific criteria defined in Worksheet #12, combined Worksheets #18, 19, 20, ad 30, and Worksheet #28. The laboratory will be requested to resubmit electronic data found to be inaccurate.

During the data validation process, the Resolution Consultants Data Validation Assistant (DVA) tool will be used to review method accuracy and precision data from field and laboratory QC samples contained in the laboratory Electronic Data Deliverable and to qualify that data according to the project specific eQAPP. The DVA tool uses EarthSoft's EQuIS™ relational database to assemble a series of Excel worksheets into a DVA workbook for the validator that present:

- Data validation QC elements that need review, compared to control limits stored in the project-specific eQAPP
- Associated sample results for duplicated samples and blanks
- A place to make the necessary qualifications and result updates directly into an electronic format documentation of qualifications using coded reasons
- A list of all samples affected by the qualification

Laboratory QC will be assessed against the criteria presented in laboratory specific SOPs using the hardcopy laboratory report; the results of these findings will be added to the Excel DVA workbook. The DVA workbook is used to update the project database with the validator's changes, eliminating the manual data entry process and allowing for 100 percent of data to be reviewed prior to uploading to the project database.

Report Preparation

A Remedial Investigation report will be prepared to present results of the investigation and satisfy data quality objectives, as identified in Worksheet #11. The report will include the following:

- Summary of the investigation/sampling activities
- Evaluation of analytic results and extent of PFOS and PFOA contamination
- Summary of Human Health and Ecological Risks
- Conclusions and recommendations

The draft RI report will be submitted to the Navy, U.S EPA, and MassDEP for comments and approval within 90 days of receiving validated laboratory data that indicates the horizontal and vertical extent of dissolved-phase PFOS and PFOA have been identified at the Hangar 1 site. Response to comments and necessary revisions will be made to the draft reports before issuing a final report.

SAP Worksheet #15: Reference Limits and Evaluation Tables

Matrix:	Groundwater						
Analytical Group:	PFCs via TestAmerica Method DV-LC-0012						
Analyte	**CAS Number**	**Project Action Levels (2) (µg/L)**	**Project Action Level Source (µg/L)**	**Project Quantitation Limit Goal (µg/L)**	**Laboratory Limit of Quantitation(1) (µg/L)**	**Laboratory Limit of Detection(1) (µg/L)**	**Laboratory Detection Limit(1) (µg/L)**
Perfluorooctanoic Acid (PFOA)	335-67-1	0.4	RSL Calc	0.04	0.02	0.02	0.00979
Perfluorooctane Sulfonate (PFOS)	1763-23-1	0.16	RSL Calc	0.06	0.03	0.019	0.0133
Perfluorobutane Sulfonate (PFBS)	375-73-5	38	RSL	0.04	0.02	0.018	00824
Perfluoroheptanoic acid (PFHpA)	375-85-9	NA	NA	0.06	0.03	0.02	0.0132
Perfluorohexane Sulfonate (PFHxS)	355-46-4	NA	NA	0.06	0.03	0.008	0.00697
Perfluorononanoic acid (PFNA)	375-95-1	NA	NA	0.08	0.04	0.02	0.0174

Notes:

(1) Laboratory quantitation, detection, and method detection limits, provided by TestAmerica, are targets that are achievable under optimal conditions and may vary during the course of project.

(2) Concentrations above Project Action Levels do not necessarily indicate the presence of unacceptable risk/hazard, but instead, indicate that further evaluation is necessary to quantify the level of potential risk/hazard to make a determination.

CAS = Chemical Abstract Services

NA = Not available.

µg/L = Micrograms per liter

RSL Calc = Tap water Regional Screening Level as calculated using the U.S. EPA Regional Screening Level (RSL) Calculator; http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search (June 2015) based on a target hazard quotient of 0.1, default exposure assumptions for the residential tapwater ingestion pathway, and U.S. EPA's provisional subchronic noncancer toxicity values of 2E-4 mg/kg-day for PFOA and 8E-5 mg/kg-day for PFOS (October 28, 2009 Memorandum: "The Toxicity of PFOA and PFOS"). If updated toxicity values for are published before the risk assessment is conducted, the project action levels will be revised based on the updated toxicity values as appropriate.

RSL = U.S. EPA Regional Screening Level (RSL) for Tap water based on a target hazard quotient of 0.1. U.S. EPA RSL Table; http://www2.epa.gov/risk/regional-screening-table (June 2015).

Matrix:	Soil						
Analytical Group:	PFCs via TestAmerica Method DV-LC-0012						
Analyte	**CAS Number**	**Project Action Levels [2] (mg/kg)**	**Project Action Level Source (mg/kg)**	**Project Quantitation Limit Goal (mg/kg)**	**Laboratory Limit of Quantitation[1] (mg/kg)**	**Laboratory Limit of Detection[1] (mg/kg)**	**Laboratory Detection Limit[1] (mg/kg)**
Perfluorooctanoic Acid (PFOA)	335-67-1	0.0213	RSL	0.00213	0.0008	0.000350	0.000230
Perfluorooctane Sulfonate (PFOS)	1763-23-1	0.023	RSL	0.0023	0.0008	0.000334	0.000140
Perfluorobutane Sulfonate (PFBS)	375-73-5	0.021	RSL	0.0021	0.0008	0.000310	0.000140
Perfluoroheptanoic acid (PFHpA)	375-85-9	NA	NA	0.0021	0.0008	0.000350	0.000120
Perfluorohexane Sulfonate (PFHxS)	355-46-4	NA	NA	0.0021	0.0008	0.000331	0.000280
Perfluorononanoic acid (PFNA)	375-95-1	NA	NA	0.0021	0.0008	0.000350	0.000220

Notes:

(1) Laboratory quantitation, detection, and method detection limits, provided by TestAmerica, are targets that are achievable under optimal conditions and may vary during the course of project.

(2) Concentrations above Project Action Levels do not necessarily indicate the presence of unacceptable risk/hazard, but instead, indicate that further evaluation is necessary to quantify the level of potential risk/hazard to make a determination.

CAS = Chemical Abstract Services

µg/L = Micrograms per liter

RSL Calc = Soil screening level protective of the soil to groundwater leaching pathway calculated using the U.S. EPA RSL Calculator; http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search (June 2015). The soil to groundwater screening levels were calculated based on a target hazard quotient of 0.1, default exposure assumptions for the residential tapwater ingestion pathway, a default dilution attenuation factor of 1, and U.S. EPA's subchronic noncancer toxicity values of 2E-4 mg/kg-day for PFOA and 8E-5 mg/kg-day for PFOS (October 28, 2009 Memorandum: "The Toxicity of PFOA and PFOS"). If updated toxicity values are published before the risk assessment is conducted, the project action levels will be revised based on the updated toxicity values as appropriate.

RSL = Risk-Based Soil Screening Level (SSL) protective of the soil to groundwater leaching pathway based on a target hazard quotient of 0.1. U.S. EPA RSL Table; http://www2.epa.gov/risk/regional-screening-table (June 2015).

SAP Worksheet #17: Sampling Design and Rationale

Groundwater Sampling

Groundwater sampling will be performed at 14 existing overburden monitoring wells. One existing monitoring well, H1-MW-2D, has been previously inaccurately identified as a bedrock well. For the 31 monitoring wells to be installed during the initial phase of this investigation, 14 will be set in the shallow overburden and the remaining 17 will be set in the deep overburden. Groundwater sampling for PFOS and PFOA will be performed using U.S. EPA Region 1 Low-Stress (Low-Flow) techniques. Sample collection will follow SOPs identified on Worksheet #21 and protocols to prevent cross contamination as outlined in Worksheet #14.

Table 17-1 identifies the monitoring wells that will be sampled for PFOS and PFOA at Hangar 1, as well as the target screened intervals. **Figure 17-1** presents the location of existing and proposed monitoring wells that will be sampled as part of the PFC investigation.

A second phase of intrusive investigations may be required to define the extent of PFOS and PFOA at Hangar 1, which could include installation of additional deep overburden or bedrock monitoring wells. Should a second mobilization be required for installing additional monitoring wells, specifics of that mobilization will be addressed in a SAP modification form and provided to the Navy, U.S. EPA, and MassDEP for review.

Table 17-1

Groundwater Sampling Locations — PFOS and PFOA
Former Naval Air Station South Weymouth, Massachusetts

Well Identification	Overburden / Bedrock	Screen Interval (feet bgs)	Rationale
MW05-031	Shallow Overburden	4.5 — 14.5	Existing Well
MW05-033	Shallow Overburden	4 — 14	Existing Well
MW05-034	Shallow Overburden	4 — 14	Existing Well
MW05-301	Shallow Overburden	5 — 10	Existing Well
MW05-302	Shallow Overburden	5 — 15	Existing Well
MW05-303	Shallow Overburden	5 — 15	Existing Well
MW05-304	Shallow Overburden	7 — 17	Existing Well
MW09-006	Shallow Overburden	4 — 14	Existing Well
H1-MW-1	Shallow Overburden	3.6 — 13.6	Existing Well
H1-MW-2	Shallow Overburden	3 — 13	Existing Well
H1-MW-2D	Deep Overburden	23.5 — 33.5	Existing Well
H1-MW-900	Shallow Overburden	3 — 13	Existing Well
H1-MW-901	Shallow Overburden	3 — 13	Existing Well
H1-MW-902	Shallow Overburden	3 — 13	Existing Well
H1-MW-101	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table

Table 17-1

Groundwater Sampling Locations — PFOS and PFOA
Former Naval Air Station South Weymouth, Massachusetts

Well Identification	Overburden / Bedrock	Screen Interval (feet bgs)	Rationale
H1-MW-102	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-103	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-104	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-105	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-106	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-107	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-108	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-109	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-110	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-111	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-112	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-113	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-114	Shallow Overburden	TBD	10-foot screened interval set across the top of the water table
H1-MW-XXX(1)	Shallow Overburden	TBD	TBD
MW05-033D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well MW05-033 (14 ft. bgs)
MW05-301D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of screen for well MW05-301 (10 ft. bgs)
MW05-302D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well MW05-302 (15 ft. bgs)
MW05-303D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well MW05-303 (15 ft. bgs)
MW05-304D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well MW05-304 (17 ft. bgs)
H1-MW-101D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW-101

Table 17-1

Groundwater Sampling Locations — PFOS and PFOA
Former Naval Air Station South Weymouth, Massachusetts

Well Identification	Overburden / Bedrock	Screen Interval (feet bgs)	Rationale
H1-MW-102D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW-102
H1-MW-103D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW-103
H1-MW-104D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW-104
H1-MW-105D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW-105D
H1-MW-106D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW-106
H1-MW-107D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW-107
H1-MW-108D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW108
H1-MW-109D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW-109
H1-MW-111D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than bottom of the screen for well MW05-303 (15 ft. bgs.)
H1-MW-901D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than bottom of screen for well H1-MW-901 (13 ft. bgs)
H1-MW-902D	Deep Overburden	TBD	10-foot screened interval set on top of bedrock and no higher than the bottom of the screen for well H1-MW-902
H1-MW-1XXD(1)	Deep Overburden	TBD	TBD
H1-MW-1XXB(1)	Bedrock	TBD	10' screened interval set 12' into Competent Bedrock

Notes:

(1) Optional wells will be installed if necessary to determine the extent of PFOS and PFOA

bgs = Below ground surface
PFOS = Perfluorooctane sulfonate
PFOA = Perfluorooctanoic acid
TBD = To be determined
XX = Sequential numeric well number for optional wells (i.e., the twelfth well would be 12)

Soil Sampling

Soil samples will be collected at 12 soil boring locations, nine of which will be completed as groundwater monitoring wells. The soil borings identified for sample collection will be located in the vicinity of the former AFFF ASTs, the floor drain system, the exterior drain trenches, and the former Crash Truck Garage of Hangar 1. **Table 17-2** identifies the soil boring locations designated for soil sampling, which are also depicted on **Figure 17-1**. A total of two soil samples will be collected from each soil boring location with one sample collected from the two-foot interval directly beneath the interpreted top of the groundwater table and one collected from the two-foot interval directly above bedrock. The soil samples are being collected from the saturated zone to determine if a continuing source is present that could be impacting groundwater at these areas. Previous investigations have been conducted to assess PFC concentrations in the unsaturated zone at the same areas identified for soil sampling as part of this RI.

Soil sampling for PFOS and PFOA will be completed following the SOPs identified on Worksheet #21 and the protocols to prevent cross contamination outlined in Worksheet #14. PFOS and PFOA will be analyzed by TestAmerica. Soil samples will be analyzed for PFOS and PFOA to determine if concentrations are present that would potentially cause exceedances in groundwater.

Table 17-2
Soil Sampling Locations — PFOS and PFOA
Former Naval Air Station South Weymouth, Massachusetts

Soil	Location
H1-SB-101	Vicinity of former east exterior trench drain.
H1-SB-102	Vicinity of former AFFF ASTs (North Lean-To).
H1-SB-103	Vicinity of former west oil-water separator.
H1-MW-110	Vicinity of former Crash Truck Garage (South Lean-To). Completed as overburden monitoring well.
H1-MW-112	Vicinity of former AFFF ASTs (North Lean-To). Completed as overburden monitoring well.
H1-MW-113	Vicinity of the former northern floor drain system of Hangar 1. Completed as overburden monitoring well.
H1-MW-114	Vicinity of the former southern floor drain system of Hangar 1. Completed as overburden monitoring well
MW05-302D	Vicinity of drain line to southern storm sewer. Completed as a deep overburden monitoring well.
MW05-303D	Vicinity of drain line to western oil-water separator. Completed as a deep overburden monitoring well.
MW05-304D	Vicinity of southwestern end of Hangar 1. Completed as a deep overburden monitoring well.

Table 17-2
Soil Sampling Locations — PFOS and PFOA
Former Naval Air Station South Weymouth, Massachusetts

H1-MW-901D	Vicinity of former Crash Truck Garage (South Lean-To). Completed as a deep overburden monitoring well.
H1-MW-902D	Vicinity of southern storm sewer line. Completed as a deep overburden monitoring well.
H1-SB-1XX[(1)]	TBD

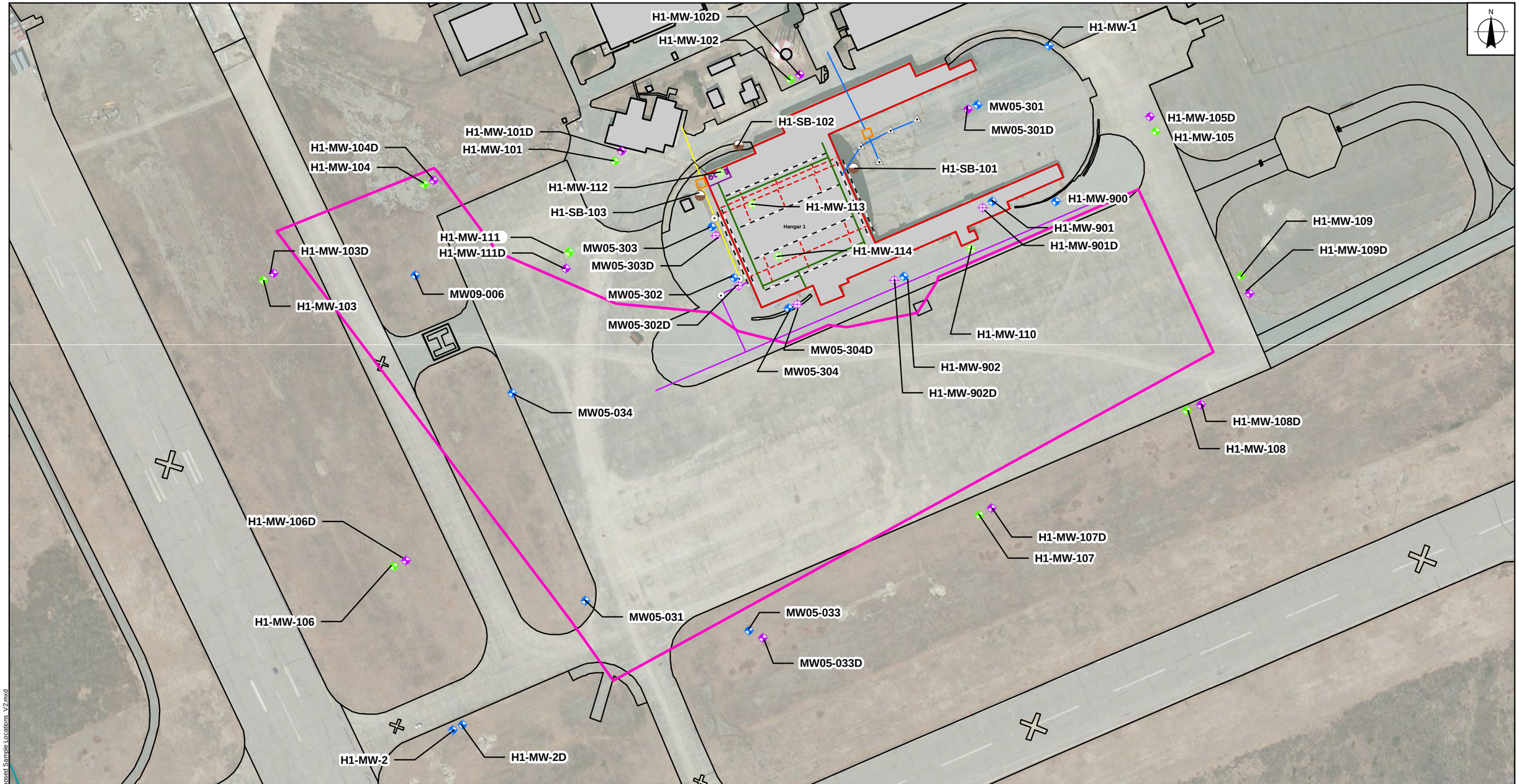
Notes:
(1) Optional soil boring will be conducted if necessary to determine continuing source of PFOS and PFOA in soil.

TBD = To be determined
XX = Sequential numeric soil boring number for optional samples

General Sampling Approach

Field activities at Hangar 1 will include the following:

- Inspect each well to gauge integrity
- If dedicated sampling equipment is present in monitoring wells, extended purging procedures will be conducted as described in Worksheet #14
- If required, re-develop those wells which exhibit excessive turbidity or poor yield
- Conduct a synoptic round of depth-to-water measurements
- Collect groundwater and soil samples (and associated QC samples), as shown on combined Worksheets #18, 19, 20, and 30



Proposed Deep Overburden Soil Sample Location Completed as a Monitoring Well
Proposed Deep Overburden Monitoring Well Location
Proposed Shallow Overburden Soil Sample Location Completed as a Monitoring Well
Proposed Shallow Overburden Monitoring Well Location
Soil Sample
Existing Monitoring Well Location

Catch Basin
Manhole
Oil-Water Separator
30" Storm Sewer
8" Sanitary Sewer
8" Storm Sewer

AFFF Pipe
Subsurface Drain Pipes
Floor Trenches
Building
Former Location of Hangar 1
Groundwater Restriction Boundary

0 200 400 Feet

FIGURE 17-1
PROPOSED SAMPLE LOCATIONS
HANGAR 1
FORMER NAS SOUTH WEYMOUTH
WEYMOUTH, MASSACHUSETTS

NAVFAC Naval Facilities Engineering Command
RESOLUTION CONSULTANTS

REQUESTED BY: M. Gibson	DATE: 10/12/2015
DRAWN BY: kburnum	TASK ORDER NUMBER: WE27

X:\Navy\NAS_SOUTH_WEYMOUTH\Figure_17-1_Proposed Sample Locations_V2.mxd

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

SAP Worksheets #18, 19, 20, and 30: Field Project Implementation (Field Project Instructions)

Laboratory Name and Address: TestAmerica 4955 Yarrow Street Arvada, CO 80002 **Laboratory Points of Contact:** Joy Chang Joy.chang@testamericainc.com 623-209-9961			**Analysis Group**	PFOS, PFOA, PFBS, PFHpA, PFHxS, and PFNA
			Preparation and Analytical Method/SOP Reference	DV-OP-0019 /DV-LC-0012
			Data Package Turnaround Time	21 calendar days
			Container Type/Volume required:	4 x 250 milliliter HDPE (free of Teflon and other PFCs)
			Preservative	Cool to ≤ 6°C
			Holding Time (Preparation/Analysis)	Soil and water: 14 days to extraction/ 40 days from extraction to analysis
Matrix	**Location ID**	**Sample ID**	**Depth/Sampling Interval (bgs)**	**Sample Count**
Groundwater	MW05-031	MW05-031-MMYY	4.5 — 14.5	1
Groundwater	MW05-033	MW05-033-MMYY	4 — 14	1
Groundwater	MW05-034	MW05-034- MMYY	4 — 14	1
Groundwater	MW05-301	MW05-301- MMYY	5 — 10	1
Groundwater	MW05-302	MW05-302- MMYY	5 — 15	1
Groundwater	MW05-303	MW05-303- MMYY	5 — 15	1
Groundwater	MW05-304	MW05-304- MMYY	7 — 17	1
Groundwater	MW09-006	MW09-006-MMYY	4 — 14	1
Groundwater	H1-MW-1	H1-MW-1- MMYY	3.6 — 13.6	1
Groundwater	H1-MW-2	H1-MW-2- MMYY	3 — 13	1
Groundwater	H1-MW-2D	H1-MW-2D-MMYY	23.5 — 33.5	1
Groundwater	H1-MW-900	H1-MW-900- MMYY	3 — 13	1
Groundwater	H1-MW-901	H1-MW-901- MMYY	3 — 13	1
Groundwater	H1-MW-902	H1-MW-902- MMYY	3 — 13	1
Groundwater	H1-MW-101	H1-MW-101- MMYY	New Well — TBD	1
Groundwater	H1-MW-102	H1-MW-102- MMYY	New Well — TBD	1
Groundwater	H1-MW-103	H1-MW-103- MMYY	New Well — TBD	1
Groundwater	H1-MW-104	H1-MW-104-MMYY	New Well — TBD	1
Groundwater	H1-MW-105	H1-MW-105-MMYY	New Well — TBD	1

Laboratory Name and Address: TestAmerica 4955 Yarrow Street Arvada, CO 80002 **Laboratory Points of Contact:** Joy Chang Joy.chang@testamericainc.com 623-209-9961		**Analysis Group**		PFOS, PFOA, PFBS, PFHpA, PFHxS, and PFNA
		Preparation and Analytical Method/SOP Reference		DV-OP-0019 /DV-LC-0012
		Data Package Turnaround Time		21 calendar days
		Container Type/Volume required:		4 x 250 milliliter HDPE (free of Teflon and other PFCs)
		Preservative		Cool to ≤ 6°C
		Holding Time (Preparation/Analysis)		Soil and water: 14 days to extraction/ 40 days from extraction to analysis
Matrix	**Location ID**	**Sample ID**	**Depth/Sampling Interval (bgs)**	**Sample Count**
Groundwater	H1-MW-106	H1-MW-106-MMYY	New Well — TBD	1
Groundwater	H1-MW-107	H1-MW-107-MMYY	New Well — TBD	1
Groundwater	H1-MW-108	H1-MW-108-MMYY	New Well — TBD	1
Groundwater	H1-MW-109	H1-MW-109-MMYY	New Well — TBD	1
Groundwater	H1-MW-110	H1-MW-110-MMYY	New Well — TBD	1
Groundwater	H1-MW-112	H1-MW-112-MMYY	New Well — TBD	1
Groundwater	H1-MW-113	H1-MW-113-MMYY	New Well — TBD	1
Groundwater	H1-MW-114	H1-MW-114-MMYY	New Well — TBD	1
Groundwater	H1-MW-XXX(1)	H1-MW-1XX-MMYY	Optional New Shallow Overburden Well(s) – TBD	1
Groundwater	H1-MW-101D	H1-MW-101D-MMYY	New Well — TBD	1
Groundwater	H1-MW-102D	H1-MW-102D-MMYY	New Well — TBD	1
Groundwater	H1-MW-103D	H1-MW-103D-MMYY	New Well — TBD	1
Groundwater	H1-MW-104D	H1-MW-104D-MMYY	New Well — TBD	1
Groundwater	H1-MW-105D	H1-MW-105D-MMYY	New Well — TBD	1
Groundwater	H1-MW-106D	H1-MW-106D-MMYY	New Well — TBD	1
Groundwater	H1-MW-107D	H1-MW-107D-MMYY	New Well — TBD	1
Groundwater	H1-MW-108D	H1-MW-108D-MMYY	New Well — TBD	1
Groundwater	H1-MW-109D	H1-MW-109D-MMYY	New Well — TBD	1
Groundwater	H1-MW-111	H1-MW-111-MMYY	New Well — TBD	1
Groundwater	H1-MW-111D	H1-MW-111D-MMYY	New Well — TBD	1

Laboratory Name and Address: TestAmerica 4955 Yarrow Street Arvada, CO 80002 **Laboratory Points of Contact:** Joy Chang Joy.chang@testamericainc.com 623-209-9961		**Analysis Group**		PFOS, PFOA, PFBS, PFHpA, PFHxS, and PFNA
		Preparation and Analytical Method/SOP Reference		DV-OP-0019 /DV-LC-0012
		Data Package Turnaround Time		21 calendar days
		Container Type/Volume required:		4 x 250 milliliter HDPE (free of Teflon and other PFCs)
		Preservative		Cool to ≤ 6°C
		Holding Time (Preparation/Analysis)		Soil and water: 14 days to extraction/ 40 days from extraction to analysis
Matrix	**Location ID**	**Sample ID**	**Depth/Sampling Interval (bgs)**	**Sample Count**
Groundwater	MW05-033D	MW05-033D-MMYY	New Well — TBD	1
Groundwater	MW05-301D	MW05-301D-MMYY	New Well — TBD	1
Groundwater	MW05-302D	MW05-302D-MMYY	New Well — TBD	1
Groundwater	MW05-303D	MW05-303D-MMYY	New Well — TBD	1
Groundwater	MW05-304D	MW05-304D-MMYY	New Well — TBD	1
Groundwater	H1-MW-901D	H1-MW-901D-MMYY	New Well — TBD	1
Groundwater	H1-MW-902D	H1-MW-902D-MMYY	New Well — TBD	1
Groundwater	H1-MW-XXXD(1)	H1-MW-1XXD-MMYY	Optional New Deep Overburden Well(s) – TBD	1
Groundwater	H1-MW-XXXB(1)	H1-MW-XXXB-MMYY	Optional New Bedrock Well(s) — TBD	1
Soil	H1-SB-101	H1-SB-101-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	H1-SB-101	H1-SB-101- X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	H1-SB-102	H1-SB-102- X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	H1-SB-102	H1-SB-102- X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	H1-SB-103	H1-SB-103- X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	H1-SB-103	H1-SB-103- X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	H1-MW-110	H1-MW-110-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	H1-MW-110	H1-MW-110-X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	H1-MW-112	H1-MW-112-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	H1-MW-112	H1-MW-112-X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	H1-MW-113	H1-MW-113-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1

Laboratory Name and Address: TestAmerica 4955 Yarrow Street Arvada, CO 80002 **Laboratory Points of Contact:** Joy Chang Joy.chang@testamericainc.com 623-209-9961		**Analysis Group**		PFOS, PFOA, PFBS, PFHpA, PFHxS, and PFNA
		Preparation and Analytical Method/SOP Reference		DV-OP-0019 /DV-LC-0012
		Data Package Turnaround Time		21 calendar days
		Container Type/Volume required:		4 x 250 milliliter HDPE (free of Teflon and other PFCs)
		Preservative		Cool to ≤ 6°C
		Holding Time (Preparation/Analysis)		Soil and water: 14 days to extraction/ 40 days from extraction to analysis
Matrix	**Location ID**	**Sample ID**	**Depth/Sampling Interval (bgs)**	**Sample Count**
Soil	H1-MW-113	H1-MW-113-X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	H1-MW-114	H1-MW-114-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	H1-MW-114	H1-MW-114-X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	MW05-302D	MW05-302D-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	MW05-302D	MW05-302D-X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	MW05-303D	MW05-303D-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	MW05-303D	MW05-303D-X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	MW05-304D	MW05-304D-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	MW05-304D	MW05-304D-X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	H1-MW-901D	H1-MW-901D-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	H1-MW-901D	H1-MW-901D-X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	H1-MW-902D	H1-MW-902D-X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	H1-MW-902D	H1-MW-902D-X'-X'-MMYY	2 ft. interval just above bedrock	1
Soil	H1-SB-XXX(1)	H1-SB-1XX- X'-X'-MMYY	Initial 2 ft. interval of saturated zone	1
Soil	H1-SB-XXX(1)	H1-SB-1XX- X'-X'-MMYY	2 ft. interval just above bedrock	1
Field Duplicate	TBD	TBD	Not Applicable	7
MS	TBD	TBD	Not Applicable	4
MSD	TBD	TBD	Not Applicable	4
Equipment Blank	—	EBMMDDYY	Not Applicable	3
Total Number of Samples to the Laboratory (minus MS/MSDs):				**92**

Notes:

(1) Additional sample IDs to be added if further sampling is deemed necessary.

SOP	=	Standard Operating Procedure
HDPE	=	High-density polyethylene
PFCs	=	Perfluorinated compound
°C	=	Degree Celsius
bgs	=	Below ground surface
TBD	=	To be determined. Depth intervals, field duplicates, and MS/MSDs will be determined in the field
X'-X'	=	soil sample interval in feet bgs
QC	=	Quality control
MS	=	Matrix spike
MSD	=	Matrix spike duplicate
MMYY	=	Month (MM), year (YY), (e.g., 0315 for March 2015)
QA	=	Quality assurance

Frequency of QA/QC sample collection:

- Field Duplicate — One per 10 field samples
- MS/MSD — One pair per 20 field samples (including field QC samples)
- Equipment Blank — One per 20 field samples per sampling equipment

SAP Worksheet #21: Field SOPs Reference Table

SOP Reference Number	Title/Author	Revision Date or Version Number	Equipment Type	Location of SOP	Any planned deviation for Project Work	Comments
SOP 3-01	Utility Clearance/Resolution Consultants	Revision 0; June 2012		Appendix A	No	
SOP 3-02	Logbooks/Resolution Consultants	Revision 0; May 2012	None	Appendix A	No	
SOP 3-03	Recordkeeping, Sample Labeling, and Chain-of-Custody/Resolution Consultants	Revision 0; May 2012	None	Appendix A	No	
SOP 3-04	Sample Handling, Storage, and Shipping / Resolution Consultants	Revision 0; May 2012	None	Appendix A	No	Used in conjunction with special requirements described in Worksheet #14
SOP 3-05	Investigation Derived Waste Management/Resolution Consultants	Revision 0; May 2012	None	Appendix A	No	
SOP 3-06	Equipment Decontamination/ Resolution Consultants	Revision 0; May 2012	Buckets, brushes	Appendix A	No	Used in conjunction with special requirements described in Worksheet #14
SOP 3-07	Land Surveying/Resolution Consultants	Revision 0; August 2012		Appendix A	No	For this project, sub-meter accuracy will be required, rather than 0.1 feet.
SOP 3-12	Monitoring Well Installation/Resolution Consultants	Revision 0; May 2012	Drill Rig	Appendix A	No	Drilling Contractor will follow local and State regulations
SOP 3-13	Monitoring Well Development/ Resolution Consultants	Revision 0; June 2012	Surge block, bailer, pump, water level probe, water quality meter	Appendix A	No	Drilling Contractor will follow local and State regulations
SOP 3-14	Monitoring Well Sampling/Resolution Consultants	Revision 0; May 2012	Pump, tubing, meters, water level probe, sample kits	Appendix A	No	Used in conjunction with SOP EQASOP-GW001 and special requirements described in Worksheet #14
SOP 3-16	Soil and Rock Classification/Resolution Consultants	Revision 0; August 2012	None	Appendix A	No	
SOP 3-21	Surface and Subsurface Soil Sampling Procedures/Resolution Consultants	Revision 0; May 2012	Direct Push Technology Drill Rig, Hand Auger	Appendix A	No	Used in conjunction with special requirements described in Worksheet #14
SOP 3-24	Water Quality Parameter Testing for Groundwater Sampling/Resolution Consultants	Revision 0; August 2012	Water quality meters	Appendix A	No	

SOP Reference Number	Title/Author	Revision Date or Version Number	Equipment Type	Location of SOP	Any planned deviation for Project Work	Comments
SOP 3-33	Subsurface Soil Sampling by Split Spoon/Resolution Consultants	Revision 0; August 2012	Drill Rig	Appendix A	No	
EQASOP-GW001	Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples From Monitoring Wells/U.S. EPA Region 1	Revision 3; January 2010	Pump, tubing, meters, water level probe, sample kits	Appendix A	No	Used in conjunction with SOP 3-14

Notes:
SOP = Standard Operating Procedure
U.S. EPA = United States Environmental Protection Agency

SAP Worksheet #22: Field Calibration, Maintenance, Testing and Inspection Table

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference	Comments
Water Level Indicator Solinst Model 101 (or similar)	Visual Inspection; field checks as per manufacturer	Once upon receiving from vendor, then daily	0.01-foot accuracy	Operator correction or replacement	Resolution Consultants FTL or designee	SOP 3-14	None
Photoionization Detector	Visual Inspection Calibration/ Verification	Daily before use, every 20 readings, or anytime unstable readings occur.	Isobutylene reads 100 ppm +/- 2 percent	Operator correction or replacement	Resolution Consultants FTL or designee	SOP 3-20	None
Multi-Parameter Water Quality Meter YSI 556 Series (or similar)	Visual Inspection Calibration/ Verification	Daily Beginning of each day	pH ± 0.2 standard units Specific Conductance ± 5% Dissolved oxygen ± 0.3 mg/L Temperature ±0.15 ºCelsius Oxygen reduction potential ± 10 mV	Operator correction or replacement	Resolution Consultants FTL or designee	SOP 3-24	None
Turbidity Meter LaMotte Model 2020e (or similar)	Visual Inspection Calibration/ Verification	Daily Beginning of each day	0.1 to 10 NTU: ±10% of the standard 11 to 40 NTU: ±8% of the standard 41 to 100 NTU: ±6.5% of the standard	Operator correction or replacement	Resolution Consultants FTL or designee	SOP 3-24	None

SAP Worksheet #23: Analytical SOP References Table

Laboratory Name and Address: TestAmerica, 495 Yarrow Street, Arvada, Colorado 80002
Laboratory Point of Contact/Project Manager: Joy Chang, joy.chang@testamericainc.com, 623-209-9961

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM	Modified for Project Work? (Yes/No)
DV-LC-0012	Analysis of Perfluorooctanoic Acid (PFOA) and other Perfluorinated Hydrocarbons (PFCs) and Perfluorinated Hydrocarbon Sulfonates (PFSs) in Water and Soil by LC/MS/MS, Revision 12, October 2014	Definitive	Groundwater and Soil will be analyzed for: PFOS, PFOA, PFBS, PFHpA, PFHxS, and PFNA	LC/MS/MS	No	No
DV-OP-0019	Extraction of Perfluorooctanoic Acid (PFOA) and Perfluorooctanoic Sulfonate (PFOS) and other Perfluorinated Hydrocarbons (PFCs) in Water and Soil, Revision 6, October 2014	Definitive	Groundwater and Soil will be analyzed for: PFOS, PFOA, PFBS, PFHpA, PFHxS, and PFNA	Solid Phase Extraction System	No	No

Notes:

SOP = Standard operating procedure
QSM = Department of Defense Quality Systems Manual for Environmental Laboratories, Version 5.0, July 2013.
GC/MS = Gas chromatograph/Mass spectrometer
LC/MS/MS = High performance liquid chromatography tandem mass spectrometer
PFOS = Perfluorooctane sulfonate
PFOA = Perfluorooctanoic acid

SAP Worksheet #24: Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria[1]	Corrective Action	Person Responsible for CA	SOP Reference[2]
PFCs	ICAL. Minimum of five points initial calibration for all target analytes	Initial calibration prior to sample analysis. Perform instrument re-calibration once per year minimum.	Coefficient of calibration: r $\geq$0.990 linear. $r^2 \geq$0.990 2nd order. RSD <20% Each calibration point for each analyte must calculate to be within 75-125% except lowest point at 70-130%	Instrument and standards are checked. Correct problem. Repeat initial calibration	Analyst/Area Supervisor	DV-LC-0012
	ICV. Initial calibration verification from a 2nd source.	Immediately following minimum five-point initial calibration	All analytes and surrogates within 25% of true value	Correct problem. Rerun ICV. If that fails correct problem and repeat initial calibration	Analyst/Area Supervisor	DV-LC-0012
	Detection Limit Calibration Verification (DLCK)	0.2 ug/L standard analyzed following the ICV	70 - 130%	Correct problem then repeat initial calibration	Analyst/Area Supervisor	DV-LC-0012
	CCV. Continuing calibration verification	50 µg/L and 100 µg/L alternately before sample analysis and after every 10 samples	All analytes and surrogates within 25% of true value	Evaluate failure and impact on samples. If samples non-detect for analytes which have a high bias, report non-detect results with case narrative comment with written approval from the client. or Immediately analyze two additional	Analyst/Area Supervisor	DV-LC-0012

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria[1]	Corrective Action	Person Responsible for CA	SOP Reference[2]
				consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze once all affected samples since the last acceptable CCV. If CCV still fails, consult client before reporting.		
	IS. Internal Standard recovery.	All samples and standards	Absolute areas of IS quantitation ions within 50-150% from the average areas measured during initial calibration	If recoveries are acceptable for QC samples, but not field samples, the field samples may be considered to suffer from a matrix effect. For failed QC samples, correct problem and rerun all associated failed field samples.	Analyst/Area Supervisor	DV-LC-0012
	Mass calibration with PEG or other appropriate material bracketing mass calibration range	Annually or after major maintenance or if large amounts of drift are observed in the tune.	+/- 0.5 amu for all compounds	Re-calibrate	Analyst/Area Supervisor	DV-LC-0012

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria[1]	Corrective Action	Person Responsible for CA	SOP Reference[2]
	Tune (while infusing or evaluation of analyte response in low standard). Check mass of spectral ion intensities.	Prior to ICAL	+/- 0.5 amu for all compounds	Perform mass calibration	Analyst/Area Supervisor	DV-LC-0012

Notes:

1. = This is a summary of the acceptance criteria; refer to the method SOP for specific or more information.
2. = SOPs are reviewed/revised on an annual schedule. The current version will be followed at the time of sample receipt.

SAP Worksheet #28: Laboratory QC Samples Table

Matrix:	Groundwater and Soil
Analytical Group:	PFOS and PFOA
Analytical Method/SOP Reference:	TestAmerica Method/DV-LC-0012

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicators	Measurement Performance Criteria
Method Blank	One per batch of 20 or fewer samples per matrix	No analytes detected >½ LOQ and >1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Correct problem; if required, re-prepare and re-analyze method blank and all samples processed with the contaminated blank. If re-analysis cannot be performed, qualify data and narrate.	Analyst, Supervisor, QA Manager	Bias, Contamination	See Method/SOP QC Acceptance Limit Column
Surrogates	All field and QC samples	**Surrogate** / **Laboratory Recovery Limits** 13C8 Perfluorooctanoic acid: 60-155% 13C8 Perfluorooctane sulfonate: 45-130%	If recoveries are acceptable for QC samples, but not field samples, the field samples may be considered to suffer from matrix effect. For failed QC samples, correct problem, and rerun all failed samples, report and narrate.	Analyst, Supervisor, QA Manager	Accuracy, Bias	See Method/SOP QC Acceptance Limit Column
LCS	One per batch of 20 or fewer samples per matrix	Recovery 70-130%	Correct problem, then re-prepare and re-analyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample volume is available.	Analyst, Supervisor, QA Manager	Accuracy, Bias	See Method/SOP QC Acceptance Limit Column
Internal Standards (Isotopically labeled)	In all field samples, QC samples, and standards	± 50% of average areas measured during initial calibration.	If recoveries are acceptable for QC samples, but not field samples, the field samples may be considered to suffer from matrix effect. For failed QC samples, correct problem, and rerun all failed samples, report and narrate.	Analyst, Supervisor, QA Manager	Accuracy, Bias	See Method/SOP QC Acceptance Limit Column

Matrix:		Groundwater and Soil				
Analytical Group:		PFOS and PFOA				
Analytical Method/SOP Reference:		TestAmerica Method/DV-LC-0012				
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicators**	**Measurement Performance Criteria**
MS/MSD	One per batch of 20 or fewer samples per matrix	Recovery — 70-130% Relative percent difference — ≤30	Contact the client to determine if additional measures are required.	Analyst, Supervisor, QA Manager	Accuracy, Bias, Precision	See Method/SOP QC Acceptance Limit Column

Notes:

PFOS = Perfluorooctane sulfonate
PFOA = Perfluorooctanoic acid
SOP = Standard operating procedure
QC = Quality control
LOQ = Limit of quantitation
QA = Quality assurance
LCS = Laboratory control sample
MS/MSD = Matrix spike/matrix spike duplicate

SAP Worksheet #31: Planned Project Assessments Table

No planned project assessments are anticipated as part of this SAP.

SAP Worksheet #32: Assessment Findings and Corrective Responses Table

No planned project assessments are anticipated as part of this SAP.

SAP Worksheet #33: Quality Assurance Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
Technical Audit of Field Activities: Audit Report	Once at start of field program; follow-up audits as needed	Dependent on field schedule	Resolution Deputy PM	Resolution PM
Safety Audit	Once during first week of field work	Dependent on field schedule	Resolution Health and Safety Officer or Deputy PM	Resolution PM; Resolution Environment Safety, Health & Environment Manager, U.S. Northeast Region
Daily Field Progress Reports	Daily	Daily	Resolution Field Team Leader	Resolution PM, Resolution Deputy PM
Data Validation Reports	One per SDG; after laboratory data is received and validated	Estimated 45 days after receipt of complete SDG	Resolution Data Validation Coordinator	Resolution PM, Resolution Project Chemist
Data Usability Report	Once per field program; after all data are validated	Estimated 30 days after completion of data validation	Resolution Project Chemist	Resolution PM
RI Report	Once per report iterate	Estimated 45 days after completion of data validation	Resolution PM	Navy, U.S. EPA, MassDEP

SAP Worksheets #34 — 36: Data Verification and Validation (Steps 1 and IIA/IIB) Process Table

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb(1)	Internal/ External(2)
Verification Chain-of-custody forms Sample Login/Receipt	Review the sample shipment for completeness, integrity, and sign accepting the shipment. All sample labels will be checked against the chain-of-custody form, and any discrepancies will be identified, investigated, and corrected. The samples will be logged in at every storage area and work station required by the designated analyses. Individual analysts will verify the completeness and accuracy of the data recorded on the forms. Verification of sample login/receipt and chain-of-custody forms will be documented on the laboratory sample receipt form.	Laboratory sample custodians and analysts	I	Internal
Verification Chain-of-custody forms	Check that the chain-of-custody form was signed/dated by the sampler relinquishing the samples and by the laboratory sample custodian receiving the samples for analyses. Verification of chain-of-custody forms will be documented in the DVA workbook.	Project Chemist or Data Validators, Resolution Consultants	I	External
Verification SAP sample tables	Verify that all proposed samples listed in the SAP tables have been collected. Sample completeness will be documented in the data validation report.	FTL or designee, Resolution Consultants	I	Internal
Verification Sample log sheets and field notes	Verify that information recorded in the log sheets and field notes are accurate and complete. Sample log sheet verification will be documented by dated signature on the last page or page immediately following the review material.	FTL or designee, Resolution Consultants	I	Internal
Verification Field QC samples	Check that field QC samples, described in Worksheet #12 and listed in Worksheet #20, were collected as required. QC sample completeness will be documented in the data validation report.	FTL or designee, Resolution Consultants	I	Internal
Verification Analytical data package	All analytical data packages will be verified internally for completeness by the laboratory performing the work. The laboratory project manager (or designee) will sign the case narrative for each data package. All laboratory data package reviews will be documented in the laboratory narratives.	Laboratory Project Manager	I	Internal
Verification Analytical data package	Verify the data package for completeness. Missing information will be requested from the laboratory and validation (if performed) will be suspended until missing data is received. Data package completeness will be documented in the DVA workbook.	FTL, Project Chemist or Data Validators, Resolution Consultants	I	External
Verification Electronic data deliverables	Verify the electronic data against the chain-of-custody and hard copy data package for accuracy and completeness before loading into project database. Electronic data deliverable verification will be documented in the DVA workbook.	Data Manager and/or Validator, Resolution Consultants	I	External

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb[1]	Internal/ External[2]
Validation Chain-of-custody	Examine the traceability of the data from time of sample collection until reporting of data. Ensure that the custody and integrity of the samples were maintained from collection to analysis and that custody records are complete and any deviations are recorded. Chain-of-custody verification will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa	External
Validation Holding Times	Review that the samples were shipped and stored at the required temperature, meeting the requirements listed in Worksheet #18, #19, #20 and #30-1. Ensure that the analyses were performed within the holding times. If holding times were not met, confirm that deviations were documented. Holding time examination will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa	External
Validation Sample results for representativeness	Check that the laboratory recorded both the temperature at sample receipt and the pH of the chemically preserved samples to ensure sample integrity was sustained from sample collection to analysis. Representativeness will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation Laboratory data results for accuracy	Ensure that the laboratory QC samples were analyzed and that the measurement performance criteria, listed in Worksheet #28, were met for all field samples and QC analyses. Check that specified field QC samples were collected and analyzed, as listed in Worksheet #12, and that the analytical QC criteria were met. Accuracy will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation Field and laboratory duplicate analyses for precision	Check the field sampling precision by calculating the RPD for field duplicate samples. Check the laboratory precision by reviewing the RPD or percent difference values from laboratory duplicate analyses; MS/MSDs; and LCS/LCS duplicates. Ensure compliance with the precision goals listed in Worksheets #12 and #28. Precision will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb[1]	Internal/ External[2]
Validation Project action limits	Assess and document the impact on matrix interferences or sample dilutions performed because of the high concentration of one or more contaminant on the other target compounds reported as undetected. Project action limit achievement will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation Data quality assessment report	Summarize deviations from methods, procedures, or contracts. Qualify data results based on method or QC deviation and explain all the data qualifications. Present tabular qualified data and data qualifier codes and summarize data qualification outliers. Determine if the data met the MPC and determine the impact of any deviations on the technical usability of the data. Result qualification will be documented in the in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation SAP QC sample documentation	Ensure that all QC samples specified in the SAP were collected and analyzed and that the associated results were within acceptance limits. QC sample documentation will be documented in the DVA workbook and data validation report	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation Analytical data deviations	Determine the impact of any deviation from sampling or analytical methods, and laboratory SOP requirements and matrix interferences effect on the analytical results. Data deviations will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIb	External
Validation Project quantitation limits for sensitivity	Ensure that the project detection limits were achieved. Project quantitation limit achievement will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIb	External
Validation Organics: PFOS/PFOA	Assess PFOS/PFOA analytical data against MPC identified in Worksheets #12, #19, and #28. *U.S. EPA New England Environmental Data Review Supplement for Regional Data Review elements and Superfund Specific Guidance/Procedures*, (April 2013) will be used as a guidance on applying qualifiers when MPC identified in Worksheets #12, #19, and #28 are not met, including identifying when samples will be qualified estimated or rejected and when individual or all samples in a batch will be qualified. Validation will be limited to reviewing laboratory quality control summary information and raw data will not be reviewed.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External

<table>
<tr><th>Data Review Input</th><th>Description</th><th>Responsible for Verification (name, organization)</th><th>Step I/IIa/IIb[1]</th><th>Internal/ External[2]</th></tr>
<tr><td>Validation
Data qualifiers</td><td>Qualifiers that will be applied during the data validation process are summarized below and, as indicated, results will be considered usable unless qualified by an R-flag. Rejected data will be evaluated and may be used in circumstances identified by the Partnering Team.
<table>
<tr><th>Data Qualifier</th><th>Qualifier Definition</th><th>Interpret Result As a Detection?</th><th>Result Usable?</th><th>Potential Result Bias</th></tr>
<tr><td>no qualifier</td><td>Acceptable</td><td>Yes</td><td>Yes</td><td>None expected</td></tr>
<tr><td>J+/J-</td><td>Estimated</td><td>Yes</td><td>Yes</td><td>High or Low</td></tr>
<tr><td>U</td><td>Undetected</td><td>No</td><td>Yes</td><td>None expected</td></tr>
<tr><td>UJ</td><td>Undetected and Estimated</td><td>No</td><td>Yes</td><td>High or Low</td></tr>
<tr><td>R</td><td>Rejected</td><td>No</td><td>No</td><td>Unspecified</td></tr>
</table></td><td>Project Chemist or Data Validators, Resolution Consultants</td><td>IIa/IIb</td><td>External</td></tr>
</table>

Notes:

(1) IIa Compliance with methods, procedures, and contracts (see Table 10, page 117, UFP-QAPP manual, V.1, March 2005.)
IIb Comparison with measurement performance criteria in the SAP (see Table 11, page 118, UFP-QAPP manual, V.1, March 2005)

(2) Internal or external (independent) from the data generation activities.

DVA = Data validation assistant
SAP = Sampling and analysis plan
FTL = Field team leader
QC = Quality control
RPD = Relative percent difference
MS/MSD = Matrix spike/Matrix Spike duplicate
LCS = Laboratory control sample
SOP = Standard operating procedure
PFOS = Perfluorooctane sulfonate
PFOA = Perfluorooctanoic acid
U.S. EPA = U.S. Environmental Protection Agency
MPC = Measurement performance criteria
UFP-QAPP = Uniform Federal Policy-Quality Assurance Project Plan

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Appendix A

Standard Operating Procedures

Utility Clearance

Procedure 3-01

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the process for determining the presence of subsurface utilities and other cultural features at locations where planned site activities involve the physical disturbance of subsurface materials.

1.2 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).

1.3 The procedure applies to the following activities: soil gas surveying, excavating, trenching, drilling of borings and installation of monitoring and extraction wells, use of soil recovery or slide-hammer hand augers, and all other intrusive sampling activities.

1.4 The primary purpose of the procedure is to minimize the potential for damage to underground utilities and other subsurface features, which could result in physical injury, disruption of utility service, or disturbance of other subsurface cultural features.

1.5 If there are procedures, whether it be from Resolution Consultants, state, and/or federal, that are not addressed in this SOP and are applicable to utility clearance, those procedures should be added as an appendix to the project specific SAP.

1.6 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 Field and subcontractor personnel shall adhere to a site-specific health and safety plan (HASP).

3.0 Terms and Definitions

3.1 **Utility**

For the proposes of this SOP, a utility is defined as a manmade underground line or conduit, cable, pipe, vault or tank that is, or was, used for the transmission of material or energy (e.g., gas, electrical, telephone, steam, water or sewage, product transfer lines, or underground storage tanks).

3.2 **As-Built Plans**

As-built plans are plans or blueprints depicting the locations of structures and associated utilities on a property.

3.3 **One-Call**

The Utility Notification Center is the one-call agency for nationwide call before you dig. The Utility Notification Center is open 24 hours a day, and accepts calls from anyone planning to dig. The phone number 811 is the designated call before you dig phone number that directly connects you to your local one-call center. Additional information can be found at www.call811.com.

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Calling before you dig ensures that any publicly owned underground lines will be marked so that you can dig around them safely. Having the utility lines marked not only prevents accidental damage to the lines, but prevents property damage and personal injuries that could result in breaking a line.

The following information will need to be provided when a call is placed to One-Call:

- Your name, phone number, company name (if applicable), and mailing address.
- What type or work is being done.
- Who the work is being done for.
- The county and city the work is taking place in.
- The address or the street where the work is taking place.
- Marking instructions, (specific instructions as to where the work is taking place).

Under normal circumstances it takes between 2 to 5 days from the time you call (not counting weekends or holidays) to have the underground lines marked. Because these laws vary from state to state, exactly how long it will take depends on where your worksite is located. You will be given an exact start time and date when your locate request is completed, which will comply with the laws in your area.

In the event of an emergency (any situation causing damage to life or property, or a service outage), lines can be marked sooner than the original given time if requested.

3.4 **Toning**

Toning is the process of surveying an area utilizing one or more surface geophysical methods to determine the presence or absence of underground utilities. Typically, toning is conducted after identifying the general location of utilities and carefully examining all available site utility plans. Each location is marked according to the type of utility being identified. In addition, areas cleared by toning are flagged or staked to indicate that all identified utilities in a given area have been toned.

4.0 Training and Qualifications

4.1 The **Contract Task Order (CTO) Manager** is responsible for verifying that these utility locating procedures are performed prior to the initiation of active subsurface exploration.

4.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all utility locating activities are performed in accordance with this procedure.

4.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.0 Equipment and Supplies

5.1 Equipment and supplies necessary for locating subsurface utilities will be provided by the subcontractor; however, the project **Field Manager/Field Personnel** will provide any additional equipment and supplies as needed as well as maintain information regarding the utility clearance activities in the field logbook.

6.0 Procedure

Proceed wtih the following steps where subsurface exploration will include excavations, drilling, or any other subsurface investigative method that could damage utilities at a site. In addition to the steps outlined below, always exercise caution while conducting subsurface exploratory work.

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6.1 Prepare Preliminary Site Plan

- Prepare a preliminary, scaled site plan depicting the proposed exploratory locations as part of the project specific Sampling and Analysis Plan (SAP) or Work Plan. Include as many of the cultural and natural features as practical in this plan.

6.2 Review Background Information

- Search existing plan files to review the as-built plans to identify the known location of utilities at the site. Plot the locations of utilities identified onto a preliminary, scaled site plan. Inform the CTO Manager if utilities lie within close proximity to a proposed exploration or excavation location. The CTO Manager will determine if it is necessary to relocate proposed sampling or excavation locations.
- Include the utility location information gathered during previous investigations (e.g., remedial investigation or remedial site evaluation) in the project design documents for removal or remedial actions. In this manner, information regarding utility locations collected during implementation of a CTO can be shared with the subcontractor during implementation of a particular task order. In many instances, this will help to reduce the amount of additional geophysical surveying work the subcontractor may have to perform.
- Conduct interviews with onsite and facility personnel familiar with the site to obtain additional information regarding the known and suspected locations of underground utilities. In addition, if appropriate, contact shall be made with local utility companies to request their help in locating underground lines. Pencil in the dimensions, orientation, and depth of utilities, other than those identified on the as-built plans, at their approximate locations on the preliminary plans. Enter the type of utility, the personnel who provided the information, and the date the information was provided into the field log.
- During the pre-field work interviewing process, the interviewer will determine which site personnel should be notified in the event of an incident involving damage to existing utilities. Record this information in the field logbook with the corresponding telephone numbers and addresses.

6.3 Site Visit/Locate Utilities/Toning

- Prior to the initiation of field activities, the Field Task Manager or similarly qualified field personnel shall visit the site and note existing structures and evidence of associated utilities, such as fire hydrants, irrigation systems, manhole and vault box covers, standpipes, telephone switch boxes, free-standing light poles, gas or electric meters, pavement cuts, and linear depression. Compare notes of the actual site configuration to the preliminary site plan. Note deviations in the field logbook and on the preliminary site plan. Accurately locate or survey and clearly mark with stakes, pins, flags, paint, or other suitable devices all areas where subsurface exploration is proposed. These areas shall correspond with the locations drawn on the preliminary site plan.
- Following the initial site visit by the Field Task Manager, a trained utility locating subcontractor will locate, identify, and tone all utilities depicted on the preliminary site plan. The Field Task Manager or similarly qualified field personnel shall visit the site and identify the areas of subsurface disturbance with white spray paint, chalk, white pin flags or some other easily identifiable marking. The utility locator should utilize appropriate sensing equipment to attempt to locate utilities that might not have appeared on the as-built plans. At a minimum, the utility subcontractor should utilize a metal detector and/or magnetometer; however, it is important to consider the possibility that non-metallic utilities or tanks might be present at the site. Use other appropriate surface geophysical methods such as Ground Penetrating Radar, Radiodetection, etc. as appropriate. Clear proposed exploration areas of all utilities in the immediate area where subsurface exploration is proposed. Clearly tone all anomalous areas. Clearly identify all toned areas on the preliminary site plan. All utilities near the area of subsurface disturbance should also be marked out by the utility subcontractor using the universal colors for subsurface utilities (i.e., red – electric; blue – water; green – sewer; yellow – gas; etc.). After toning the site and plotting all known or suspected buried utilities on the preliminary site plan, the utility locator shall provide the Field Task Manager with a copy of the completed preliminary

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site plan. Alternatively, the Field Task Manager or designee shall document the results of the survey on the preliminary site plan.

- Report to the Field Task Manager anomalous areas detected and toned that are in close proximity to the exploration or excavation areas. The Field Task Manager shall determine the safe distance to maintain from the known or suspected utility. It may be necessary to relocate the proposed exploration or excavation areas. If this is required, the Field Task Manager or designee shall relocate them and clearly mark them using the methods described above. Completely remove the markings at the prior location. Plot the new locations on the site plan and delete the prior locations from the plan. In some instances, such as in areas extremely congested with subsurface utilities, it may be necessary to dig by hand or use techniques such as air knife to determine the location of the utilities.

6.4 **Prepare Site Plan**

- Prior to the initiation of field activities, draft a final site plan that indicates the location of subsurface exploration areas and all known or suspected utilities present at the site. Provide copies of this site plan to the Navy Technical Representative (NTR), the CTO Manager, and the subcontractor who is to conduct the subsurface exploration/excavation work. Review the site plan with the NTR to verify its accuracy prior to initiating subsurface sampling activities.

7.0 Quality Control and Assurance

7.1 Utility locating must incorporate quality control measures to ensure conformance to these and the project requirements.

8.0 Records, Data Analysis, Calculations

8.1 A bound field logbook will be kept detailing all activities conducted during the utility locating procedure.

8.2 The logbook will describe any changes and modifications made to the original exploration plan. The trained utility locator shall prepare a report and keep it in the project file. Also, a copy of the final site plan will be kept in the project file.

9.0 Attachments or References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual.* Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Author	Reviewer	Revisions (Technical or Editorial)
Caryn DeJesus Senior Scientist	Bob Shoemaker Senior Scientist	Rev 0 – Initial Issue (June 2012)

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Logbooks

Procedure 3-02

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the activities and responsibilities pertaining to the identification, use, and control of logbooks and associated field data records.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 In order to keep the logbook clean, store it in a clean location and use it only when outer gloves used for PPE have been removed.

3.0 Terms and Definitions

3.1 **Logbook**

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person assigned responsibility for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 **Data Form**

A data form is a predetermined format utilized for recording field data that may become, by reference, a part of the logbook (e.g., soil boring logs, trenching logs, surface soil sampling logs, groundwater sample logs, and well construction logs are data forms).

4.0 Training and Qualifications

4.1 The **Contract Task Order (CTO) Manager** or **designee** is responsible for determining which team members shall record information in field logbooks and for obtaining and maintaining control of the required logbooks. The **CTO Manager** shall review the field logbook on at least a monthly basis. The **CTO Manager** or **designee** is responsible for reviewing logbook entries to determine compliance with this procedure and to ensure that the entries meet the project requirements.

4.2 A knowledgeable individual such as the **Field Manager**, **CTO Manager**, or **Program Quality Manager** shall perform a technical review of each logbook at a frequency commensurate with the level of activity (weekly is suggested, or, at a minimum, monthly). Document these reviews by the dated signature of the reviewer on the last page or page immediately following the material reviewed.

4.3 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.4 The **Field Manager** is responsible for ensuring that all **field personnel** follow these procedures and that the logbook is completed properly and daily. The **Field Manager** is also responsible for submitting copies to the **CTO Manager**, who is responsible for filing them and submitting a copy (if required by the CTO Statement of Work).

4.5 The **logbook user** is responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. The **logbook user** is also responsible for safeguarding the logbook while having custody of it.

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4.6 All **field personnel** are responsible for the implementation of this procedure.

5.0 Equipment and Supplies

5.1 Field logbooks shall be bound field notebooks with water-repellent pages.

5.2 Pens shall have indelible black ink.

6.0 Procedure

6.1 The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct the applicable events. Store the logbook in a clean location and use it only when outer gloves used for personal protective equipment (PPE) have been removed.

6.2 Individual data forms may be generated to provide systematic data collection documentation. Entries on these forms shall meet the same requirements as entries in the logbook and shall be referenced in the applicable logbook entry. Individual data forms shall reference the applicable logbook and page number. At a minimum, include names of all samples collected in the logbook even if they are recorded elsewhere.

6.3 Enter field descriptions and observations into the logbook, as described in Attachment 1, using indelible black ink.

6.4 Typical information to be entered includes the following:

- Dates (month/day/year) and times (military) of all on-site activities and entries made in logbooks/forms;
- Site name and description;
- Site location by longitude and latitude, if known;
- Weather conditions, including temperature and relative humidity;
- Fieldwork documentation, including site entry and exit times;
- Descriptions of, and rationale for, approved deviations from the work plan (WP) or field sampling plan;
- Field instrumentation readings;
- Names, job functions, and organizational affiliations of on-site personnel;
- Photograph references;
- Site sketches and diagrams made on site;
- Identification and description of sample morphology, collection locations, and sample numbers;
- Sample collection information, including dates (month/day/year) and times (military) of sample collections, sample collection methods and devices, station location numbers, sample collection depths/heights, sample preservation information, sample pH (if applicable), analysis requested (analytical groups), etc., as well as chain-of-custody (COC) information such as sample identification numbers cross-referenced to COC sample numbers;
- Sample naming convention;
- Field quality control (QC) sample information;
- Site observations, field descriptions, equipment used, and field activities accomplished to reconstruct field operations;

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- Meeting information;
- Important times and dates of telephone conversations, correspondence, or deliverables;
- Field calculations;
- PPE level;
- Calibration records;
- Contractor and subcontractor information (address, names of personnel, job functions, organizational affiliations, contract number, contract name, and work assignment number);
- Equipment decontamination procedures and effectiveness;
- Laboratories receiving samples and shipping information, such as carrier, shipment time, number of sample containers shipped, and analyses requested; and
- User signatures.

6.5 The logbook shall reference data maintained in other logs, forms, etc. Correct entry errors by drawing a single line through the incorrect entry, then initialing and dating this change. Enter an explanation for the correction if the correction is more than for a mistake.

6.6 At least at the end of each day, the person making the entry shall sign or initial each entry or group of entries.

6.7 Enter logbook page numbers on each page to facilitate identification of photocopies.

6.8 If a person's initials are used for identification, or if uncommon acronyms are used, identify these on a page at the beginning of the logbook.

6.9 At least weekly and preferably daily, the **preparer** shall photocopy and retain the pages completed during that session for backup. This will prevent loss of a large amount of information if the logbook is lost.

7.0 Quality Control and Assurance

7.1 Review per Section 4.2 shall be recorded.

8.0 Records, Data Analysis, Calculations

8.1 Retain the field logbook as a permanent project record. If a particular CTO requires submittal of photocopies of logbooks, perform this as required.

8.2 Deviations from this procedure shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

9.0 Attachments or References

9.1 Attachment 1 – Description of Logbook Entries

9.2 Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue

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Attachment 1
Description of Logbook Entries

Logbook entries shall be consistent with Section A.1.4 *Field Documentation SOPs* of the UFP-QAPP Manual (DoD 2005) and contain the following information, as applicable, for each activity recorded. Some of these details may be entered on data forms, as described previously.

Name of Activity	For example, Asbestos Bulk Sampling, Charcoal Canister Sampling, Aquifer Testing.
Task Team Members and Equipment	Name all members on the field team involved in the specified activity. List equipment used by serial number or other unique identification, including calibration information.
Activity Location	Indicate location of sampling area as indicated in the field sampling plan.
Weather	Indicate general weather and precipitation conditions.
Level of PPE	Record the level of PPE (e.g., Level D).
Methods	Indicate method or procedure number employed for the activity.
Sample Numbers	Indicate the unique numbers associated with the physical samples. Identify QC samples.
Sample Type and Volume	Indicate the medium, container type, preservative, and the volume for each sample.
Time and Date	Record the time and date when the activity was performed (e.g., 0830/08/OCT/89). Use the 24-hour clock for recording the time and two digits for recording the day of the month and the year.
Analyses	Indicate the appropriate code for analyses to be performed on each sample, as specified in the WP.
Field Measurements	Indicate measurements and field instrument readings taken during the activity.
Chain of Custody and Distribution	Indicate chain-of-custody for each sample collected and indicate to whom the samples are transferred and the destination.
References	If appropriate, indicate references to other logs or forms, drawings, or photographs employed in the activity.
Narrative (including time and location)	Create a factual, chronological record of the team's activities throughout the day including the time and location of each activity. Include descriptions of general problems encountered and their resolution. Provide the names and affiliations of non-field team personnel who visit the site, request changes in activity, impact the work schedule, request information, or observe team activities. Record any visual or other observations relevant to the activity, the contamination source, or the sample itself. It should be emphasized that logbook entries are for recording data and chronologies of events. The logbook author must include observations and descriptive notations, taking care to be objective and recording no opinions or subjective comments unless appropriate.
Recorded by	Include the signature of the individual responsible for the entries contained in the logbook and referenced forms.
Checked by	Include the signature of the individual who performs the review of the completed entries.

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Recordkeeping, Sample Labeling, and Chain-of-Custody

Procedure 3-03

1.0 Purpose and Scope

1.1 The purpose of this standard operating procedure is to establish standard protocols for all field personnel for use in maintaining field and sampling activity records, writing sample logs, labeling samples, ensuring that proper sample custody procedures are utilized, and completing chain-of-custody/analytical request forms.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

Not applicable.

3.0 Terms and Definitions

3.1 **Logbook**

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person responsible for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 **Chain-of-Custody**

Chain-of-custody (COC) is documentation of the process of custody control. Custody control includes possession of a sample from the time of its collection in the field to its receipt by the analytical laboratory, and through analysis and storage prior to disposal.

4.0 Training and Qualifications

4.1 The **CTO Manager** is responsible for determining which team members shall record information in the field logbook and for checking sample logbooks and COC forms to ensure compliance with these procedures. The **CTO Manager** shall review COC forms on a monthly basis at a minimum.

4.2 The **CTO Manager** and **Program Quality Manager** are responsible for evaluating project compliance with the Project Procedures Manual.

4.3 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.4 The **Laboratory Project Manager** or **Sample Control Department Manager** is responsible for reporting any sample documentation or COC problems to the **CTO Manager** or **CTO Laboratory Coordinator** within 24 hours of sample receipt.

4.5 The **Field Manager** is responsible for ensuring that all **field personnel** follow these procedures. The **CTO Laboratory Coordinator** is responsible for verifying that the COC/analytical request forms have been completed properly and match the sampling and analysis plan. The **CTO Manager** or **CTO Laboratory Coordinator** is responsible for notifying the **laboratory**, **data managers**, and **data validators** in writing if analytical request changes are required as a corrective action. These small changes are different from change orders, which involve changes to the scope of the subcontract with

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the laboratory and must be made in accordance with a respective contract (e.g., CLEAN remedial action contract).

4.6 All **field personnel** are responsible for following these procedures while conducting sampling activities. **Field personnel** are responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature.

5.0 Procedure

This procedure provides standards for documenting field activities, labeling the samples, documenting sample custody, and completing COC/analytical request forms. The standards presented in this section shall be followed to ensure that samples collected are maintained for their intended purpose and that the conditions encountered during field activities are documented.

5.1 Recordkeeping

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct each day's events. Field logs such as soil boring logs and ground-water sampling logs will also be used. These procedures are described in Procedure 3-02, *Logbooks*.

5.2 Sample Labeling

Affix a sample label with adhesive backing to each individual sample container. Place clear tape over each label (preferably prior to sampling) to prevent the labels from tearing off, falling off, being smeared, and to prevent loss of information on the label. Record the following information with a waterproof marker on each label:

- Project name or number (optional);
- COC sample number;
- Date and time of collection;
- Sampler's initials;
- Matrix (optional);
- Sample preservatives (if applicable); and
- Analysis to be performed on sample (this shall be identified by the method number or name identified in the subcontract with the laboratory).

These labels may be obtained from the analytical laboratory or printed from a computer file onto adhesive labels.

5.3 Custody Procedures

For samples intended for chemical analysis, sample custody procedures shall be followed through collection, transfer, analysis, and disposal to ensure that the integrity of the samples is maintained. Maintain custody of samples in accordance with the U.S. Environmental Protection Agency (EPA) COC guidelines prescribed in EPA *NEIC Policies and Procedures*, National Enforcement Investigations Center, Denver, Colorado, revised May 1986; EPA *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (TEGD); *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA OSWER Directive 9355 3-01); Appendix 2 of the *Technical Guidance Manual for Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports*; and *Test Methods for Evaluating Solid Waste* (EPA SW-846)

A description of sample custody procedures is provided below.

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5.3.1 Sample Collection Custody Procedures

According to the U.S. EPA guidelines, a sample is considered to be in custody if one of the following conditions is met:

- It is in one's actual physical possession or view;
- It is in one's physical possession and has not been tampered with (i.e., it is under lock or official seal);
- It is retained in a secured area with restricted access; and
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal.

Place custody seals on sample containers immediately after sample collection and on shipping coolers if the cooler is to be removed from the sampler's custody. Place custody seals in such a manner that they must be broken to open the containers or coolers. Label the custody seals with the following information:

- Sampler's name or initials; and
- Date and time that the sample/cooler was sealed.

These seals are designed to enable detection of sample tampering. An example of a custody seal is shown in Attachment 1.

Field personnel shall also log individual samples onto COC forms (carbon copy or computer generated) when a sample is collected. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 7.4, indicating sample identification number, matrix, date and time of collection, number of containers, analytical methods to be performed on the sample, and preservatives added (if any). The **samplers** will also sign the COC form signifying that they were the personnel who collected the samples. The COC form shall accompany the samples from the field to the laboratory. When a cooler is ready for shipment to the analytical laboratory, the **person delivering the samples for transport** will sign and indicate the date and time on the accompanying COC form. One copy of the COC form will be retained by the **sampler** and the remaining copies of the COC form shall be placed inside a self-sealing bag and taped to the inside of the cooler. Each cooler must be associated with a unique COC form. Whenever a transfer of custody takes place, **both parties** shall sign and date the accompanying carbon copy COC forms, and the **individual relinquishing the samples** shall retain a copy of each form. One exception is when the samples are shipped; the **delivery service personnel** will not sign or receive a copy because they do not open the coolers. The **laboratory** shall attach copies of the completed COC forms to the reports containing the results of the analytical tests. An example COC form is provided in Attachment 2.

5.3.2 Laboratory Custody Procedures

The following custody procedures are to be followed by an **independent laboratory** receiving samples for chemical analysis; the procedures in their Naval Facilities Engineering Service Center-evaluated Laboratory Quality Assurance Plan must follow these same procedures. A **designated sample custodian** shall take custody of all samples upon their arrival at the analytical laboratory. The **custodian** shall inspect all sample labels and COC forms to ensure that the information is consistent, and that each is properly completed. The **custodian** will also measure the temperature of the temperature blank in the coolers upon arrival using either a National Institute for Standards and Technology calibrated thermometer or an infra-red temperature gun. The **custodian** shall note the condition of the samples including:

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- If the samples show signs of damage or tampering;
- If the containers are broken or leaking;
- If headspace is present in sample vials;
- If proper preservation of samples has occurred (made by pH measurement, except volatile organic compounds [VOCs] and purgeable total petroleum hydrocarbons [TPH] and temperature). The pH of VOC and purgeable TPH samples will be checked by the **laboratory analyst** after the sample aliquot has been removed from the vial for analysis; and
- If any sample holding times have been exceeded.

All of the above information shall be documented on a sample receipt sheet by the **custodian**.

Discrepancies or improper preservation shall be noted by the **laboratory** as an out-of-control event and shall be documented on an out-of-control form with corrective action taken. The out-of-control form shall be signed and dated by the **sample control custodian** and **any other persons** responsible for corrective action. An example of an out-of-control form is included as Attachment 4.

The **custodian** shall then assign a unique laboratory number to each sample and distribute the samples to secured storage areas maintained at 4 degrees Celsius (soil samples for VOC analysis are to be stored in a frozen state until analysis). The unique laboratory number for each sample, COC sample number, client name, date and time received, analysis due date, and storage shall also be manually logged onto a sample receipt record and later entered into the laboratory's computerized data management system. The **custodian** shall sign the shipping bill and maintain a copy.

Laboratory personnel shall be responsible for the care and custody of samples from the time of their receipt at the laboratory through their exhaustion or disposal. Samples should be logged in and out on internal laboratory COC forms each time they are removed from storage for extraction or analysis.

5.4 Completing COC/Analytical Request Forms

COC form/analytical request form completion procedures are crucial in properly transferring the custody and responsibility of samples from field personnel to the laboratory. This form is important for accurately and concisely requesting analyses for each sample; it is essentially a release order from the analysis subcontract.

Attachment 2 is an example of a generic COC/analytical request form that may be used by **field personnel**. Multiple copies may be tailored to each project so that much of the information described below need not be handwritten each time. Attachment 3 is an example of a completed site-specific COC/analytical request form, with box numbers identified and discussed in text below.

COC forms tailored to each CTO can be drafted and printed onto multi-ply forms. This eliminates the need to rewrite the analytical methods column headers each time. It also eliminates the need to write the project manager, name, and number; QC Level; TAT; and the same general comments each time.

Complete one COC form per cooler. Whenever possible, place all VOC analyte vials into one cooler in order to reduce the number of trip blanks. Complete all sections and be sure to sign and date the COC form. One copy of the COC form must remain with the field personnel.

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Box 2 **Bill To:** List the name and address of the person/company to bill only if it is not in the subcontract with the laboratory.

Box 3 **Sample Disposal Instructions:** These instructions will be stated in the Master Service Agreement or each CTO statement of work with each laboratory.

Shipment Method: State the method of shipment (e.g., hand carry or air courier via FedEx or DHL).

Comments: This area shall be used by the field team to communicate observations, potential hazards, or limitations that may have occurred in the field or additional information regarding analysis (e.g., a specific metals list, samples expected to contain high analyte concentrations).

Box 4 **Cooler No.:** This will be written on the inside or outside of the cooler and shall be included on the COC. Some laboratories attach this number to the trip blank identification, which helps track samples for VOC analysis. If a number is not on the cooler, field personnel shall assign a number, write it on the cooler, and write it on the COC.

QC Level: Enter the reporting quality control (QC) requirements (e.g., Full Data Package, Summary Data Package).

Turnaround time (TAT): TAT will be determined by a sample delivery group (SDG), which may be formed over a 14-day period, not to exceed 20 samples. Once the SDG has been completed, standard TAT is 21 calendar days from receipt of the last sample in the SDG. Entering NORMAL or STANDARD in this field will be acceptable. If quicker TAT is required, it shall be in the subcontract with the laboratory and reiterated on each COC to remind the laboratory.

Box 5 **Type of Containers:** Write the type of container used (e.g., 1-liter glass amber, for a given parameter in that column).

Preservatives: Field personnel must indicate on the COC the correct preservative used for the analysis requested. Indicate the pH of the sample (if tested) in case there are buffering conditions found in the sample matrix.

Box 6 **Sample Identification (ID) Number:** This is typically a five-character alphanumeric identifier used by the contractor to identify samples. The use of this identifier is important since the laboratories are restricted to the number of characters they are able to use. Sample numbering shall be in accordance with the project-specific sampling and analysis plan.

Description (Sample ID): This name will be determined by the location and description of the sample, as described in the project-specific sampling and analysis plan. This sample identification should not be submitted to the laboratory, but should be left blank. If a computer COC version is used, the sample identification can be input, but printed with this block black. A cross-referenced list of the COC Sample Number and sample identification must be maintained separately.

Date Collected: Record the collection date in order to track the holding time of the sample. Note: For trip blanks, record the date it was placed in company with samples.

Time Collected: When collecting samples, record the time the sample is first collected. Use of the 24-hour military clock will avoid a.m. or p.m. designations (e.g., 1815 instead of 6:15 p.m.). Record local time; the laboratory is responsible for calculating holding times to local time.

Lab ID: This is for laboratory use only.

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Box 7 **Matrix/QC:** Identify the matrix (e.g., water, soil, air, tissue, fresh water sediment, marine sediment, or product). If a sample is expected to contain high analyte concentrations (e.g., a tank bottom sludge or distinct product layer), notify the laboratory in the comment section. Mark an "X" for the sample(s) that have extra volume for laboratory QC matrix spike/matrix spike duplicate (MS/MSD) purposes. The sample provided for MS/MSD purposes is usually a field duplicate.

Box 8 **Analytical Parameters:** Enter the parameter by descriptor and the method number desired (e.g., BTEX 8260B, PAHs 8270C, etc.). Whenever practicable, list the parameters as they appear in the laboratory subcontract to maintain consistency and avoid confusion.

If the COC does not have a specific box for number of sample containers, use the boxes below the analytical parameter, to indicate the number of containers collected for each parameter.

Box 9 **Sampler's Signature:** The person who collected samples must sign here.

Relinquished By: The person who turned over the custody of the samples to a second party other than an express mail carrier, such as FedEx or DHL, must sign and date here.

Received By: Typically, a representative of the receiving laboratory signs and dates here. Or, a field crew member who delivered the samples in person from the field to the laboratory might sign here. A courier, such as FedEx or DHL, does not sign here because they do not open the coolers. It must also be used by the prime contracting laboratory when samples are to be sent to a subcontractor.

Relinquished By: In the case of subcontracting, the primary laboratory will sign and date the Relinquished By space and fill out an additional COC to accompany the samples being subcontracted.

Received By (Laboratory): This space is for the final destination (e.g., at a subcontracted laboratory). A representative of the final destination (e.g., subcontracted laboratory) must sign and date here.

Box 10 **Lab No. and Questions:** This box is to be filled in by the laboratory only.

Box 11 **Control Number:** This number is the "COC" followed by the first contractor identification number in that cooler, or contained on that COC. This control number must be unique (i.e., never used twice). Record the date the COC is completed. It should be the same date the samples are collected.

Box 12 **Total # of Containers:** Sum the number of containers in that row.

Box 13 **Totals:** Sum the number of containers in each column. Because COC forms contain different formats depending on who produced the form, not all of the information listed in items 1 to 13 may be recorded; however, as much of this information as possible shall be included.

6.0 Quality Control and Assurance

6.1 Recordkeeping, sample labeling, and chain-of-custody activities must incorporate quality control measures to ensure accuracy and completeness.

6.2 Deviations from this procedure or the project-specific CTO work plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

7.0 Records, Data Analysis, Calculations

7.1 The COC/analytical request form shall be faxed approximately daily to the **CTO Laboratory Coordinator** for verification of accuracy. Following the completion of sampling activities, the sample

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logbook and COC forms will be transmitted to the **CTO Manager** for storage in project files. The **data validators** shall receive a copy also. The original COC/analytical request form shall be submitted by the **laboratory** along with the data delivered. Any changes to the analytical requests that are required shall be made in writing to the laboratory. A copy of this written change shall be sent to the data validators and placed in the project files. The reason for the change shall be included in the project files so that recurring problems can be easily identified.

7.2 Deviations from this procedure or the project-specific sampling and analysis plan shall be documented in the records. Significant changes shall be approved by the **Program Quality Manager**.

8.0 Attachments or References

8.1 Attachment 1 – Chain-of-Custody Seal

8.2 Attachment 2 – Generic Chain-of-Custody/Analytical Request Form

8.3 Attachment 3 – Sample Completed Chain-of-Custody

8.4 Attachment 4 – Sample Out-of-Control Form

8.5 Environmental Protection Agency, United States (EPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Interim Final. EPA/540/G-89/004. Office of Emergency and Remedial Response. October.

8.6 EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

8.7 EPA. 1997. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846. 3rd ed., Final Update IIIA. Office of Solid Waste.

8.8 Water Resources Control Board, State of California. 1988. *Technical Guidance Manual for Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports*. August.

8.9 Procedure 3-02, *Logbooks.*

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue

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Attachment 1
Chain-of-Custody Seal

CHAIN-OF-CUSTODY SEAL

<table>
<tr><td rowspan="3">[LABORATORY]</td><td>SAMPLE NO.</td><td>DATE</td><td>SEAL BROKEN BY</td></tr>
<tr><td colspan="2">SIGNATURE</td><td>DATE</td></tr>
<tr><td colspan="3">PRINT NAME AND TITLE (Inspector, Analyst or Technician</td></tr>
</table>

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Attachment 2
Generic Chain-of-Custody / Analytical Request Form

M601376

CHAIN OF CUSTODY RECORD

Page ____ of ____

Client/Project Name:	Project Location:
Project Number:	Field Logbook No.:
Sampler: (Print Name) /Affiliation:	Chain of Custody Tape No.:
Signature:	Send Results/Report to:

Analysis Requested

Field Sample No./ Identification	Date	Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Sludge, Etc.)	Preservative	Field Filtered								Lab I.D.	Remarks

Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:	Analytical Laboratory (Destination):
Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:	
Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:	Serial No.

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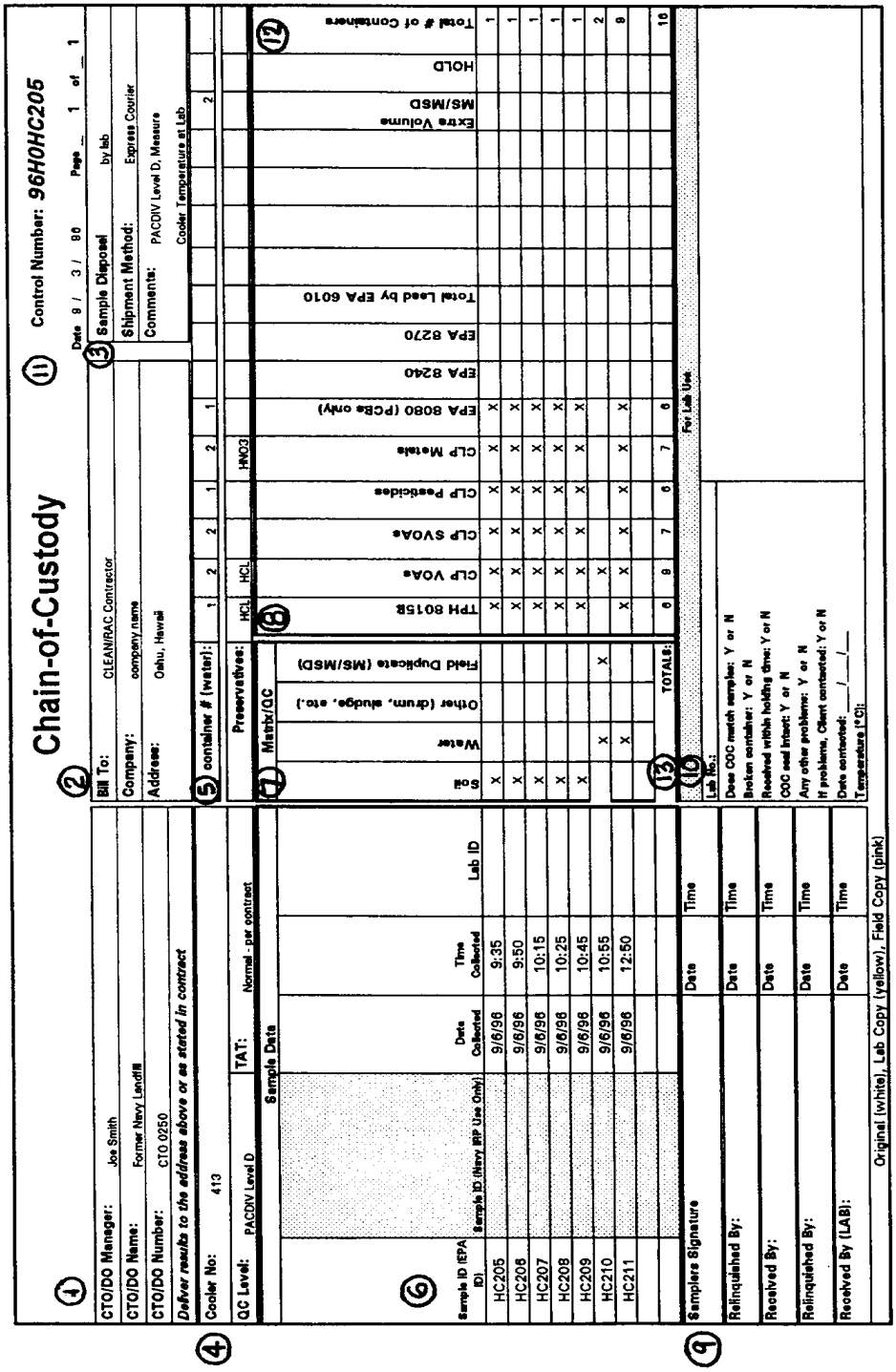
Attachment 3
Sample Completed Chain-of-Custody



Chain-of-Custody

Control Number: 96H0HC205

Date 9 / 3 / 96 Page 1 of 1

CTO/DO Manager: Joe Smith
CTO/DO Name: Former Navy Landfill
CTO/DO Number: CTO 0250
Deliver results to the address above or as stated in contract

Bill To: CLEAN/RAC Contractor
Company: company name
Address: Oahu, Hawaii

Sample Disposal: by lab
Shipment Method: Express Courier
Comments: PACDIV Level D, Measure Cooler Temperature at Lab

Cooler No: 413
QC Level: PACDIV Level D
TAT: Normal - per contract

container # (water): 1 2 2 1 2 1 2
Preservatives: HCL HCL HNO3

Sample Data

Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010				Extra Volume MS/MSD	HOLD	Total # of Containers
HC205		9/6/96	9:35		X				X	X	X	X	X	X									1
HC206		9/6/96	9:50		X				X	X	X	X	X	X									1
HC207		9/6/96	10:15		X				X	X	X	X	X	X									1
HC208		9/6/96	10:25		X				X	X	X	X	X	X									1
HC209		9/6/96	10:45		X				X	X	X	X	X	X									1
HC210		9/6/96	10:55			X		X		X	X												2
HC211		9/6/96	12:50			X			X	X	X	X	X	X									8
								TOTALS:	6	8	7	6	7	6									16

Samplers Signature: Date Time
Relinquished By: Date Time
Received By: Date Time
Relinquished By: Date Time
Received By (LAB): Date Time

For Lab Use
Lab No.:
Does COC match samples: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Original (white), Lab Copy (yellow), Field Copy (pink)

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Attachment 4
Sample Out-of-Control Form

OUT OF CONTROL FORM	Status	Date	Initial
	Noted OOC		
	Submit for CA*		
	Resubmit for CA*		
	Completed		

Date Recognized:	By:
Dated Occurred:	Matrix
Parameter (Test Code):	Method:
Analyst:	Supervisor:

Samples Affected (List by Accession AND Sample No.)

1. Type of Event (Check all that apply)		2. Corrective Action (CA)* (Check all that apply)	
	Calibration Corr. Coefficient <0.995		Repeat calibration
	%RSD>20%		Made new standards
	Blank >MDL		Reran analysis
	Does not meet criteria:		Sample(s) redigested and rerun
	Spike		Sample(s) reextracted and rerun
	Duplicate		Recalculated
	LCS		Cleaned system
	Calibration Verification		Ran standard additions
	Standard Additions		Notified
	MS/MSD		Other (please explain)
	BS/BSD		
	Surrogate Recovery		
	Calculations Error		
	Holding Times Missed		
	Other (Please explain	Comments:	

3. Results of Corrective Action	
	Return to Control (indicated with)
	Corrective Actions Not Successful - DATA IS TO BE FLAGGED with _____.

Analyst:	Date:
Supervisor:	Date:
QA Department:	Date:

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Sample Handling, Storage, and Shipping

Procedure 3-04

1.0 Purpose and Scope

1.1 This standard operating procedure describes the actions to be used by personnel engaged in handling, storing, and transporting samples. The objective is to obtain samples of actual conditions with as little alteration as possible.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 Avoid lifting heavy coolers with back muscles; instead, use leg muscles or dollies.

2.2 Wear proper gloves, such as blue nitrile and latex, as defined in the project-specific health and safety plan, when handling sample containers to avoid contacting any materials that may have spilled out of the sample containers.

3.0 Terms and Definitions

None.

4.0 Training and Qualifications

4.1 The **Contract Task Order (CTO) Manager** and the **Laboratory Project Manager** are responsible for identifying instances of non-compliance with this procedure and ensuring that future sample transport activities comply with this procedure.

4.2 The **Field Manager** is responsible for ensuring that all samples are shipped according to this procedure.

4.3 **Field personnel** are responsible for the implementation of this procedure.

4.4 The **Program Quality Manager** is responsible for ensuring that sample handling, storage, and transport activities conducted during all CTOs comply with this procedure.

4.5 All **field personnel** are responsible for the implementation of this procedure.

5.0 Procedure

5.1 Handling and Storage

Immediately following collection, label all samples according to Procedure 3-03, *Recordkeeping, Sample Labeling, and Chain-of-Custody*. The lids of the containers shall not be sealed with duct tape, but may be covered with custody seals or placed directly into self-sealing bags. Place the sample containers in an insulated cooler with frozen gel packs (e.g., “blue ice”) or ice in double, sealed self-sealing bags. Samples should occupy the lower portion of the cooler, while the ice should occupy the upper portion. Place an absorbent material (e.g., proper absorbent cloth material) on the bottom of the cooler to contain liquids in case of spillage. Fill all empty space between sample containers with Styrofoam® “peanuts” or other appropriate material. Prior to shipping, wrap glass sample containers on the sides, tops, and bottoms with bubble wrap or other appropriate padding and/or surround them in Styrofoam to

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prevent breakage during transport. Pack all glass containers for water samples in an upright position, never stacked or on their sides. Prior to shipment, replace the ice or cold packs in the coolers so that samples will be maintained as close to 4 degrees Celsius (°C) as possible from the time of collection through transport to the analytical laboratory. Ship samples within 24 hours or on a schedule allowing the laboratory to meet holding times for analyses. The procedures for maintaining sample temperatures at 4°C pertain to all field samples.

5.2 Shipping

Follow all appropriate U.S. Department of Transportation regulations (e.g., 49 Code of Federal Regulations [CFR], Parts 171-179) for shipment of air, soil, water, and other samples. Elements of these procedures are summarized below.

5.2.1 Hazardous Materials Shipment

Field personnel must state whether any sample is suspected to be a hazardous material. A sample should be assumed hazardous unless enough evidence exists to indicate it is non-hazardous. If not suspected to be hazardous, shipments may be made as described in the Section 5.2.2 for non-hazardous materials. If hazardous, follow the procedures summarized below.

Any substance or material that is capable of posing an unreasonable risk to life, health, or property when transported is classified as hazardous. Perform hazardous materials identification by checking the list of dangerous goods for that particular mode of transportation. If not on that list, materials can be classified by checking the Hazardous Materials Table (49 CFR 172.102 including Appendix A) or by determining if the material meets the definition of any hazard class or division (49 CFR Part 173), as listed in Attachment 2.

All **persons shipping hazardous materials** <u>must</u> be properly trained in the appropriate regulations, as required by HM-126F, Training for Safe Transportation of Hazardous Materials (49 CFR HM-126F Subpart H). The training covers loading, unloading, handling, storing, and transporting of hazardous materials, as well as emergency preparedness in the case of accidents. **Carriers**, such as commercial couriers, must also be trained. Modes of shipment include air, highway, rail, and water.

When shipping hazardous materials, including bulk chemicals or samples suspected of being hazardous, the proper shipping papers (49 CFR 172 Subpart C), package marking (49 CFR 172 Subpart D), labeling (49 CFR 172 Subpart E), placarding (49 CFR 172 Subpart F, generally for carriers), and packaging must be used. Attachment 1 shows an example of proper package markings. Refer to a copy of 49 CFR each time hazardous materials/potentially hazardous samples are shipped.

According to Section 2.7 of the International Air Transport Association Dangerous Goods Regulations publication, very small quantities of certain dangerous goods may be transported without certain marking and documentation requirements as described in 49 CFR Part 172; however, other labeling and packing requirements must still be followed. Attachment 2 shows the volume or weight for different classes of substances. A “Dangerous Goods in Excepted Quantities” label must be completed and attached to the associated shipping cooler (Attachment 3). Certain dangerous goods are not allowed on certain airlines in any quantity.

As stated in item 4 of Attachment 4, the Hazardous Materials Regulations do not apply to hydrochloric acid (HCl), nitric acid (HNO_3), sulfuric acid (H_2SO_4), and sodium hydroxide (NaOH) added to water samples if their pH or percentage by weight criteria is met. These samples may be shipped as non-hazardous materials as discussed below.

5.2.2 Non-Hazardous Materials Shipment

If the samples are suspected to be non-hazardous based on previous site sample results, field screening results, or visual observations, if applicable, then samples may be shipped as non-hazardous.

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When a cooler is ready for shipment to the laboratory, place two copies of the chain-of-custody form inside a self-sealing bag and tape it to the inside of the insulated cooler. Then, seal the cooler with waterproof tape and label it with "Fragile," "This-End-Up" (or directional arrows pointing up), or other appropriate notices. Place chain-of-custody seals on the coolers as discussed in Procedure 3-03, *Recordkeeping, Sample Labeling, and Chain-of-Custody*.

5.2.3 Shipments from Outside the Continental United States

Shipment of sample coolers to the United States from locations outside the continental United States is controlled by the U.S. Department of Agriculture (USDA) and is subject to their inspection and regulation. A "USDA Soil Import Permit" is required to prove that the receiving analytical laboratory is certified by the USDA to receive and properly dispose of soil. In addition, all sample coolers must be inspected by a **USDA representative**, affixed with a label indicating that the coolers contain environmental samples, and accompanied by shipping forms stamped by the **USDA inspector** prior to shipment.

In addition, the U.S. Customs Service must clear samples shipped from U.S. territorial possessions or foreign countries upon entry into the United States. As long as the commercial invoice is properly completed (see below), shipments typically pass through U.S. Customs Service without the need to open coolers for inspection.

Completion and use of proper paperwork will, in most cases, minimize or eliminate the need for the USDA and U.S. Customs Service to inspect the contents. Attachment 5 shows an example of how paperwork may be placed on the outside of coolers for non-hazardous materials. For hazardous materials, refer to Section 5.2.1.

In summary, tape the paperwork listed below to the outside of the coolers to accompany sample shipments. If a shipment is made up of multiple pieces (e.g., more than one cooler), the paperwork need only be attached to one cooler, provided that the **courier** agrees. All other coolers in the shipment need only to be taped and have the address and chain-of-custody seals affixed.

1. **Courier Shipping Form & Commercial Invoice:** See Attachment 6 and Attachment 7 for examples of the information to be included on the commercial invoices for soil and water, respectively. Place the courier shipping form and commercial invoice inside a clear, plastic, adhesive-backed pouch that adheres to the package (typically supplied by the courier) and place it on the cooler lid as shown in Attachment 5.

2. **Soil Import Permit (soil only):** See Attachment 8 and Attachment 9 for examples of the soil import permit and soil samples restricted entry labels, respectively. The **laboratory** shall supply these documents prior to mobilization. The USDA often stops shipments of soil without these documents. Staple together the 2-inch × 2-inch USDA label (described below) and soil import permit, and place them inside a clear plastic pouch. The **courier** typically supplies the clear, plastic, adhesive-backed pouches that adhere to the package.

   Placing one restricted entry label as shown in Attachment 5 (covered with clear packing tape) and one stapled to the actual permit is suggested.

   The USDA does not control water samples, so the requirements for soil listed above do not apply.

3. **Chain-of-Custody Seals:** The **laboratory** should supply the seals. **CTO personnel** must sign and date these. At least two seals should be placed in such a manner that they stick to both the cooler lid and body. Placing the seals over the tape (as shown in Attachment 5), then covering it with clear packing tape is suggested. This prevents the seal from coming loose and enables detection of tampering.

4. **Address Label:** Affix a label stating the destination (laboratory address) to each cooler.

5. **Special Requirements for Hazardous Materials:** See Section 5.2.1.

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Upon receipt of sample coolers at the laboratory, the **sample custodian** shall inspect the sample containers as discussed in Procedure 3-03, *Recordkeeping, Sample Labeling, and Chain-of-Custody*. The samples shall then be immediately extracted and/or analyzed, or stored in a refrigerated storage area until they are removed for extraction and/or analysis. Whenever the samples are not being extracted or analyzed, they shall be returned to refrigerated storage.

6.0 Quality Control and Assurance

6.1 Sample handling, storage, and shipping must incorporate quality control measures to ensure conformance to these and the project requirements.

7.0 Records, Data Analysis, Calculations

7.1 Maintain records as required by implementing these procedures.

7.2 Deviations from this procedure or the project-specific sampling and analysis plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

8.0 Attachments or Reference

8.1 Attachment 1 – Example Hazardous Material Package Marking

8.2 Attachment 2 – Packing Groups

8.3 Attachment 3 – Label for Dangerous Goods in Excepted Quantities

8.4 Attachment 4 – SW-846 Preservative Exception

8.5 Attachment 5 – Non-Hazardous Material Cooler Marking Figure for Shipment from Outside the Continental United States

8.6 Attachment 6 – Commercial Invoice – Soil

8.7 Attachment 7 – Commercial Invoice – Water

8.8 Attachment 8 – Soil Import Permit

8.9 Attachment 9 – Soil Samples Restricted Entry Labels

8.10 NAVSEA T0300-AZ-PRO-010. *Navy Environmental Compliance Sampling and Field Testing Procedures Manual*. August 2009.

8.11 Procedure 3-03, *Recordkeeping, Sample Labeling, and Chain-of-Custody*.

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue

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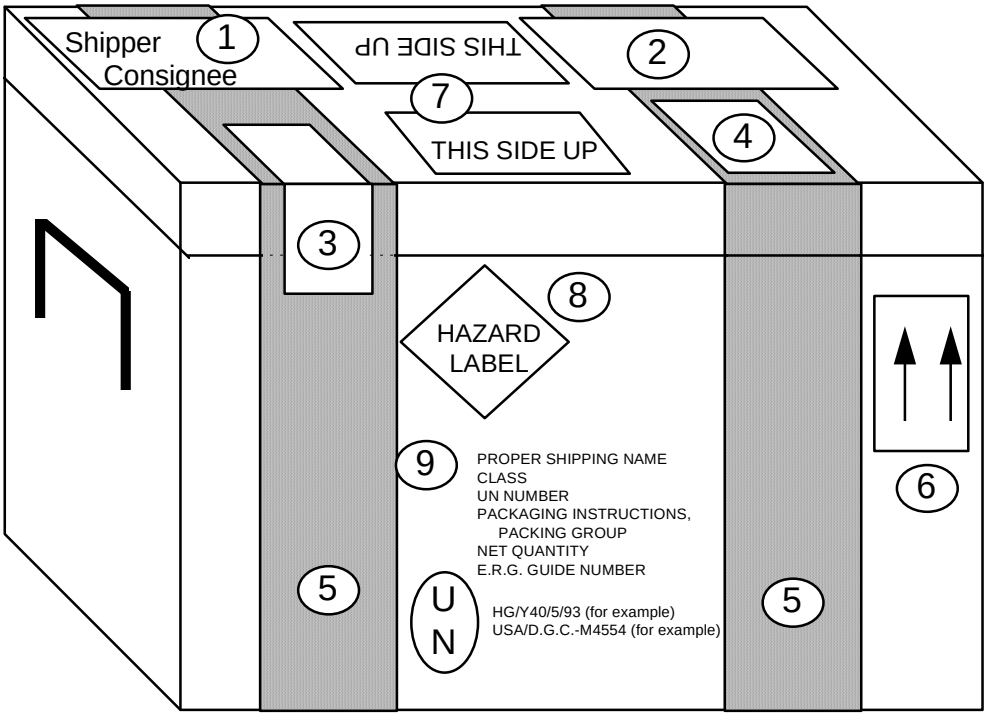
Attachment 1
Example Hazardous Material Package Marking



1. **AIR BILL/COMMERCIAL INVOICE**
2. **USDA PERMIT (Letter to Laboratory from USDA)**
3. **CUSTODY SEAL**
4. **USDA 2" X 2" SOIL IMPORT PERMIT**
5. **WATERPROOF STRAPPING TAPE**
6. **DIRECTION ARROWS STICKER - TWO REQUIRED**
7. **THIS SIDE UP STICKERS**
8. **HAZARD LABEL**
9. **HAZARDOUS MATERIAL INFORMATION**
10. **PACKAGE SPECIFICATIONS**

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Attachment 2
Packing Groups

PACKING GROUP OF THE SUBSTANCE	PACKING GROUP 1		PACKING GROUP II		PACKING GROUP III	
CLASS or DIVISION of PRIMARY or SUBSIDIARY RISK	Packagings		Packagings		Packagings	
	Inner	Outer	Inner	Outer	Inner	Outer
1: Explosives	---------- Forbidden (Note A) ----------					
2.1: Flammable Gas	---------- Forbidden (Note B) ----------					
2.2: Non-Flammable, non-toxic gas	---------- See Notes A and B ----------					
2.3: Toxic gas	---------- Forbidden (Note A) ----------					
3. Flammable liquid	30 mL	300 mL	30 mL	500 mL	30 mL	1 L
4.1 Self-reactive substances	Forbidden		Forbidden		Forbidden	
4.1: Other flammable solids	Forbidden		30 g	500 g	30 g	1 kg
4.2: Pyrophoric substances	Forbidden		Not Applicable		Not Applicable	
4.2 Spontaneously combustible substances	Not Applicable		30 g	500 g	30 g	1 kg
4.3: Water reactive substances	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.1: Oxidizers	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.2: Organic peroxides (Note C)	See Note A		30 g or 30 mL	500 g or 250 mL	Not Applicable	
6.1: Poisons - Inhalation toxicity	Forbidden		1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - oral toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - dermal toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.2: Infectious substances	---------- Forbidden (Note A) ----------					
7: Radioactive material (Note D)	---------- Forbidden (Note A) ----------					
8: Corrosive materials	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
9: Magnetized materials	---------- Forbidden (Note A) ----------					
9: Other miscellaneous materials (Note E)	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L

Note A: *Packing groups are not used for this class or division.*
Note B: *For inner packagings, the quantity contained in receptacle with a water capacity of 30 mL. For outer packagings, the sum of the water capacities of all the inner packagings contained must not exceed 1 L.*
Note C: *Applies only to Organic Peroxides when contained in a chemical kit, first aid kit or polyester resin kit.*
Note D: *See 6.1.4.1, 6.1.4.2, and 6.2.1.1 through 6.2.1.7, radioactive material in excepted packages.*
Note E: *For substances in Class 9 for which no packing group is indicated in the List of Dangerous Goods, Packing Group II quantities must be used.*

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Attachment 3
Dangerous Goods in Excepted Quantities

DANGEROUS GOODS IN EXCEPTED QUANTITIES

This package contains dangerous goods in excepted small quantities and is in all respects in compliance with the applicable international and national government regulations and the IATA Dangerous Goods Regulations.

_____
Signature of Shipper

_____ _____
Title Date

_____

_____
Name and address of Shipper

This package contains substance(s) in Class(es)
(check applicable box(es))

Class:	2	3	4	5	6	8	9
	☐	☐	☐	☐	☐	☐	☐

and the applicable UN Numbers are:

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Attachment 4
SW-846 Preservative Exception

Measurement	Vol. Req. (mL)	Container[2]	Preservative[3,4]	Holding Time[5]
MBAS	250	P, G	Cool, 4ºC	48 Hours
NTA	50	P, G	Cool, 4ºC	24 Hours

1. More specific instructions for preservation and sampling are found with each procedure as detailed in this manual. A general discussion on sampling water and industrial wastewater may be found in ASTM, Part 31, p. 72-82 (1976) Method D-3370.

2. Plastic (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

3. Sample preservation should be performed immediately upon sample collection. For composite samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4ºC until compositing and sample splitting is completed.

4. When any sample is 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 Part 172). The person offering such material for transportation is responsible for ensuring such compliance. for the preservation requirements of Table 1, 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 concentration of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_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); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

5. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of sample under study are stable for the longer time, and has received a variance from the Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show this is necessary to maintain sample stability.

6. Should only be used in the presence of residual chlorine.

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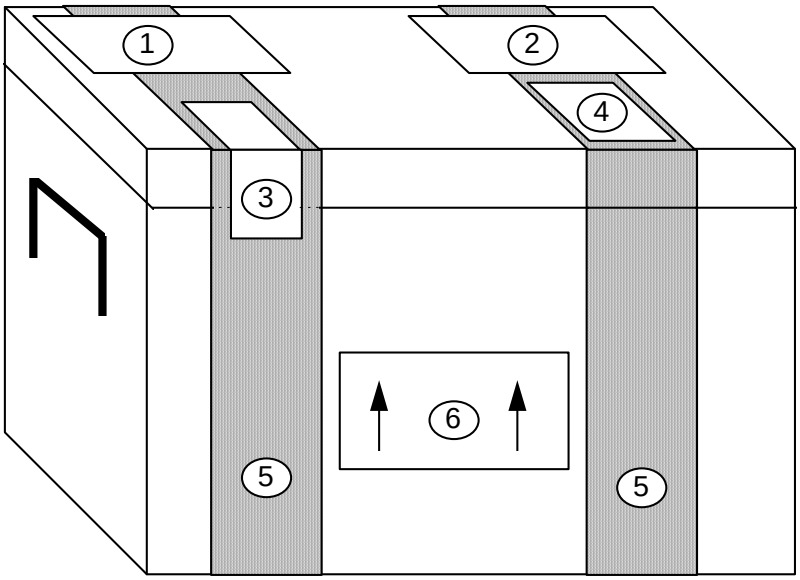
Attachment 5
Non-Hazardous Material Cooler Marking Figure for Shipment from Outside the Continental United States



1. **AIR BILL/COMMERCIAL INVOICE**
2. **USDA PERMIT (Letter to Laboratory from USDA)**
3. **CUSTODY SEAL**
4. **USDA 2" X 2" SOIL IMPORT PERMIT**
5. **WATERPROOF STRAPPING TAPE**
6. **DIRECTION ARROWS STICKER - TWO REQUIRED**

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Attachment 6
Commercial Invoice – Soil

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <COC #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Receipt <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	
INTERNATIONAL AIR WAYBILL NO.	(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Soil samples for laboratory analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00
								Check one ☐ F.O.B. ☐ C&F ☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Joe Smith, Ogden	Joe Smith	1/1/94
Name/Title	Signature	Date

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Attachment 7
Commercial Invoice – Water

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CJO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Receipt <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL AIR WAYBILL NO. [ ] (NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Water samples for laboratory analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00
								Check one ☐ F.O.B. ☐ C&F ☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Joe Smith, Ogden _____ Joe Smith _____ 1/1/94 _____

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Attachment 8
Soil Import Permit

UNITED STATES DEPARTMENT OF AGRICULTURE

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

Soil Permit

Permit Number: S-52299

Issued To: Columbia Analytical Services
(Lee Wolf)
1317 S. 13th Avenue
Kelso, Washington 98626

TELEPHONE: (360) 577-7222

Under the authority of the Federal Plant Pest Act of May 23, 1957, permission is hereby granted to the facility/individual named above subject to the following conditions:

1. Valid for shipments of soil not heat treated at the port of entry, only if a compliance agreement (PPQ Form 519) has been completed and signed. Compliance Agreements and Soil permits are non-transferable. If you hold a Soil Permit and you leave your present employer or company, you must notify your local USDA office promptly.
2. To be shipped in sturdy, leakproof, containers.
3. To be released without treatment at the port of entry.
4. To be used only for analysis and only in the facility of the permittee at Columbia Analytical Services, located in Kelso, Washington.
5. No use of soil for growing purposes is authorized, including the isolation or culture of organisms imported in soil.
6. All unconsumed soil, containers, and effluent is to be autoclaved, incinerated, or heat treated by the permittee at the conclusion of the project as approved and prescribed by Plant Protection and Quarantine.
7. This permit authorizes shipments from all foreign sources, including Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands through any U.S. port of entry.

JUNE 30, 2006
Expiration Date

Approving Official DEBORAH M. KNOTT

WARNING: Any alteration, forgery, or unauthorized use of this Federal form is subject to civil penalties of up to $250,000 (7 U.S.C. s 7734(b)) or punishable by a fine of not more than $10,000, or imprisonment of not more than 5 years, or both (18 U.S.C. s 1001).

PPQ FORM 525B (8/94)

Pt. 1 - PERMITTEE

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Attachment 9
Soil Samples Restricted Entry Labels

U.S. DEPARTMENT OF AGRICULTURE

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

PLANT PROTECTION AND QUARANTINE

HYATTSVILLE, MARYLAND 20782

SOIL SAMPLES

RESTRICTED ENTRY

The material contained in this package is imported under authority of the Federal Plant Pest Act of May 23, 1957.

For release without treatment if addressee is currently listed as approved by Plant Protection and Quarantine.

PPQ FORM 550 *Edition of 12/77 may be used*

(JAN 83)

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Investigation Derived Waste Management

Procedure 3-05

1.0 Purpose and Scope

This standard operating procedure (SOP) describes activities and responsibilities of the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command, Atlantic (NAVFAC Atlantic) with regard to management of investigation-derived waste (IDW). The purpose of this procedure is to provide guidance for the minimization, handling, labelling, temporary storage, inventory, classification, and disposal of IDW generated under the ER Program. This procedure will also apply to personal protective equipment (PPE), sampling equipment, decontamination fluids, non-IDW trash, non-indigenous IDW, and hazardous waste generated during implementation of removal or remedial actions. The information presented will be used to prepare and implement work plans (WPs) for IDW-related field activities. The results from implementation of WPs will then be used to develop and implement final IDW disposal plans.

If there are procedures whether it be from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to IDW then those procedures may be added as an appendix to the project specific SAP.

This procedure applies to all Navy ER projects performed in the NAVFAC Atlantic Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by both the Contract Task Order (CTO) Manager and the Quality Assurance (QA) Manager or Technical Director, and documented.

This procedure was developed to serve as management-approved professional guidance for the management of IDW generated under the ER Program. It focuses on the requirements for minimizing, segregating, handling, labeling, storing, and inventorying IDW in the field. Certain drum inventory requirements related to the screening, sampling, classification, and disposal of IDW are also noted in this procedure.

2.0 Safety

The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Health and Safety Plan (HASP). In the absence of a HASP, work will be conducted according to the CTO WP and/or direction from the **Site Safety Officer (SSO)**.

All **Field Personnel** responsible for IDW management must adhere to the HASP and must wear the PPE specified in the site-specific HASP. Generally, this includes, at a minimum, steel-toed boots or steel-toed rubber boots, safety glasses, American National Standards Institute-standard hard hats, and hearing protection (if heavy equipment is in operation). If safe alternatives are not achievable, discontinue site activities immediately.

3.0 Terms and Definitions

None.

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4.0 Training and Qualifications

4.1 The **CTO Manager** is responsible for ensuring that IDW management activities comply with this procedure. The **CTO Manager** is responsible for ensuring that all personnel involved in IDW management shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all IDW is managed according to this procedure.

4.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.0 Equipment and Supplies

The equipment and supplies required for implementation of this SOP include the following:

- Containers for waste (e.g., [U.S. Department of Transportation] DOT approved 55-gallon open and closed top drums) and material to cover waste to protect from weather (e.g., plastic covering);
- Hazardous /non-hazardous waste drum labels (weatherproof);
- Permanent marking pens;
- Inventory forms for project file;
- Plastic garbage bags, zip lock storage bags, roll of plastic sheeting; and
- Steel-toed boots, chemical resistant gloves, coveralls, safety glasses, and any other PPE required in the HASP.

6.0 Procedure

The following procedures are used to handle the IDW.

6.1 Drum Handling

6.1.1 IDW shall be containerized using DOT approved drums. The drums shall be made of steel or plastic, have a 55-gallon capacity, be completely painted or opaque, and have removable lids (i.e., United Nations Code 1A2 or 1H2). Typically 55-gallon drums are used, however small drums may be used depending on the amount of waste generated. New steel drums are preferred over recycled drums.

6.1.2 Recycled drums should not be used for hazardous waste, PCBs or other regulated shipments. For short-term storage of liquid IDW prior to discharge, double-walled bulk steel or plastic storage tanks may be used. For this scenario, consider the scheduling and cost-effectiveness of this type of bulk storage, treatment, and discharge system versus longer-term drum storage.

6.1.3 For long-term IDW storage at other project locations, the DOT approved drums with removable lids are recommended. Verify the integrity of the foam or rubber sealing ring located on the underside of some drum lids prior to sealing drums containing IDW liquids.

6.1.4 If the ring is only partially attached to the drum lid, or if a portion of the ring is missing, select another drum lid with a sealing ring that is in sound condition.

6.1.5 To prepare IDW drums for labeling, wipe clean the outer wall surfaces and drum lids of all material that might prevent legible and permanent labeling. If potentially contaminated material adheres to the outer surface of a drum, wipe that material from the drum, and segregate the paper towel or rag used to remove the material with visibly soiled PPE and

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disposable sampling equipment. Label all IDW drums and place them on pallets prior to storage.

6.2 Labelling

6.2.1 Containers used to store IDW must be properly labelled. Two general conditions exist: 1) from previous studies or on-site data, waste characteristics are known to be either hazardous or nonhazardous; or 2) waste characteristics are unknown until additional data are obtained.

6.2.2 For situations where the waste characteristics are known, the waste containers should be packaged and labelled in accordance with state regulations and any federal regulations that may govern the labelling of waste.

6.2.3 The following information shall be placed on all non-hazardous waste labels:

- Description of waste (i.e., purge water, soil cuttings);
- Contact information (i.e., contact name and telephone number);
- Date when the waste was first accumulated.

6.2.4 The following information shall be placed on all hazardous waste labels:

- Description of waste (i.e., purge water, soil cuttings);
- Generator information (i.e., name, address, contact telephone number);
- EPA identification number (supplied by on-site client representative);
- Date when the waste was first accumulated.

6.2.5 When the final characterization of a waste is unknown, a notification label should be placed on the drum with the words “waste characterization pending analysis” and the following information included on the label:

- Description of waste (i.e., purge water, soil cuttings);
- Contact information (i.e., contact name and telephone number);
- Date when the waste was first accumulated.

6.2.6 Once the waste has been characterized, the label should be changed as appropriate for a nonhazardous or hazardous waste.

6.2.7 Waste labels should be constructed of a weatherproof material and filled out with a permanent marker to prevent being washed off or becoming faded by sunlight. It is recommended that waste labels be placed on the side of the container, since the top is more subject to weathering. However, when multiple containers are accumulated together, it also may be helpful to include labels on the top of the containers to facilitate organization and disposal.

6.2.8 Each container of waste generated shall be recorded in the field notebook used by the person responsible for labelling the waste. After the waste is disposed of, either by transportation off-site or disposal on-site in an approved disposal area, an appropriate record shall be made in the same field notebook to document proper disposition of IDW.

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6.3 Types of Site Investigation Waste

Several types of waste are generated during site investigations that may require special handling. These include solid, liquid, and used PPE, as discussed further below.

Solid Waste

Soil cuttings from boreholes will typically be placed in containers unless site specific requirements allow for soil cuttings to be placed back into the borehole after drilling is complete. Drilling mud generated during investigation activities shall be collected in containers. Covers should be included on the containers and must be secured at all times and only open during filling activities. The containers shall be labelled in accordance with this SOP. An inventory containing the source, volume, and description of material put in the containers shall be logged on prescribed forms and kept in the project file.

Non-hazardous solid waste can be disposed on-site in the designated site landfill or in a designated evaporation pond if it is liquefied. Hazardous wastes must be disposed off-site at an approved hazardous waste landfill.

Liquid Waste

Groundwater generated during monitoring well development, purging, and sampling can be collected in truck-mounted containers and/or other transportable containers (i.e., 55-gallon drums). Lids or bungs on drums must be secured at all times and only open during filling or pumping activities. The containers shall be labelled in accordance with this SOP. Non-hazardous liquid waste can be disposed of in one of the designated lined evaporation ponds on-site. Hazardous wastes must be handled separately and disposed off-site at an approved hazardous waste facility.

Personal Protective Equipment

PPE that is generated throughout investigation activities shall be placed in plastic garbage bags. If the solid or liquid waste that was being handled is characterized as hazardous waste, then the corresponding PPE should also be disposed as hazardous waste. If not, all PPE should be disposed as non-hazardous waste in the designated on-site landfill. Trash that is generated as part of field activities may be disposed of in the landfill as long as the trash was not exposed to hazardous media.

6.4 Waste Accumulation On-Site

6.4.1 Solid, liquid, or PPE waste generated during investigation activities that are classified as nonhazardous or “characterization pending analysis” should be disposed of as soon as possible. Until disposal, such containers should be inventoried, stored as securely as possible, and inspected regularly, as a general good practice.

6.4.2 Solid, liquid, or PPE waste generated during investigation activities that are classified as hazardous shall not be accumulated on-site longer than 90 days. All hazardous waste containers shall be stored in a secured storage area. The following requirements for the hazardous waste storage area must be implemented:

- Proper hazardous waste signs shall be posted as required by any state or federal statutes that may govern the labelling of waste;
- Secondary containment to contain spills;
- Spill containment equipment must be available;
- Fire extinguisher;
- Adequate aisle space for unobstructed movement of personnel.

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6.4.3 Weekly storage area inspections shall be performed and documented to ensure compliance with these requirements. Throughout the project, an inventory shall be maintained to itemize the type and quantity of the waste generated.

6.5 **Waste Disposal**

6.5.1 Solid, liquid, and PPE waste will be characterized for disposal through the use of client knowledge, laboratory analytical data created from soil or groundwater samples gathered during the field activities, and/or composite samples from individual containers.

6.5.2 All waste generated during field activities will be stored, transported, and disposed of according to applicable state, federal, and local regulations. All wastes classified as hazardous will be disposed of at a licensed treatment storage and disposal facility or managed in other approved manners.

6.5.3 In general, waste disposal should be carefully coordinated with the facility receiving the waste. Facilities receiving waste have specific requirements that vary even for non-hazardous waste, so characterization should be conducted to support both applicable regulations and facility requirements.

6.6 **Regulatory Requirements**

The following federal and state regulations shall be used as resources for determining waste characteristics and requirements for waste storage, transportation, and disposal:

- Code of Federal Regulations (CFR), Title 40, Part 261;
- CFR, Title 49, Parts 172, 173, 178, and 179.

6.7 **Waste Transport**

A state-certified hazardous waste hauler shall transport all wastes classified as hazardous. Typically, the facility receiving any waste can coordinate a hauler to transport the waste. Shipped hazardous waste shall be disposed of in accordance with all RCRA/USEPA requirements. All waste manifests or bills of lading will be signed either by the client or the client's designee.

7.0 Quality Control and Assurance

7.1 Management of IDW must incorporate quality control measures to ensure conformance to these and the project requirements.

8.0 Records, Data Analysis, Calculations

8.1 Maintain records as required by implanting the procedures in this SOP.

8.2 Deviations from this procedure or the sampling and analysis plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

9.0 Attachments or References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual.* Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/-fedfac/pdf/ufp_qapp_v1_0305.pdf.

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(No Date). *Compliance with the Off-Site Rule During Removal Actions.* Office of Regional Counsel (Region 3). Hendershot, Michael.

NAVFAC NW Standard Operating Procedure Number I-D-1, *Drum Sampling.*

NAVFAC NW Standard Operating Procedure Number I-F, *Equipment Decontamination.*

NAVFAC NW Standard Operating Procedure Number III-D, *Logbooks.*

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)

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Equipment Decontamination

Procedure 3-06

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes methods of equipment decontamination, to be used for activities where samples for chemical analysis are collected or where equipment will need to be cleaned before leaving the site or before use in subsequent activities.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

It is the responsibility of the **Site Safety Officer (SSO)** to set up the site zones (i.e., exclusion, transition, and clean) and decontamination areas. Generally the decontamination area is located within the transition zone, upwind of intrusive activities, and serves as the washing area for both personnel and equipment to minimize the spread of contamination into the clean zone. Typically, for equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing cleaning solvents as described in this procedure or the Contract Task Order (CTO) Work Plan (WP) and distilled water are used for final rinsing of equipment. Depending on the nature of the hazards and the site location, decontamination of heavy equipment, such as augers, pump drop pipe, and vehicles, may be accomplished using a variety of techniques.

All **Field Personnel** responsible for equipment decontamination must adhere to the site-specific health and safety plan (HSP) and must wear the personal protective equipment (PPE) specified in the site-specific HSP. Generally this includes, at a minimum, Tyvek® coveralls, steel-toed boots with boot covers or steel-toed rubber boots, safety glasses, American National Standards Institute-standard hard hats, and hearing protection (if heavy equipment is in operation). Air monitoring by the **SSO** may result in an upgrade to the use of respirators and cartridges in the decontamination area; therefore, this equipment must be available on site. If safe alternatives are not achievable, discontinue site activities immediately.

In addition to the aforementioned precautions, the following sections describe safe work practices that will be employed.

2.1 Chemical Hazards associated with Equipment Decontamination

- Avoid skin contact with and/or incidental ingestion of decontamination solutions and water.
- Utilize PPE as specified in the site-specific HSP to maximize splash protection.
- Refer to material safety data sheets, safety personnel, and/or consult sampling personnel regarding appropriate safety measures (i.e., handling, PPE including skin and respiratory).
- Take the necessary precautions when handling detergents and reagents.

2.2 Physical Hazards associated with Equipment Decontamination

- To avoid possible back strain, it is recommended to raise the decontamination area 1 to 2 feet above ground level.
- To avoid heat stress, over exertion, and exhaustion, it is recommended to rotate equipment decontamination among all site personnel.

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- Take necessary precautions when handling field sampling equipment.

3.0 Terms and Definitions

None.

4.0 Training and Qualifications

4.1 The **CTO Manager** is responsible for ensuring that decontamination activities comply with this procedure. The **CTO Manager** is responsible for ensuring that all personnel involved in equipment decontamination shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all field equipment is decontaminated according to this procedure.

4.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.0 Procedure

Decontamination of equipment used in soil/sediment sampling, groundwater monitoring, well drilling and well development, as well as equipment used to sample groundwater, surface water, sediment, waste, wipe, asbestos, and unsaturated zone, is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program requires consideration of the following factors:

- Location where the decontamination procedures will be conducted
- Types of equipment requiring decontamination
- Frequency of equipment decontamination
- Cleaning technique and types of cleaning solutions appropriate to the contaminants of concern
- Method for containing the residual contaminants and wash water from the decontamination process
- Use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsections describe standards for decontamination, including the frequency of decontamination, cleaning solutions and techniques, containment of residual contaminants and cleaning solutions, and effectiveness.

5.1 Decontamination Area

Select an appropriate location for the decontamination area at a site based on the ability to control access to the area, the ability to control residual material removed from equipment, the need to store clean equipment, and the ability to restrict access to the area being investigated. Locate the decontamination area an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

5.2 Types of Equipment

Drilling equipment that must be decontaminated includes drill bits, auger sections, drill-string tools, drill rods, split barrel samplers, tremie pipes, clamps, hand tools, and steel cable. Decontamination of monitoring well development and groundwater sampling equipment includes submersible pumps, bailers, interface probes, water level meters, bladder pumps, airlift pumps, peristaltic pumps, and lysimeters. Other sampling equipment that requires decontamination includes, but is not limited to, hand trowels,

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hand augers, slide hammer samplers, shovels, stainless-steel spoons and bowls, soil sample liners and caps, wipe sampling templates, composite liquid waste samplers, and dippers. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and shall be properly disposed of after one use.

5.3 Frequency of Equipment Decontamination

Decontaminate down-hole drilling equipment and equipment used in monitoring well development and purging prior to initial use and between each borehole or well. Down-hole drilling equipment, however, may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, decontaminate the drilling tools prior to drilling deeper. Initiate groundwater sampling by sampling groundwater from the monitoring well where the least contamination is suspected. Decontaminate groundwater, surface water, and soil sampling devices prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

5.4 Cleaning Solutions and Techniques

Decontamination can be accomplished using a variety of techniques and fluids. The preferred method of decontaminating major equipment, such as drill bits, augers, drill string, and pump drop-pipe, is steam cleaning. To steam clean, use a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, thoroughly steam wash equipment and rinse it with potable tap water to remove particulates and contaminants.

A rinse decontamination procedure is acceptable for equipment such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following: (1) wash with a non-phosphate detergent (Alconox®, Liquinox®, or other suitable detergent) and potable water solution; (2) rinse with potable water; (3) spray with laboratory-grade isopropyl alcohol; (4) rinse with deionized or distilled water; and (5) spray with deionized or distilled water. If possible, disassemble equipment prior to cleaning. Add a second wash at the beginning of the process if equipment is very soiled.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. Decontaminate these pumps by washing and rinsing the outside surfaces using the procedure described for small equipment or by steam cleaning. Decontaminate the internal surfaces by recirculating fluids through the pump while it is operating. This recirculation may be done using a relatively long (typically 4 feet) large-diameter pipe (4-inch or greater) equipped with a bottom cap. Fill the pipe with the decontamination fluids, place the pump within the capped pipe, and operate the pump while recirculating the fluids back into the pipe. The decontamination sequence shall include: (1) detergent and potable water; (2) potable water rinse; (3) potable water rinse; and (4) deionized water rinse. Change the decontamination fluids after each decontamination cycle.

Solvents other than isopropyl alcohol may be used, depending upon the contaminants involved. For example, if polychlorinated biphenyls or chlorinated pesticides are contaminants of concern, hexane may be used as the decontamination solvent; however, if samples are also to be analyzed for volatile organics, hexane shall not be used. In addition, some decontamination solvents have health effects that must be considered. Decontamination water shall consist of distilled or deionized water. Steam-distilled water shall not be used in the decontamination process as this type of water usually contains elevated concentrations of metals. Decontamination solvents to be used during field activities will be specified in the CTO WP.

Rinse equipment used for measuring field parameters, such as pH (indicates the hydrogen ion concentration – acidity or basicity), temperature, specific conductivity, and turbidity with deionized or distilled water after each measurement. Also wash new, unused soil sample liners and caps with a fresh

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detergent solution and rinse them with potable water followed by distilled or deionized water to remove any dirt or cutting oils that might be on them prior to use.

5.5 Containment of Residual Contaminants and Cleaning Solutions

A decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water.

When contaminated material and cleaning fluids must be contained from heavy equipment, such as drill rigs and support vehicles, the area must be properly floored, preferably with a concrete pad that slopes toward a sump pit. If a concrete pad is impractical, planking can be used to construct solid flooring that is then covered by a nonporous surface and sloped toward a collection sump. If the decontamination area lacks a collection sump, use plastic sheeting and blocks or other objects to create a bermed area for collection of equipment decontamination water. Situate items, such as auger flights, which can be placed on metal stands or other similar equipment, on this equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Store clean equipment in a separate location to prevent recontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers as described below.

Use wash buckets or tubs to catch fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices. Collect the decontamination fluids and store them on site in secured containers, such as U.S. Department of Transportation-approved drums, until their disposition is determined by laboratory analytical results. Label containers in accordance with Procedure 3-05, *IDW Management*.

6.0 Quality Control and Assurance

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment blank samples or wipe testing. Equipment blanks consist of analyte-free water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a cloth over the surface of the equipment after cleaning. These quality control measures provide "after-the fact" information that may be useful in determining whether or not cleaning methods were effective in removing the contaminants of concern.

7.0 Records, Data Analysis, Calculations

Any project where sampling and analysis is performed shall be executed in accordance with an approved sampling and analysis plan. This procedure may be incorporated by reference or may be incorporated with modifications described in the plan.

Deviations from this procedure or the sampling and analysis plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

8.0 Attachments or References

8.1 ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites.* ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.

8.2 NAVSEA T0300-AZ-PRO-010. *Navy Environmental Compliance Sampling and Field Testing Procedures Manual*. August 2009.

8.3 Procedure 3-05, *IDW Management*.

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Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue

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Land Surveying

Procedure 3-07

1.0 Purpose and Scope

1.1 The purpose of this document is to define the standard operating procedure (SOP) for acquiring land surveying data to facilitate the location and mapping of geologic, hydrologic, geotechnical data, and analytical sampling points and to establish topographic control over project sites.

1.2 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review. If there are procedures whether it be from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to surface water sampling then those procedures may be added as an appendix to the project specific SAP.

1.4 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Program Quality Manager. Deviations to this SOP will be documented in the field records.

1.5 If there are procedures, whether it be from Resolution Consultants, state and/or federal, that are not addressed in this SOP and are applicable to land surveying then those procedures may be added as an appendix to the project specific Sampling and Analysis Plan (SAP).

2.0 Safety

2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to conducting fieldwork. All **field sampling personnel** must review the project-specific health and safety plan (HASP) paying particular attention to the control measures planned for the specific field tasks. Conduct preliminary area monitoring to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor and liquid phase through the use of respirators and disposable clothing.

2.2 In addition, observe standard health and safety practices according to the project-specific HASP. Suggested minimum protection includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves, rubberized steel-toed boots, and an American National Standards Institute-standard hard hat. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations, and shall always be available on site.

2.3 Daily safety briefs will be conducted at the start of each working day before any work commences. These daily briefs will be facilitated by the **Site Safety Officer (SSO)** or designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the HASP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.

2.4 The health and safety considerations for the work associated with land surveying include:

- Slip, trips and falls associated with work in the field;

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- Biological hazards associated with work in the field; and,
- Potential hazards associated with contaminants of concern (COC) that may be located in the survey area,

3.0 Terms and Definitions

3.1 Boundary Survey

Boundary surveys are conducted by Certified Land Surveyors in order to delineate a legal property line for a site or section of a site.

3.2 Global Positioning System (GPS)

A system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

4.0 Interferences

4.1 Commercially available GPS units typically have a level of precision of (±) 3 to 5 meters. Field corrections can be made as described in Section 8.3 below.

5.0 Training and Qualifications

5.1 Qualifications and Training

5.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **Contract Task Order (CTO) Manager** is responsible for ensuring that land surveying activities comply with this procedure. The CTO Manager is responsible for ensuring that all field sampling personnel involved in land surveying shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Field Manager (FM)** is responsible for ensuring that all field personnel follow these procedures. In virtually all cases, subcontractors will conduct these procedures. The FM or designee is responsible for overseeing the activities of the subcontractor and ensuring that sampling points and topographic features are properly surveyed.

6.0 Equipment and Supplies

6.1 The following equipment list contains materials that may be needed in carrying out the procedures outlined in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- Personal protective equipment (PPE) and other safety equipment, as required by the HASP;
- Commercially available GPS unit; and,
- Field Logbook.

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7.0 Calibration or Standardization

7.1 An authorized manufacturer's representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than six months prior to the start of the survey work.

7.2 Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet.

8.0 Procedure

8.1 Theodolite/Electronic Distance Measurement (EDM)

Follow the procedures listed below during theodolite/EDM land surveying conducted under the NAVFAC CLEAN Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- Reference surveys to the local established coordinate systems and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- Reference surveyed points to Mean Sea Level (Lower Low Water Level).
- Jointly determine appropriate horizontal and vertical control points prior to the start of survey activities. If discrepancies in the survey (e.g., anomalous water level elevations) are observed, the surveyor may be required to verify the survey by comparison to a known survey mark. If necessary, a verification survey may be conducted by a qualified third party.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified by the project Work Plan or SAP.
- Begin and end all surveys at the designated horizontal and vertical control points to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and paint.
- Clearly mark the point on a monitoring well casing or well riser that is surveyed by filing grooves into the casing/riser on either side of the surveyed point, or by marking the riser with a permanent ink marker.

8.2 Global Positioning System (GPS) to Conduct Land Survey

Follow the procedures listed below during land surveying using GPS:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- Reference surveys to the local established coordinate systems and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.

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- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified in the project Work Plan or SAP.
- Begin and end all surveys at the designated horizontal and vertical control points (as applicable) to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

8.3 Global Positioning System (GPS) to Position Sample Locations or Locate Site Features

Experienced field personnel may use a GPS system unit to position sample locations (e.g. grid positioned samples, soil boring locations) at a site. The decision to use field personnel or a licensed land surveyor will depend on the objectives of the survey (e.g. vertical elevation is not required) and the levels of precision required. Typically when a level of precision greater than (±) 3 to 5 meters is required, a licensed surveyor will be required. When a level of precision of (±) 3 to 5 meters is sufficient to meet project requirements (i.e. when laying sampling grids, identifying significant site features, or locating features identified in GIS figures) experienced field personnel may use commercially available, consumer-grade GPS units. Follow the procedures listed below to locate samples or site features using GPS:

- A commercially available GPS unit with Wide Angle Averaging System (WAAS), topographic map display, and waypoint storage capabilities should be used.
- If waypoints are to be imported into a GIS database, the same grid projection system should be used.
- If a permanent reference point near the site is available, it is recommended that a waypoint at this location be taken every day waypoints are stored.
- When laying out a sampling grid from a GIS map, upload the coordinates from GIS to the GPS unit, including coordinates for an easily identified, permanent, nearby feature (i.e. building corner, roadway intersection, or USGS benchmark).
- If during the initial site walk, the permanent feature identified does not overlay within (±) 5 meters as identified in the GPS unit, field corrections of the waypoints should be made.
- Field corrections can be made by adding/subtracting the difference in x,y coordinates between the field measurement of the permanent site feature and the anticipated x,y coordinates. This correction should then be applied to the x,y coordinates for each sampling location to be marked. Corrected x,y coordinates can then be uploaded into the GPS unit.
- Sampling points and site features can then be located in the field using the GPS units “Go To” function. When the distance to the sampling point or feature remains close to zero, the location can be marked.
- If no field corrections to the sampling location need to be made, or if sampling locations are to be surveyed by a licensed surveyor at a later date, no additional waypoints need to be taken. If significant changes to the sampling location are made, GPS coordinates at the corrected location shall be stored and labeled.

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- It is recommended that GPS coordinates be uploaded to a storage device such as PC at the end of each day.
- Field logs shall indicate manufacturer and model number for GPS unit used, map datum and projection used, and any field corrections made. If the GPS unit cannot lock onto a WAAS system at the site, this should also be noted.

9.0 Quality Control and Assurance

None.

10.0 Data and Records Management

The surveyor shall record field notes daily using generally accepted practices. The data shall be neat, legible, in indelible ink, and easily reproducible. Copies of the surveyor's field notes and calculation forms generated during the work shall be obtained and placed in the project files.

Surveyor's field notes shall, at a minimum, clearly indicate:

- The date of the survey;
- General weather conditions;
- The name of the surveying firm;
- The names and job titles of personnel performing the survey work;
- Equipment used, including serial numbers; and,
- Field book designations, including page numbers.

A land surveyor registered in the state or territory in which the work was done shall sign, seal, and certify the drawings and calculations submitted by the surveyor.

Dated records of land surveying equipment calibration shall be provided by the surveyor and placed in the project files. Equipment serial numbers shall be provided in the calibration records.

11.0 Attachments or References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Robert Shoemaker Senior Scientist	Naomi Ouellette, Project Manager	Rev 0 – Initial Issue

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Monitoring Well Installation

Procedure 3-12

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the methods to be used during the installation of groundwater monitoring wells. It describes the components of monitoring well design and installation and sets forth the rationale for use of various well installation techniques in specific situations.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Health and Safety Plan (HASP). In the absence of a HASP, work will be conducted according to the Contract Task Order (CTO) Work Plan (WP) and/or direction from the **Site Safety Officer (SSO)**.

2.2 Before well installation commences, appropriate entities (e.g. DigSafe, local public works departments, company facilities) must be contacted to assure the anticipated well locations are marked for utilities, including electrical, telecommunications, water, sewer, and gas.

2.3 Physical Hazards Associated with Well Installation

- Stay clear of all moving equipment and avoid wearing loose fitting clothing.
- When using an approved retractable-blade knife, always cut away from one self and make sure there are no other people in the cutting path or the retractable-blade knife.
- To avoid slip/trip/fall conditions during drilling activities, keep the area clear of excess soil cuttings and groundwater. Use textured boots/boot cover bottoms in muddy areas.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and personal protective equipment (PPE), drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- To avoid hazards associated with subsurface utilities, ensure all sampling locations have been properly surveyed as described in SOP 3-01, Utility Clearance.
- Be aware of restricted mobility caused by PPE.

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3.0 Terms and Definitions

3.1 **Annulus:** The annulus is the down-hole space between the borehole wall and the well casing and screen.

3.2 **Bridge:** A bridge is an obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by the placement of filter pack materials during well completion. Bridging can also occur in the formation during well development.

3.3 **Filter Pack:** Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

3.4 **Grout:** Grout is a fluid mixture of cement and water that can be forced through a tremie pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

3.5 **Heaving (Running) Sands:** Loose sands in a confined water-bearing zone or aquifer which tend to rise up into the drill stem when the confining unit is breached by the drill bit. Heaving sands occur when the water in the aquifer has a pressure head great enough to cause upward flow into the drill stem with enough velocity to overcome the weight of the sand.

3.6 **Sieve Analysis:** Sieve analysis is the evaluation of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

4.0 Interferences

4.1 Heaving sands may be problematic in unconsolidated sands encountered below the water table.

4.2 Rotary drilling methods requiring bentonite-based drilling fluids should be used with caution to drill boreholes that will be used for monitoring well installation. The bentonite mud builds up on the borehole walls as a filter cake and permeates the adjacent formation, potentially reducing the permeability of the material adjacent to the well screen.

4.3 If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids should be obtained and analyzed for chemical constituents that may be of interest at the site. In addition, an attempt should be made to recover the quantity of fluid or water that was introduced, either by flushing the borehole prior to well installation and/or by overpumping the well during development.

4.4 Track-mounted drill rigs are suitable for travelling on many types of landscapes that truck-mounted units cannot access, but may have limitations on extremely uneven or soft terrain.

4.5 Care should be taken to prevent cross-contamination between well locations. All drilling equipment coming in contact with potentially contaminated soil and/or groundwater will be decontaminated by the drilling subcontractor prior to initial drilling activities and between drilling locations in accordance with SOP 3-06, Equipment Decontamination.

5.0 Training and Qualifications

5.1 **Qualifications and Training**

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

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5.2 **Responsibilities**

5.2.1 **Contract Task Order (CTO) Managers** are responsible for issuing sampling and analysis plans (SAPs) that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and possibly state regulatory agencies enforce regulations that may include well construction and installation requirements. The **CTO Manager** shall be familiar with current local and state regulations, and ensure that these regulations are followed. The **CTO Manager** is responsible for ensuring that all personnel involved in monitoring well installation shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Field Manager** is responsible for direct supervision of the installation of monitoring wells and ensuring that procedures and specifications are implemented in the field in accordance with the approved SAP and well installation permits. The qualifications for the **Field Manager** must be in accordance with local jurisdictions with authority over the operations conducted.

5.2.4 All field personnel are responsible for the implementation of this procedure.

5.2.5 The on-site hydrogeologist/engineer is expected to obtain a description of the lithologic samples obtained during the excavation and construction of a monitoring well. These data are often required to provide guidance regarding the installation of specific components of the monitoring well. Guidance for lithologic sample collection and sample description is contained within SOP 3-16, Soil and Rock Classification.

6.0 Equipment and Supplies

6.1 Materials provided by the drilling contractor may include:

- Drill rig, drill rods, hollow stem augers, etc.
- Decontamination equipment (e.g., steam cleaner, high-pressure washer, brushes, etc.)
- Decontamination pad materials
- Well screen/riser pipe with flush-threaded couplings including riser and bottom caps
- Clean, filter sand
- Bentonite chips or pellets
- Cement grout and tremie pipe
- Portland cement for well pad completion
- Steel protective riser covers and locking caps
- Weighted calibrated tape
- Split-spoon samplers
- 55-gallon drums or containers for drill cuttings, decontamination fluids, etc.

6.2 In addition to those materials provided by the drilling contractor, equipment and materials required by the project geologist/engineer may include, but is not limited to, the following:

- Photoionization Detector (PID)
- Spill kit, including at a minimum sorbent pads and shovel (if not provided by subcontractor)

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- Plastic sheeting
- Teaspoon or spatula
- Resealable plastic bags
- Boring Log Records
- Decontamination materials (per SOP No. 3-06 - Equipment Decontamination)
- Weighted measuring tape for depth measurement
- Soil logging materials (e.g. USCS classification field card, millimeter rule, hand lens, etc.)
- Survey lathes or pin flags
- Digital camera
- PPE as required by the HASP
- Planning documents including the site-specific HASP and SAP
- Large indelible ink or paint pen
- Field logbook/field forms/site maps (water proof)

7.0 Procedure

7.1 General Procedures

- Specific drilling, sampling, and installation equipment and methodology will be dictated by the type of well to be installed (e.g., single case (Type II), double case (Type III), bedrock, etc.), geologic characteristics of the site, the type of contaminants being monitored, and local and state regulations.
- For access to locations when travelling over difficult terrain, an appropriate line should be chosen before mobilizing the drill rig or other support vehicles. If clearing of trees or ground cover is required, perform these activities in advance to avoid down time. Avoid wet or soft areas where possible or use ground mats and/or timbers to aid in supporting the rig as it travels. If drilling on soft material, place geomatting and ground mats under the rig tracks or stabilizers prior to drilling.
- A utility locate must be conducted to identify all underground utilities at the site prior to drilling (refer to SOP 3-01, Utility Clearance*)*. Proper clearance procedures for aboveground/overhead utilities must also be followed as specified in the HASP.
- Although new well materials (well screen and riser pipe) generally arrive at the site boxed and sealed within plastic bags, it is sometimes necessary to decontaminate the materials prior to their use. Well materials should be inspected by the project geologist/engineer upon delivery to check for cleanliness. If the well materials appear dirty, or if local or regional regulatory guidance requires decontamination, then well material decontamination should be performed by the drilling subcontractor in accordance with SOP 3-06, Equipment Decontamination.
- The diameter of the borehole must be a minimum of 2 inches greater than the outside diameter of the well screen or riser pipe used to construct the well. This is necessary so that sufficient annular space is available to install filter packs, bentonite seals, and grout seals, and allow the passage of tremie pipe where grouting at depth is required. Bedrock wells may require reaming after coring in order to provide a large enough borehole diameter for well installation.
- When soil sampling is required (refer to the SAP), soil samples will be collected for visual logging by advancing split-spoon samplers through the augers. The soil will be visually logged by a field geologist and include lithologic characteristics (i.e., soil type, color, density, moisture content, etc.) using the the

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methods described in SOP 3-16, Soil and Rock Classification. This information will be recorded on a boring/well log form, along with well construction details.

7.2 Drilling Techniques

Drilling of monitoring well boreholes may be accomplished by a variety of methods as described below. Preferred methods include those that temporarily case the borehole during drilling (i.e., hollow stem auger and sonic methods) using an override system. Other methods can be used where specific subsurface conditions or well design criteria dictate.

- Hollow stem auger (HSA) – Borings are advanced by rotating steel hollow stem augers with an attached cutting head. Soil cuttings are displaced by the cutting head and transported to the surface via continuous spiral flights attached to each auger stem. This method is widely used for unconsolidated soils that have a tendency to collapse within the boring. A bottom plug can be placed in the bottom auger to prevent soils from entering and clogging the auger, especially in the case of heaving sands. However, a bottom plug cannot be used when soil samples are to be collected through the augers. Soil plugs that accumulate in the bottom of the auger must be removed or knocked out prior to sampling or well installation.
- Solid stem auger – This type of drilling method is similar to HSA drilling using a solid stem or sealed hollow stem auger flights to advance the boring. Solid stem, continuous flight auger use is limited to semi-consolidated sediments or to cohesive or semi-cohesive unconsolidated sediments that don't have a tendency to collapse when disturbed.
- Sonic methods – Sonic drilling consists of advancing concentric hollow drill casings (inner and outer) using rotation in conjunction with axial vibration of the drill casing. Once the casings are advanced to the appropriate depth, the inner string is removed with a core of drill cuttings while the outer casing remains in place to keep the borehole open. Cuttings are removed from the inner casing relatively intact for logging or sampling purposes. This drilling method is used for a variety of soil types, from heaving sands to consolidated or indurated formations. Smearing of the formation along the borehole walls is minimal since moderate vibration and rotation techniques are used to advance the casings. Since the total borehole diameter in sonic drilling is only incrementally larger than the inner casing diameter, care should be taken during installation of the monitoring well to ensure the well is centered and adequate space is available for annular materials.
- Rotary methods (water or mud) – Rotary drilling methods consist of drill rods coupled to a drill bit that rotates and cuts through the soils to advance the borehole. Water or drilling fluid ("mud") is forced through the hollow drill rods and drill bit as the rods are rotated. The soil cuttings are forced up the borehole with the drilling fluids to the surface and the fluids recirculated. The drilling fluid provides a hydrostatic pressure that reduces or prevents the borehole from collapsing. Clean, potable water must be used for water-rotary drilling to prevent introducing trace contaminants. A sample of the potable water should be collected during the course of well installation for analysis of the same parameters defined for the groundwater samples. If mud-rotary is used to advance boreholes, potable water and bentonite drilling mud should only be used. No chemical additives shall be mixed in the drilling fluid to alter viscosity or lubricating properties. Adequate well development is essential for removal of drilling mud and fluids from the formation materials and ensure collection of representative groundwater samples.
- Rotary methods (Air) – Air rotary methods are similar to water rotary but use high air velocities in place of drilling fluids to rotate the drill bit and carry the soil cuttings up the borehole to the surface. Care must be taken to ensure that contaminants are not introduced into the air stream from compressor oils, etc. Most compressor systems are compatible with a coalescing filter system. Cuttings exiting the borehole under pressure must be controlled, especially when drilling in a zone of potential contamination. This can be accomplished by using an air diverter with hose or pipe to carry the cuttings to a waste container. Letting the cuttings blow uncontrolled from the borehole is not acceptable.

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7.3 Well Construction and Installation

- If rotary drilling techniques are used, the borehole should be flushed or blown free of material prior to well installation. If hollow stem augers are used, the soil or bottom plug should be removed and the augers raised approximately six inches above the bottom of the borehole, while slowly rotating the augers to remove cuttings from the bottom of the boring. The depth of the borehole should be confirmed with a weighted, calibrated tape.
- The riser pipe and screen should be connected with flush-threaded joints and assembled wearing clean, disposable gloves. No solvent or anti-seize compound should be used on the connections. The full length of the slotted portion of the well screen and unslotted riser pipe should be measured and these measurements recorded on a well construction form (Attachment 1).
- If placed in an open borehole, the assembled well should be carefully lowered and centered in the borehole so that the well is true, straight, and vertical throughout. Centering can also be accomplished with the use of centralizers, if necessary. However, centralizers should be placed so that they do not inhibit the installation of filter sand, bentonite seal, and annular grout. Wells less than 50 deep generally do not require centralizers.
- If hollow stem augers are used, the well should be lowered through the augers and each auger flight removed incrementally as the filter sand, bentonite seal, and grout are tremmied or poured into the annular space of the well. The well should be temporarily capped before filter sand and other annular materials are installed.
- Clean, silica sand should be placed around the well screen to at least 1 foot above the top of the screen. The filter sand should be appropriately graded and compatible with the selected screen size and surrounding formation materials. In general, the filter pack should not extend more than 3 feet above the top of the screen to limit the thickness of the monitoring zone. As the filter pack is placed, a weighted tape should be lowered in the annular space to verify the depth to the top of the layer. This measurement will be recorded on the well construction form (Attachment 1). If necessary, to eliminate possible bridging or creation of voids, placement of the sand pack may require the use of a tremie pipe. Tremie pipe sandpack installations are generally suggested for deeper wells and for wells which are screened some distance beneath the water table.
- A minimum 2-foot thick layer of bentonite pellets or slurry seal will be installed immediately above the filter sand to prevent vertical flow within the boring from affecting the screened interval. Bentonite chips/pellets must be hydrated if place above the water table prior to grouting. If bridging is of concern as in the case of deep wells, powdered bentonite may be mixed with water into a very thick slurry and a tremie pipe used to place the seal to the desired depth. Placement of the bentonite seal in the borehole will be recorded on the well construction form (Attachment 1).
- The remaining annular space around the well will be grouted from the top of the bentonite seal to the surface with a grout composed of neat cement, a bentonite cement mixture, or high solids sodium bentonite grout.
- Each well riser will be secured with an expandable, locking cap (vented if possible). Optionally, a hole can be drilled in the upper portion of the riser to allow venting of the well.
- The well will be completed within a concrete well pad consisting of a Portland cement/sand mixture. Well pads are generally 3 feet by 3 feet square but may be larger or smaller depending on site conditions and state-specific well construction standards. Round concrete well pads are also acceptable. A minimum of 1 inch of the finished pad should be below grade to prevent washing and undermining by soil erosion.
- If completed as a flush-mount well, the well riser will be cut off approximately 4 to 6 inches below ground surface and an expandable, locking cap placed on the well riser. The area around the riser is dug out and a steel well vault or manhole cover placed over the riser and set almost flush to the ground

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to protect the well. The manhole cover should be water-tight and secured with bolts to prevent casual access. The well pad will then be constructed around the well vault and slightly mounded at the center and sloping away to prevent surface water from accumulating in the well vault.

- If completed as a stick-up well, the well riser is cut approximately 2.5 to 3 feet above the ground surface and an expandable, locking cap placed on the well riser. A steel guard pipe with hinged, locking cap is placed over the well riser as a protective casing. The bottom of the guard pipe will be set approximately 2 feet below ground surface and sealed by pouring concrete from the top of the annular grout around the pipe to grade. The concrete well pad should be completed at the same time. Weep holes will be drilled in the base of the guard pipe to facilitate draining of rainwater or purge water from inside the guard pipe.
- Bumper posts or bollards may be necessary for additional well protection, especially in high traffic areas. The bumper posts should be placed around the well pad in a configuration that provides maximum protection to the well and extend a minimum of 3 feet above the ground.

7.4 Double Cased Wells

Under certain site conditions, the use of a double-cased or telescoping (Type III) well may be necessary. Installation of double-cased wells may be required to prevent the interconnection of two separate aquifers, seal off a perched aquifer without creating a vertical hydraulic conduit, prevent cross-contamination during construction of wells in deeper aquifers hydro-stratigraphically below impacted aquifers, or case off highly impacted soils present above the aquifer to prevent potential “dragging down” of contaminants.

Similar to conventional wells, construction of double-cased wells can be accomplished using a varety of drilling methods. Well construction is initiated by “keying” a large diameter, outer casing into a stratigraphic zone of low permeability (clay layer or bedrock). The size of the outer casing should be a minimum of 2 inches greater than the outside diameter of the inner casing to allow installation of annular seal materials during well completion. A pilot borehole should be drilled through the overburden soil and/or contaminated zone into a clay confining layer or bedrock. The borehole for the outer casing should be of sufficient size to contain the outer casing with a minimum of 2 inches around the outside diameter to allow sufficient annular space for tremie or pressure grouting. The boring should extend a minimum of 2 feet into a clay layer and a minimum of 1 foot into bedrock, if possible, to ensure an adequate seal. The boring should never breach a confining layer or keyed zone under any circumstances.

Once the boring is completed, the outer casing can be set in the borehole and sealed with grout. The outer casing can be set two ways, with or without a bottom cap. If no bottom cap is applied, the casing is usually driven approximately 6 inches into the clay confining unit. A grout plug is generally placed in the bottom of the casing and once set, standing water in the casing is evacuated prior to drilling below the casing. As an alternative, a cap can be placed on the bottom of the casing and if set below the water table, the casing can be filled with clean, potable water to hold down the casing in the boring. Grouting should be conducted using tremie-grouting or pressure-grouting methods by pumping grout into the annular space between the outer casing and the borehole wall from the bottom of the casing to the ground surface. Grout around the casing should be allowed to cure at least 24 hours before attempting to drill through the bottom.

Once the grout is cured, a smaller diameter drill pipe/bit is used to bore through the grout plug or bottom cap to the desired well depth. The well is then constructed as described in Section 7.3 above.

7.5 Post Installation Procedures

- Wells should be permanently labelled or marked for identification. Well tags can be used to record the site name, well number, total depth, installation date, etc. At a minimum, the well number will be written in indelible marker or paint on both the outside of the protective casing and inside beneath the casing lid, as well as on the riser pipe.

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- A measuring point will be marked on the top of the riser pipe for taking water level measurements. The measuring point can be notched using a knife or saw or can be marked with a waterproof marker or paint. The measuring point will also be the point which will be surveyed for vertical elevation data.
- Upon completion, the following measurements will be taken by the field geologist/engineer and recorded on the well construction diagram.
    - Depth to static water level
    - Depth of non-aqueous phase liquid (NAPL), if present
    - Total depth of well measured from top of casing (TOC)
    - Height of well casing above ground surface
    - Height of protective casing above ground surface
- All monitoring wells will be surveyed for horizontal and vertical control by a licensed surveyor.
- Investigation-derived waste (IDW) including drill cuttings, spent materials (e.g., PPE), and decontamination water should be properly managed in accordance with SOP 3-05, IDW Management.

8.0 Quality Control and Assurance

8.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the SAP. Certain quality control (QC) measures should be taken to ensure proper well installation and construction in accordance with this SOP, project specific SAP, and applicable well standards.

8.2 The borehole will be checked for total open depth, and extended by further drilling or shortened by backfilling, as required before installation of the well materials.

8.3 Water level and NAPL presence will be checked during well installation to ensure that the positions of well screen, filter sand, and seals relative to water level conform to project requirements

8.4 The depth to top of each layer of annular materials (i.e., filter sand, bentonite, grout) will be verified and adjusted as necessary for proper placement.

9.0 Records, Data Analysis, Calculations

All field information will be recorded in the field logbook and/or standardized field forms by field personnel. Field data recorded will include drilling contractor information, drilling methods, well material and construction information provided on the boring logs and well construction forms, observations or problems encountered during drilling, fluid level data, and any deviations from the procedures in this SOP and other project plans. Well Construction Forms (Attachment 1) will provide visual and descriptive information the monitoring well and are often the most critical form of documentation generated during the installation of a monitoring well. The field logbook is kept as a general log of activities and should not be used in place of the boring log.

10.0 Attachments or References

10.1 Attachment 1 – Monitoring Well Construction Form

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10.2 Environmental Protection Agency, United States (EPA). 1987. *A Compendium of Superfund Field Operations Methods*. Office of Solid Waste and Emergency Response. EPA/540/P-87/001.

10.3 EPA. 1990. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*. EPA/600/4-89/034. Office of Research and Development, Washington. March.

10.4 EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

10.5 EPA, 2008. SESD Operating Procedure SESDGUID-101-R0: *Design and Installation of Monitoring Wells*. USEPA, Science and Ecosystem Support Division (SESD), Athens, Georgia. Effective Date February 18, 2008.

10.6 U.S. Army Corps of Engineers. 2008. Manual No. EM 385-1-1. *Safety and Health Requirements*. 15 November 2008. http://140.194.76.129/publications/eng-manuals/em385-1-1/2008_English/toc.html.

10.7 SOP 3-01, *Utility Clearance*.

10.8 SOP 3-05, *IDW Management*

10.9 SOP 3-06, *Equipment Decontamination*.

10.10 SOP 3-16, *Soil and Rock Classification.*

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)

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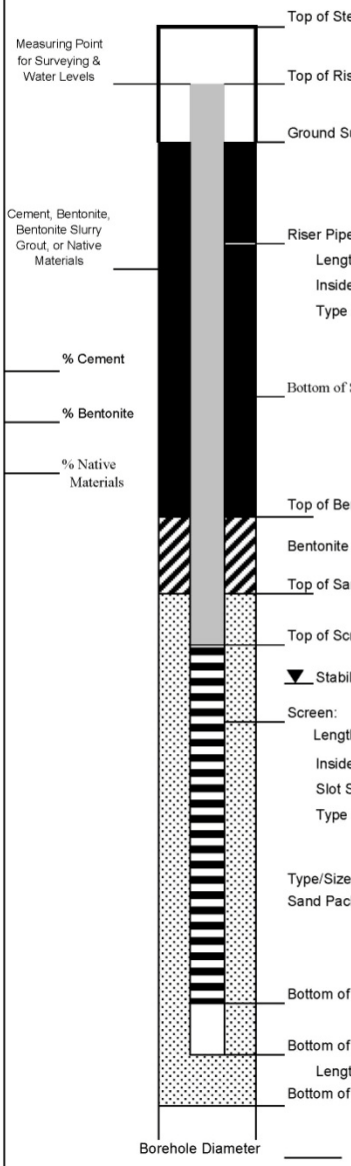
Attachment 1
Monitoring Well Construction Form

RESOLUTION CONSULTANTS	*Client:*	***WELL ID:***
	Project Number:	
	Site Location:	*Date installed:*
	Well Location: *Coords:*	*Inspector:*
	Method:	*Contractor:*

MONITORING WELL CONSTRUCTION DETAIL



	Depth from G.S. (feet)	Elevation(feet) Datum _____
Top of Steel Guard Pipe		
Measuring Point for Surveying & Water Levels — Top of Riser Pipe		
Ground Surface (G.S.)	0.0	
Cement, Bentonite, Bentonite Slurry Grout, or Native Materials — Riser Pipe:		
Length _____		
Inside Diameter (ID) _____		
Type of Material _____		
_____ % Cement		
Bottom of Steel Guard Pipe		
_____ % Bentonite		
_____ % Native Materials		
Top of Bentonite		
Bentonite Seal Thickness _____		
Top of Sand		
Top of Screen		
▼ Stabilized Water Level		
Screen:		
Length _____		
Inside Diameter (ID) _____		
Slot Size _____		
Type of Material _____		
Type/Size of sand _____		
Sand Pack Thickness _____		
Bottom of Screen		
Bottom of Tail Pipe:		
Length _____		
Bottom of Borehole		

Borehole Diameter _____ Approved:

Describe Measuring Point:

_____ Signature _____ Date

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Monitoring Well Development

Procedure 3-13

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the procedures used for developing newly installed monitoring wells and/or redeveloping existing wells.

1.2 The purpose of well development is to remove interferences from a well to provide better connection between the well and the formation, to improve pumping performance of the well, and to be able to collect more representative information from the well (e.g., samples, test results, etc.). Proper well development will:

- Remove drilling residuals (e.g., water, mud) from the borehole and surrounding formations;
- Improve or restore hydraulic conductivity of the surrounding formations which may have been disturbed during the drilling process;
- Remove residual fines from the well screen and sand pack (filter pack) materials, thus reducing turbidity of groundwater and permitting the collection of more representative groundwater samples.

1.3 There may be circumstances where well development is not desirable, for example, in the presence of non-aqueous phase liquids (NAPL) or other significant contamination if development could worsen the contaminant impact. If NAPL begins to intrude during development, the development process will be halted. This situation will be considered a cause for sample modification requiring approval by the CTO Manager and other stakeholders, as applicable.

1.4 The applicable well development procedures for a particular site may be subject to State or local regulatory requirements. In all cases, the project team should consult their local regulatory requirements and document the selected well development procedure in the project-specific Sampling and Analysis Plan (SAP). For project-specific information refer to the SAP, which takes precedence over these procedures.

1.5 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).

1.6 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Health and Safety Plan (HASP). In the absence of a HASP, work will be conducted according to the Contract Task Order (CTO) SAP and/or direction from the Site Safety Officer (SSO).

2.2 Monitoring well development may involve chemical hazards associated with potential contaminants in the soil or aquifer being characterized and may involve physical hazards associated with use of well development equipment.

3.0 Terms and Definitions

None.

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4.0 Interferences

4.1 Equipment/materials used for development may react with the groundwater during development. Appropriate development equipment has been selected for the anticipated condition of the groundwater.

4.2 Appropriate development methods such as using a surge-block to flush suspended fines in the groundwater in and out of the well screen can improve the yield of wells and improve their potential to be developed successfully. However, the effectiveness of development can be significantly reduced in wells that do not yield sufficient water to allow this flushing to take place.

4.3 For formations with a significant content of fine-grained materials (silts and clays), or wells with improperly sized screens, it may not be possible to reduce turbidity to commonly acceptable levels. Possible solutions may include collecting a sample even if excessively turbid, or installing a replacement well.

4.4 Development itself disturbs the surrounding formation and disrupts equilibrium conditions within the well. Groundwater samples will not be collected until a minimum of 24 hours after a well is developed to allow conditions to stabilize. For sites with fine-grained formations (silts and clays) and highly sorptive contamination, a longer time period between development and sampling should be considered.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **CTO Manager** is responsible for ensuring that well development activities comply with this procedure. The **CTO Manager** is responsible for ensuring that all personnel involved in well development shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Field Manager** is responsible for ensuring that all well development activities are conducted according to the either this procedure or the applicable procedure presented in the project-specific SAP.

5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure.

5.2.5 The field sampler and/or task manager is responsible for directly supervising the well development procedures to ensure that they are conducted according to this procedure and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

6.1 This equipment list was developed to aid in field organization and should be used in planning and preparation. Depending on the site-specific requirements and the development method selected, additional or alternative material and equipment may be necessary. In addition, for sites where groundwater is expected to be contaminated, the materials to be placed down the well and in contact with groundwater should be evaluated so that they are compatible with the chemical conditions expected in the well.

6.2 Equipment and materials used for well development may include, but is not limited to:

Well development equipment

- Surge block

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- Disposable Teflon bailers, appropriate to the diameter of the well(s): 1-inch to 1.5-inch for 2-inch inside diameter (ID) monitoring wells.
- Watterra® footvalve
- Electric submersible pump
- 12-volt power source for electric pump
- High density polyethylene (HDPE) tubing appropriately sized for Watterra® footvalve and/or electric submersible pump
- Drums or containers for storage of purge water
- Nephelometer to measure turbidity
- Multi-parameter water quality meter(s) to measure temperature, pH, conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP)
- Instrument calibration solutions
- Water level meter
- Oil/water interface probe

General equipment

- Project-specific plans including the site-specific HASP and SAP
- Field notebook/field forms/site maps
- Indelible markers/pens
- 5-gallon buckets

Equipment decontamination supplies (refer to SOP 3-06, Equipment Decontamination)

- Health and safety supplies, including personal protective equipment (PPE)
- Appropriate hand tools
- Keys or combinations to access monitoring wells
- Distilled/deionized water supply
- Disposable bailer string (polypropylene)
- Plastic trash bags

7.0 Procedure

Development generally consists of removing water and entrained sediment from the well until the water is clear (to the extent feasible) and the turbidity is reduced, which indicates the well is in good hydraulic connection with the surrounding formation. In addition to simply removing water, development can be improved when flushing through the well screen and gravel pack takes place in both directions, that is, both into the well and into the formation. This action breaks down sediment bridges that can occur in the formation or sand pack, which reduce the connection between the well and the formation

7.1 General Preparation

- All down-well equipment should be decontaminated prior to use and between well locations in accordance with SOP 3-06, Equipment Decontamination
- Although equipment is decontaminated between well locations, if wells are known or suspected to be contaminated based on observations during well installation, it is recommended that well development be conducted in order from the least contaminated to the most contaminated well to minimize the chances of cross-contamination.
- Management of investigation-derived waste (IDW), including development purge water and miscellaneous expendable materials generated during the development process, will be conducted in accordance with SOP 3-05, IDW Management.

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- Prior to accessing the well, the wellhead should be cleared of debris and/or standing water. Nothing from the ground surface should be allowed to enter the well.
- The depth to water and total well depth should be measured with a water level meter and recorded in the field logbook or on a Well Development Record (Attachment 1). This information will be used to calculate the volume of standing water (i.e., the well volume) within the well, and plan the specific details of the well development. If wells are suspected to contain NAPL, an oil/water interface probe should be used to measure liquid levels and depth to bottom of the well.
- Permanent monitoring wells will be developed no sooner than 24 hours after well installation is completed in order to allow well completion materials to set properly.

7.2 Monitoring Well Development Procedures

Generally, development will begin by gently surging the well with a surge block or bailer as described in Sections 7.2.1 and 7.2.2, respectively. Surging can become more vigorous as development progresses but initially the well must be gently surged to allow material blocking the screen to become suspended without damaging the well. Next, a bailer can be used to remove the sediment settled at the base of the well. A bailer, Watterra® pump, or electric submersible pump will then be used to purge the well, per Sections 7.2.2, 7.2.3, or 7.2.4, respectively. The well will be purged until the removed water becomes less turbid or per the requirements of the project-specific SAP, or State or local requirements. At this point the well will be surged again with a surge block or bailer. The well can be surged more vigorously at this point. After surging, the well will be purged again until the turbidity once again decreases. The surge/purge cycle should be completed at least three times during the development process. After the last surge, the well will be purged until the development completion criteria outlined in 7.3.2 or per the project-specific SAP are met.

7.2.1 Surge Block

The default method of well development is the use of a surge block in conjunction with pumping or bailing to remove sediment-laden water.

- The construction of the surge block must be appropriate for the diameter of the well. The surge block must be mounted on rods or other stiff materials to extend it to the appropriate depths and to allow for the surge block to be moved up and down in the well.
- Insert the surge block into the well and lower it slowly to the screened or open interval below the static water level. Start the surge action by slowly and gently moving the surge block up and down in the well. A slow initial surging, using plunger strokes of approximately 1 meter or 3 feet, will allow material which is blocking the screen to separate and become suspended.
- After 5 to 10 plunger strokes, remove water from the well using a separate bailer (Section 7.2.2) or pumping techniques (Sections 7.2.3 or 7.2.4). The returned water should be heavily laden with suspended fines. The water will be discharged to 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific SAP.
- In some cases, the bailer or Watterra® foot valve can act as a surge block, flushing water in and out of the well screen as groundwater is removed.
- Repeat the process of surging and pumping/bailing. As development continues, slowly increase the depth of surging to the bottom of the well screen. Surging within the riser portion of the well is neither necessary nor effective.

7.2.2 Bailer

- Tie a string or other cable securely to the bailer. Lower it to the screened or open interval of the monitoring well below the static water level.
- The bailer may be raised and lowered repeatedly within the screened interval to attempt to simulate the action of a surge block by pulling fines through the well screen, and pushing water out into the formation to break down bridging.

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- With the bailer full of water, remove it from the well and discharge the water into 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific SAP.
- The Watterra® system (Section 7.2.3) or electric submersible pump (Section 7.2.4) may be used as a complementary development method to the bailer, especially when removal of additional water at a faster rate is beneficial.
- Continue alternately surging and bailing, monitoring the purge water periodically (Section 7.3.1) until development completion criteria are met (Section 7.3.2).

7.2.3 Watterra® system

- Attach high-density polyethylene (HDPE) tubing to the decontaminated Watterra® pump foot valve
- Lower the foot valve and tubing assembly near the bottom of the well.
- Lift and lower the tubing to allow water to enter the Watterra® foot valve and travel up the tubing and discharge the water into 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific SAP.
- The lifting and lowering action of the Watterra® sysem will cause some surging action to aid in breaking up fine material in the surrounding formation.
- A bailer (Section 7.2.2) may be used as a complementary development method to the Watterra® system, especially during the initial stages of development when a high volume of sediment may be required to be removed.
- An electric submersible pump (Section 7.2.4) may also be used as a complementary development method to the Watterra® system, especially when more volume of water is desired to be pumped or the turbidity criteria cannot be met due to the surging action of the Watterra® system.
- Continue alternately surging and pumping, monitoring the purge water periodically (Section 7.3.1) until well development completion criteria are met (Section 7.3.2).

7.2.4 Electric Submersible Pump

- Attach HDPE tubing to the decontaminated electric submersible pump.
- Lower the pump and tubing assembly near the bottom of the well, at least a few inches above the well total depth.
- Begin pumping, discharging the water into 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific SAP.
- Continue alternately surging and pumping, monitoring the purge water discharge periodically (Section 7.3.1) until well development completion criteria are met (Section 7.3.2).

7.3 Discharge Monitoring

7.3.1 Monitoring the Progress of Development

The progress of the development is evaluated through visual observation of the suspended sediment load and measurement of the turbidity and other parameters in the purged diischarge water. As development progresses, the water should become clearer, measured turbidity should decrease, and specific capacity (pumping rate divided by drawdown) should stabilize. Water quality parameters, including DO, conductivity, ORP, pH, temperature, and turbidity may be measured and recorded periodically to determine the progress of development using the criteria outlined in Section 7.3.2 or per the project-specific SAP. Water quality parameters should be measured on each well volume removed.

7.3.2 Completion of Development

The well will be considered developed when the following criteria are met or per the criteria set forth in the project-specific SAP:

- A minimum of three times the standing water volume in a well (to include the well screen and casing plus saturated annulus, assuming 30 percent porosity) is removed.

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- Groundwater parameters for three consecutive standing water volumes are within the following:
    - pH – within ± 0.2 units
    - Specific conductivity – within ± 3%
    - ORP – within ± 10 mV
    - Temperature – within ±1 degree Celsius
    - Turbidity – at or below 10 nephelometric turbidity units (NTU) or within ± 10% if above 10 NTU.
- The sediment thickness remaining within the well is less than 1 percent of the screen length or less than 30 millimeters (0.1 ft) for screens equal to or less than 10 feet long.

Dissolved oxygen (DO) readings may be recorded but DO readings will not be used as development completion criteria because DO may not stabilize.

If the well has slow groundwater recharge and is purged dry, the well will be considered developed when bailed or pumped dry three times in succession and the turbidity has decreased, or per the requirements set forth in the project-specific SAP. Water quality parameters may be recorded if feasible using the flow-through cell.

If any water is added to the well's borehole during development or drilling, three times the volume of water added will also be removed during well development, or per the requirements set forth in the project-specific SAP.

7.4 Development of Wells with Low Yield

Water is the primary mechanism to remove fines and flush water through the gravel pack for effective development. Therefore, development can be a challenge in wells that do not yield sufficient water to recharge when water is removed. However, often these wells are the most in need of development to improve their performance as they are typically installed in low permeability formations with a high content of fines. Development of these wells can improve their yield.

The surging portion of the development can be successfully performed in a well with standing water regardless of its yield. It is the subsequent removal of fine materials that is hindered when insufficient water is recharged to the well. When wells go dry or drawdown significantly during development, development can be performed intermittently, allowing sufficient water to recharge prior conducting the next stage of surging. These intermittent procedures can take place hours or even days apart, depending on project-specific time constraints.

7.5 Wells containing NAPL

Additional care should be taken when planning development of wells that contain NAPL. If the NAPL is flammable, there are health and safety as well as handling issues to consider. If NAPL in excess of a persistent sheen is noted, the recharge rate will be evaluated through hand bailing. In most cases, it is generally preferable to remove NAPL by bailing to the extent practical prior to performing development. Groundwater parameters, excluding turbidity, will not be collected during well development if NAPL or excessive sheen is noticed in the purged water during development to ensure the meter probes are not fouled or destroyed. Well development will be halted.

Development by surging or pumping the well dry can result in the spreading of NAPL vertically in the soil column around the well. These methods can be used, if information exists describing the vertical thickness of the NAPL smear zone around the well, and if the methods do not result in mounding or drawdown that exceeds this thickness. Alternate methods such as bailing may also be used, but any method should not allow the well to be pumped dry or result in significant drawdown that would spread the NAPL vertically.

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7.6 Temporary Well Points

For certain projects, temporary well points (TWPs) may be installed to collect groundwater samples at a site. Since no sand pack, bentonite chips, or bentonite grout are generally used in the construction of the TWPs, development can proceed as soon as sufficient water has entered the well to static conditions. Due to the small diameter of these wells, generally ¾-inch to 1-inch ID, development will be performed using either a small diameter (0.5-inch) bailer and/or a peristaltic pump with dedicated tubing. The TWPs will have minimal water column and may purge dry during development. However, attempts will be made to remove fines from the well prior to sampling. Purging and sampling may occur as soon as approximately 80% of the static water has re-entered the TWP, or per the requirements set forth in the project-specific SAP.

8.0 Quality Control and Assurance

8.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific SAP.

8.2 Quality control (QC) requirements are dependent on project-specific sampling objectives. The project-specific SAP will provide requirements for equipment decontamination (frequency and materials) and IDW handling.

9.0 Records, Data Analysis, Calculations

9.1 All data and information (e.g., development method used) must be documented on field data sheets (Attachment 1) or within site logbooks with permanent ink. Data recorded may include the following:

- Well Location
- Weather conditions
- Date and Time
- Purge Method
- Reading/measurements obtained

10.0 Attachments or References

Attachment 1 – Well Development Record

SOP 3-05, *IDW Management*.

SOP 3-06, *Equipment Decontamination*.

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Shawn Dolan Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (June 2012)

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Attachment 1
Well Development Record

Well/Piezometer Development Record

Well ID:

Client: _____

Project No: _____ Date: _____ Developer: _____

Site Location: _____

Well/Piezometer Data

Well ☐ Piezometer ☐ Diameter _____ Material _____

Measuring Point Description _____

Depth to Top of Screen (ft.) _____

Depth to Bottom of Screen (ft.) _____

Total Well Depth (ft.) _____

Depth to Static Water Level (ft.) _____

Geology at Screen Interval (if known) _____

Time of Water Level Measurement _____

Calculate Purge Volume (gal.) _____

Disposal Method _____

Headspace _____

Original Well Development ☐ Redevelopment ☐ Date of Original Development _____

DEVELOPMENT METHOD _____

PURGE METHOD _____

Time	Total Volume Purged (gal.)	Flow Rate (gpm)	Turbidity (NTU)	Color	pH	Temp	Other

ACCEPTANCE CRITERIA (from workplan)

Minimum Purge Volume Required _____ gallons
Maximum Turbidity Allowed _____ NTUs
Stabilization of parameters _____%

	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Has parameters stabilized	☐	☐	☐

If no or N/A explain below:

_____

Signature _____ Date: _____

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Monitoring Well Sampling

Procedure 3-14

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the actions to be used during monitoring well sampling activities and establishes the method for sampling groundwater monitoring wells for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples that are representative of aquifer conditions with as little alteration to water chemistry as possible.

1.2 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. All field sampling personnel responsible for sampling activities must review the project-specific health and safety plan (HASP) paying particular attention to the control measures planned for the well sampling tasks. Conduct preliminary area monitoring of sampling wells to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor phase and liquid matrix through the use of of appropriate personal protective equipment (PPE).

2.2 Observe standard health and safety practices according to the project-specific HASP. Suggested minimum protection during well sampling activities includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves and rubberized steel-toed boots. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations. Refer to the project-specific HASP for the required PPE.

2.3 Physical Hazards associated with Well Sampling

- To avoid lifting injuries associated with pump and bailers retrieval, use the large muscles of the legs, not the back.
- Stay clear of all moving equipment, and avoid wearing loose fitting clothing.
- When using tools for cutting purposes, cut away from yourself. The use of appropriate, task specific cutting tools is recommended.
- To avoid slip/trip/fall conditions as a result of pump discharge, use textured boots/boot cover bottoms.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- Be aware of restricted mobility due to PPE.

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3.0 Terms and Definitions

None.

4.0 Interferences

4.1 Potential interferences could result from cross-contamination between samples or sample locations. Minimization of the cross-contamination will occur through the following:

- The use of clean sampling tools at each location as necessary.
- Avoidance of material that is not representative of the media to be sampled.

5.0 Training and Qualifications

5.1 **Qualifications and Training**

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 **Responsibilities**

5.2.1 The **Contract Task Order (CTO) Manager** is responsible for ensuring that monitoring well sampling activities comply with this procedure. The **CTO Manager** is responsible for ensuring that all field sampling personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Field Manager** is responsible for ensuring that all field sampling personnel follow these procedures.

5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure.

5.2.5 The field sampler and/or task manager is responsible for directly supervising the groundwater sampling procedures to ensure that they are conducted according to this procedure and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

6.1 Purging and Sampling Equipment

- Pump (Peristaltic, Portable Bladder, Submersible)
- Polyethylene or Teflon bladders (for portable bladder pumps)
- Bladder pump controller (for portable bladder pumps)
- Air compressor (for portable bladder pumps)
- Nitrogen cylinders (for portable bladder pumps)
- 12-volt power source
- Polyethylene inlet and discharge tubing (except for VOC analysis which requires Teflon tubing)
- Silicone tubing appropriate for peristaltic pump head
- Teflon bailer appropriately sized for well

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- Disposable bailer string (polypropylene)
- Individual or multi-parameter water quality meter(s) with flow-through cell to measure temperature, pH, specific conductance, dissolved oxygen (DO), oxidation reduction potential (ORP), and/or turbidity
- Turbidity meter
- Water level meter
- Oil/water interface probe

6.2 General Equipment

- Sample kit (i.e., bottles, labels, preservatives, custody records and tape, cooler, ice)
- Sample Chain-of-Custody (COC) forms
- Sample Collection Records
- Sample packaging and shipping supplies
- Waterproof marker or paint
- Distilled/deionized water supply
- Water dispenser bottles
- Flow measurement cup or bucket
- 5-gallon buckets
- Instrument calibration solutions
- Stopwatch or watch
- Disposable Nitrile gloves
- Paper towels
- Trash bags
- Zipper-lock bags
- Equipment decontamination supplies
- Health and safety supplies (as required by the HASP)
- Approved plans such as: project-specific HASP and Sampling and Analysis Plan (SAP)
- Well keys or combinations
- Monitoring well location map(s)
- Field project logbook/pen

7.0 Calibration or Standardization

7.1 Field instruments will be calibrated daily according to the requirements of the SAP and manufacturer's specifications for each piece of equipment. Equipment will be checked daily with the calibration solutions at the end of use of the equipment. Calibration records shall be recorded in the field logbook or appropriate field form.

7.2 If readings are suspected to be inaccurate, the equipment shall be checked with the calibration solutions and/or re-calibrated.

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8.0 Procedure

8.1 Preparation

8.1.1 Site Background Information

Establish a thorough understanding of the purposes of the sampling event prior to field activities. Conduct a review of all available data obtained from the site and pertinent to the water sampling. Review well history data including, but not limited to, well locations, sampling history, purging rates, turbidity problems, previously used purging methods, well installation methods, well completion records, well development methods, previous analytical results, presence of an immiscible phase, historical water levels, and general hydrogeologic conditions.

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that might be encountered during sampling, such as excessive turbidity and low well yield. They may also indicate where dedicated pumps are placed in the water column. To help minimize the potential for cross-contamination, well purging and sampling and water level measurement collection shall proceed from the least contaminated to the most contaminated well as indicated by previous analytical results. This order may be changed in the field if conditions warrant it, particularly if dedicated sampling equipment is used. A review of prior sampling procedures and results may also identify which purging and sampling techniques are appropriate for the parameters to be tested under a given set of field conditions.

8.1.2 Groundwater Analysis Selection

Establish the requisite field and laboratory analyses prior to water sampling. Decide on the types and numbers of quality assurance/quality control (QA/QC) samples to be collected (refer to the project-specific SAP), as well as the type and volume of sample preservatives, the type and number of sample containers, the number of coolers required, and the quantity of ice or other chilling materials. The field sampling personnel shall ensure that the appropriate number and size sample containers are brought to the site, including extras in case of breakage or unexpected field conditions. Refer to the project-specific SAP for the project analytical requirements.

8.2 Groundwater Sampling Procedures

Groundwater sampling procedures at a site shall include:

1) An evaluation of the well security and condition prior to sampling;
2) Decontamination of equipment;
3) Measurement of well depth to groundwater;
4) Assessment of the presence or absence of an immiscible phase;
5) Assessment of purge parameter stabilization;
6) Purging of static water within the well and well bore; and
7) Obtaining a groundwater sample.

Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events. In all cases, consult the State and local regulations for the site, which may require more stringent time separation between well development and sampling.

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8.2.1 Well Security and Condition

At each monitoring well location, observe the conditions of the well and surrounding area. The following information may be noted on a Groundwater Sample Collection Record (Attachment 1) or in the field logbook:

- Condition of the well's identification marker.
- Condition of the well lock and associated locking cap.
- Integrity of the well – well pad condition, protective outer casing, obstructions or kinks in the well casing, presence of water in the annular space, and the top of the interior casing.
- Condition of the general area surrounding the well.

8.2.2 Decontamination of Equipment

Where possible, dedicated supplies should be used at each well location to minimize the potential for cross-contamination and minimize the amount of investigation derived waste (IDW) fluids resulting from the decontamination process. If decontamination is necessary, establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with plastic sheeting and be located upwind of the well being sampled. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in SOP 3-06, Equipment Decontamination.

Decontaminate each piece of equipment prior to entering the well. Also, conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without on-site decontamination.

8.2.3 Measurement of Static Water Level Elevation

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. The best practice, if possible, is to measure all site wells (or wells within the monitoring well network) prior to sampling. If the well cap is not vented, remove the cap several minutes before measurement to allow water levels to equilibrate to atmospheric pressure.

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). If not already present, mark an easily identified reference point for water level measurements which will become the measuring point for all water level measurements. This location and elevation must be surveyed.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. An electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

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At each location, measure water levels several times in quick succession to ensure that the well has equilibrated to atmospheric conditions prior to recording the measurement. As stated above, measure all site wells (or wells within the monitoring well network) prior to sampling whenever possible. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Prior to sampling, measure the water level in each well immediately prior to purging the well to ascertain that static conditions have been achieved prior to sampling.

8.2.4 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL before the well is purged for conventional sampling. These procedures may not be required for all wells. Consult the project-specific SAP to determine if assessing the presence of LNAPL and/or DNAPL is necessary.

1) Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a PID or an organic vapor analyzer, and record the measurements.
2) Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements.
3) Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.
4) In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water table contour maps until they are corrected for depression by the product.
5) If the well contains an immiscible phase, it may be desirable to sample this phase separately. Section 8.2.6 presents immiscible phase sampling procedures. It may not be meaningful to conduct water sample analysis of water obtained from a well containing LNAPLs or DNAPLs. Consult the **CTO Manager** and **Program Quality Manager** if this situation is encountered.

8.2.5 Purging Equipment and Use

General Requirements

The water present in a well prior to sampling may not be representative of in situ groundwater quality and shall be removed prior to sampling. Handle all groundwater removed from potentially contaminated wells in accordance with the IDW handling procedures in SOP 3-05, IDW Management. Purging shall be accomplished by methods as indicated in the project-specific SAP or by those required by State requirements. For the purposes of this SOP, purging methods will be described by removing groundwater from the well using low-flow techniques.

According to the U.S. Environmental Protection Agency (EPA) (EPA, 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/minute. EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated

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corrosion or reaction products in the well. EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. In addition, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of increasing the turbidity of the sample due to mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The field sampler shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells should not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated based on the results of either the well development task or historical sampling events. In general, place the intake of the purge pump in the middle of the saturated screened interval within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified. If the well is purged dry, allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis during well purging and analyze them in the field preferably using in-line devices (i.e., flow through cell) for temperature, pH, specific conductivity, dissolved oxygen (DO), and oxidation-reduction (redox) potential. Turbidity should be measured separately (outside of the flow-through cell) with a nephelometer or similar device.

Readings should be taken every 2 to 5 minutes during the purging process. These parameters are measured to demonstrate that the natural character of the formation waters has been restored.

Purging shall be considered complete per the requirements set forth in the project-specific SAP, State requirements, or when three consecutive field parameter measurements of temperature, pH, specific conductivity, DO and ORP stabilize within approximately 10 percent and the turbidity is at or below 10 nephelometric turbidity units (NTU) or within ± 10% if above 10 NTU. This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process into a groundwater sampling log. Attachment 1 shows an example of a groundwater sampling log and the information typically included in the form. Whatever form is used, all blanks need to be completed on the field log during field sampling.

Groundwater removed during purging shall be stored according to the project-specific SAP or per SOP 3-05, IDW Management.

Purging Equipment and Methods

Submersible Pump

A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling the groundwater for semivolatile and non-volatile constituents, but are generally not preferred for VOCs unless there are no other options (e.g., well over 200 feet deep). For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to overpumpage of the wells (<1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to limit the amount of

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water that will flow back down the drop pipe into the well. Place the pump in the middle of the saturated screened interval within the well and maintain it in that position during purging.

Bladder Pump

A stainless steel bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Use of the bladder pump is most effective in low to moderate yield wells and are often the preferred method for low-flow sampling. When sampling for VOCs and/or SVOCs, Teflon bladders should be used. Polyethylene bladders may be used when sampling for inorganics.

Either compressed dry nitrogen or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use.

Centrifugal, Peristaltic, or Diaphragm Pump

A centrifugal, peristaltic, or diaphragm pump may be utilized to purge a well if the water level is within 20 feet of ground surface. New or dedicated tubing is inserted into the midpoint of the saturated screened interval of the well. Water should be purged at a rate that satisfies low-flow requirements (i.e., does not cause drawdown). Centrifugal, peristaltic, or diaphragm pump are generally discouraged for VOCs sampling; however, follow methods allowed per the project-specific SAP or State requirements.

Air Lift Pump

Airlift pumps are not appropriate for purging or sampling.

Bailer

Avoid using a bailer to purge a well because it can result in overdevelopment of the well and create excessive purge rates. If a bailer must be used, the bailer should either be dedicated or disposable. Teflon-coated cable mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well.

8.2.6 Monitoring Well Sampling Methodologies

Sampling Light, Non-Aqueous Phase Liquids (LNAPL)

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water interface depth as determined by measurement with the interface probe. Allow the bailer to fill with LNAPL and retrieve it.

When sampling LNAPLs, never drop bailers into a well and always remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. Teflon bailers should always be used when sampling LNAPL. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

Sampling Dense, Non-Aqueous Phase Liquids (DNAPL)

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

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Groundwater Sampling Methodology

The well shall be sampled when groundwater within it is representative of aquifer conditions per the methods described in Section 8.2.5. Prior to sampling the flow-through cell shall be removed and the samples collected directly from the purge tubing. Flow rates shall not be adjusted once aquifer conditions are met. Additionally, a period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling in order to monitor drawdown when using low-flow techniques and gauge well volumes removed and recharged when using non-low-flow techniques.

Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers, minimizing exposure to sunlight, and immediately placing the sample on ice once collected.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride (PVC) bailers, Tygon® tubing, silicon rubber bladders, neoprene impellers, polyethylene, and Viton® are not acceptable when sampling for organics. If bailers are used, an inert cable/chain (e.g., fluorocarbon resin-coated wire or stainless steel wire or cable) shall be used to raise and lower the bailer. Dedicated equipment is highly recommended for all sampling programs.

Submersible Pumps

The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and Teflon, sample discharge lines composed of Teflon) and must have a controller mechanism allowing the required low-flow rate. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low-flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low-flow rate.

Bladder Pumps

A gas-operated stainless steel bladder pump with adjustable flow control and equipped with a Teflon bladder and Teflon-lined tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. If only inorganics are being sampled, polyvinyl bladders and tubing may be used. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge.

When using a compressor, take several precautions. If the compressor is being powered by a gasoline generator, position the generator downwind of the well. Ground fault circuit interrupters (GFCIs) should always be used when using electric powered equipment. Do not connect the compression hose from the compressor to the pump controller until after the engine has been started.

When all precautions are completed and the compressor has been started, connect the compression hose to the pump controller. Slowly adjust the control knobs to discharge water in the shortest amount of time while maintaining a near constant flow. This does not mean that the compressor must be set to discharge the water as hard as possible. The optimal setting is one that produces the largest volume of purge water per minute (not per purge cycle) while maintaining a near constant flow rate.

Prior to sampling, adjust the flow rate (purge rate) to yield 100 to 300 mL/minute. Avoid settings that produce pulsating streams of water instead of a steady stream if possible. Operate the pump at this low flow rate for several minutes to ensure that drawdown is not occurring. At no time shall the sample flow rate exceed the flow rate used while purging.

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For those samples requiring filtration, it is recommended to use an in-line high capacity filter after all non-filtered samples have been collected.

***Peristaltic Pumps*:**

A peristaltic pump is a type of positive displacement pump that moves water via the process of peristalsis. The pump uses a flexible hose fitted inside a circular pump casing. A rotor with cams compresses the flexible tube as the rotor turns, which forces the water to be pumped to move through the tube. In peristaltic pumps, no moving parts of the pump are in contact with the water being pumped. Displacement is determined by tube size, so delivery rate can only be changed during operation by varying pump speed. Peristaltic pumps are simple and quite inexpensive for the flow rates they provide.

There are several methods available for transferring the sample into the laboratory containers. The selected method may vary based on State requirements and should be documented in the project-specific SAP. Samples typically can be collected directly from the discharge end of the Teflon tubing, after it has been disconnected from the flow through cell. For volatile analyses, the sampler should make sure that the pump is set such that a smooth laminar flow is achieved. In all cases, the project team should consult their local regulatory requirements and document the selected sample collection procedure in the project-specific SAP.

Bailers

A single- or double-check valve Teflon or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical, regulatory, or logistical reasons.

Dedicated or disposable bailers should always be used in order to eliminate the need for decontamination and to limit the potential of cross-contamination. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

8.2.7 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable and require preservation. The U.S. EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods (SW-846)* (EPA 1997), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 provides guidance on the types of sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory or State requirements prior to obtaining field samples. In many cases, the laboratory will supply the necessary sample bottles and required preservatives. In some cases, the field sampling personnel may add preservatives in the field.

Improper sample handling may alter the analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the project-specific SAP. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens (TOX)

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2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Nitrate and ammonia
10. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. The analytical laboratory performing the analysis shall provide these vials. Collect groundwater from the sampling device in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that has high concentrations of dissolved gasses. In these cases, the field sampling personnel shall document the occurrence in the field logbook and/or sampling worksheet at the time the sample was collected. Likewise, the analytical laboratory shall note in the laboratory analysis reports any headspace in the sample container(s) at the time of receipt by the laboratory.

Special Handling Considerations

In general, samples for organic analyses should not be filtered. However, high turbidity samples for PCB analysis may require filtering. Consult the project-specific SAP for details on filtering requirements. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples should be handled in the same manner as VOC samples.

When collecting total and dissolved metals samples, the samples should be collected sequentially. The total metals sample is collected from the pump unfiltered. The dissolved metals sample is collected after filtering with a 0.45-micron membrane in-line filter. Allow at least 500 mL of effluent to flow through the filter prior to sampling to ensure that the filter is thoroughly wetted and seated in the filter capsule. If required by the project-specific SAP, include a filter blank for each lot of filters used and always record the lot number of the filters.

Field Sampling Preservation

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. Guidance for the preservation of environmental samples can be found in the U.S. EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other U.S. EPA documents (EPA 1992, 1996).

Field Sampling Log

A groundwater sampling log provided as Attachment 1 shall document the following:

- Identification of well

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- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Types of sample containers used
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data
- Field observations on sampling event
- Name of sampler
- Weather conditions

9.0 Quality Control and Assurance

9.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific SAP. The goal of the QA program should be to ensure precision, accuracy, representativeness, completeness, and comparability in the project sampling program.

9.2 Quality control (QC) requirements for sample collection are dependent on project-specific sampling objectives. The project-specific SAP will provide requirements for sample preservation and holding times, container types, sample packaging and shipment, as well as requirements for the collection of various QC samples such as trip blanks, field blanks, equipment rinse blanks, and field duplicate samples.

10.0 Data and records management

10.1 Records will be maintained in accordance with SOP 3-03, Recordkeeping, Sample Labelling, and Chain-of-Custody. Various forms are required to ensure that adequate documentation is made of the sample collection activities. These forms may include:

- Sample Collection Records;
- Field logbook;
- Chain-of-custody forms; and
- Shipping labels.

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10.2 Sample collection records (Attachment 1) will provide descriptive information for the purging process and the samples collected at each monitoring well.

10.3 The field logbook is kept as a general log of activities and should not be used in place of the sample collection record.

10.4 Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes.

10.5 Shipping labels are required is sample coolers are to be transported to a laboratory by a third party (courier service).

11.0 Attachments or References

Attachment 1 – Groundwater Sampling Collection Record

ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites.* ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.

Environmental Protection Agency, United States (EPA). 1982. *Handbook for Sampling and Sample Preservation of Water and Wastewater.* EPA-600/4-82-029. Cincinnati: EPA Office of Research and Development, Environmental Monitoring and Support Laboratory.

EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

EPA. 1996. *Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA/540/S-95/504. Office of Solid Waste and Emergency Response. April.

EPA. 1997. *Test Methods for Evaluating Solid Waste, Physical/Chemical Method (SW-846)*. 3rd ed., Final Update IIIA. Office of Solid Waste. Online updates at: http://www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

NAVSEA T0300-AZ-PRO-010. *Navy Environmental Compliance Sampling and Field Testing Procedures Manual*. August 2009.

SOP 3-03, *Recordkeeping, Sample Labelling, and Chain-of-Custody*.

SOP 3-05, *IDW Management.*

SOP 3-06, *Equipment Decontamination*.

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)

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Attachment 1
Groundwater Sample Collection Record

Well ID:

Groundwater Sample Collection Record

Client: _____ Date: _____ Time: Start _____ am/pm
Project No: _____ Finish _____ am/pm
Site Location: _____
Weather Conds: _____ Collector(s): _____

1. WATER LEVEL DATA: (measured from Top of Casing)

a. Total Well Length _____ **c.** Length of Water Column _____ (a-b)

Casing Diameter/Material _____

b. Water Table Depth _____ **d.** Calculated Well Volume (see back) _____

2. WELL PURGEABLE DATA

a. Purge Method: _____

b. Acceptance Criteria defined (see SAP or Work Plan)
- Minimum Required Purge Volume (@ _____ well volumes) _____
- Maximum Allowable Turbidity _____ NTUs
- Stabilization of parameters _____ %

c. Field Testing Equipment used: Make Model Serial Number

Time (min)	Volume Removed (gal)	Temp. (°C)	pH s.u.	Spec. Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (m)	Color/Odor/etc.

(continued on back)

d. Acceptance criteria pass/fail

	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Have parameters stabilized	☐	☐	☐

If no or N/A - Explain below.

_____

3. SAMPLE COLLECTION: Method: _____

Sample ID	Container Type	No. of Containers	Preservation	Analysis Req.	Time

Comments _____

Signature _____ Date _____

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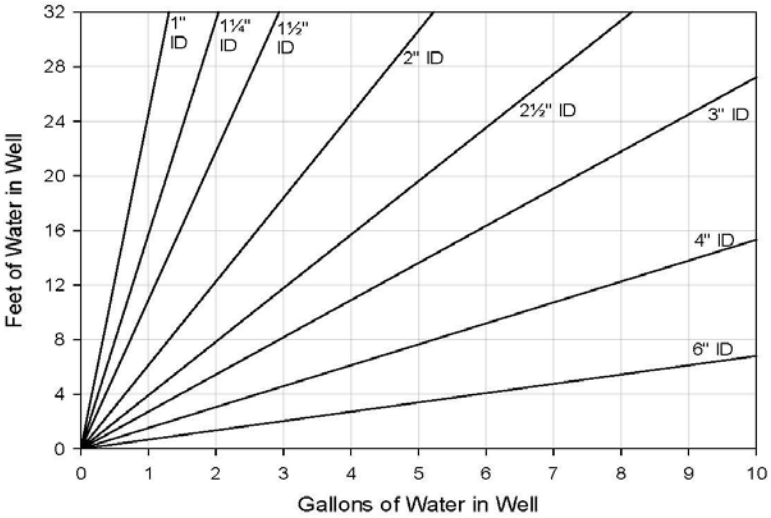
Purge Volume Computation

Well ID:



Volume / Linear Ft. of Pipe		
ID (in)	Gallon	Liter
¼	0.0025	0.0097
3/8	0.0057	0.0217
½	0.0102	0.0386
¾	0.0229	0.0869
1	0.0408	0.1544
1¼	0.0637	0.2413
1½	0.0918	0.3475
2	0.1632	0.6178
2½	0.2550	0.9653
3	0.3672	1.3900
4	0.6528	2.4711
6	1.4688	5.5600

(continued from front)

Time (min)	Volume Removed (gal)	Temp. (°C)	pH s.u.	Spec. Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (m)	Color/Odor/etc.

Signature _____ Date _____

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Soil and Rock Classification

Procedure 3-16

1.0 Purpose and Scope

1.1 The purpose of this document is to define the standard operating procedure (SOP) to thoroughly describe the physical characteristics of the sample and classify it according to the Unified Soil Classification System (USCS).

1.2 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review. If there are procedures whether it be from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to surface water sampling then those procedures may be added as an appendix to the project specific SAP.

1.4 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Program Quality Manager. Deviations to this SOP will be documented in the field records.

2.0 Safety

2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling. All **field sampling personnel** responsible for sampling activities must review the project-specific health and safety plan (HASP) paying particular attention to the control measures planned for the sampling tasks. Conduct preliminary area monitoring to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor and liquid phase through the use of respirators and disposable clothing.

2.2 In addition, observe standard health and safety practices according to the project-specific HASP. Suggested minimum protection during well sampling activities includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves, rubberized steel-toed boots, and an American National Standards Institute-standard hard hat. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations, and shall always be available on site.

2.3 Daily safety briefs will be conducted at the start of each working day before any work commences. These daily briefs will be facilitated by the **Site Safety Officer (SSO)** or designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the HASP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.

2.4 The health and safety considerations for the work associated with soil classification include:

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- At no time during classification activities are personnel to reach for debris near machinery that is in operation, place any samples in their mouth, or come in contact with the soils/rocks without the use of gloves.
- Stay clear of all moving equipment and be aware of pinch points on machinery. Avoid wearing loose fitting clothing.
- When using cutting tools, cut away from yourself. The use of appropriate, task specific cutting tools is recommended.
- To avoid heat/cold stress as a results of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and in case of extreme cold, wear insulating clothing.

3.0 Terms and Definitions

None.

4.0 Interference

None.

5.0 Training and Qualifications

5.1 The **Contract Task Order (CTO) Manager** is responsible for ensuring that the soil and rock classification procedures comply with this procedure. The **CTO Manager** is responsible for ensuring that all personnel involved in soil and rock classification shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.3 The **Field Manager** is responsible for ensuring that all project **field personnel** follow these procedures.

5.4 Field personnel are responsible for the implementation of this procedure. Minimum qualifications for **field sampling personnel** require that one individual on the field team shall have a minimum of 6 months of experience with soil and rock classification.

5.5 The **project geologist** and/or **task manager** is responsible for directly supervising the soil and rock classification procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the **Program Quality Manager** and then documented in the field logbook and associated report or equivalent document.

6.0 Equipment and Supplies

6.1 The following equipment list contains materials which may be needed in carrying out the procedures outlined in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- Personal protective equipment (PPE) and other safety equipment, as required by the HASP
- Field log book and pen with indelible ink
- Boring log

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- Munsell Soil Color Chart
- Scoopula, spatula, and/or other small hand tools
- California Sampler
- Hand-held penetrometer

7.0 Calibration or Standardization

None.

8.0 Procedure

8.1 Soil Classification

The basic purpose of the classification of soil is to thoroughly describe the physical characteristics of the sample and to classify it according to an appropriate soil classification system. The USCS was developed so that soils could be described on a common basis by different investigators and serve as a "shorthand" description of soil. A classification of a soil in accordance with the USCS includes not only a group symbol and name, but also a complete word description.

Describing soil on a common basis is essential so that soil described by different site qualified personnel is comparable. Site individuals describing soil as part of site activities *must* use the classification system described herein to provide the most useful geologic database for all present and future subsurface investigations and remedial activities.

The site geologist or other qualified individual shall describe the soil and record the description in a boring log, logbook, and/or electronic field data collection device. The essential items in any written soil description are as follows:

- Classification group name (e.g., silty sand)
- Color, moisture, and odor
- Range of particle sizes and maximum particle size
- Approximate percentage of boulders, cobbles, gravel, sand, and fines
- Plasticity characteristics of the fines
- In-place conditions, such as consistency, density, and structure
- USCS classification symbol

The USCS serves as ”shorthand“ for classifying soil into 15 basic groups:

GW[1] Well graded (poorly sorted) gravel (>50 percent gravel, <5percent fines)

GP[1] Poorly graded (well sorted) gravel (>50percent gravel, <5percent fines)

GM[1] Silty gravel (>50 percent gravel, >15 percent silt)

GC[1] Clayey gravel (>50 percent gravel, >15 percent clay)

SW[1] Well graded (poorly sorted) sand (>50 percent sand, <5 percent fines)

SP[1] Poorly graded (well sorted) sand (>50 percent sand, <5 percent fines)

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[1] If percentage of fine is 5 percent to 15 percent, a dual identification shall be given (e.g., a soil with more than 50 percent poorly sorted gravel and 10 percent clay is designated GW-GC.

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SM[1] Silty sand (>50 percent sand, >15 percent silt)

SC[1] Clayey sand (>50 percent sand, >15 percent clay)

ML[2] Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness, and plasticity)

CL[2] Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)

MH[2] Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)

CH[2] Inorganic, high plasticity (fat) clay (no dilatancy, high toughness, and plasticity)

OL Organic low plasticity silt or organic silty clay

OH Organic high plasticity clay or silt

PT Peat and other highly organic soil

Figure8-1 defines the terminology of the USCS. Flow charts presented in Figure 8-2 and indicate the process for describing soil. The particle size distribution and the plasticity of the fines are the two properties of soil used for classification. In some cases, it may be appropriate to use a borderline classification (e.g., SC/CL) if the soil has been identified as having properties that do not distinctly place the soil into one group.

8.1.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. Being proficient in estimating this factor requires extensive practice and frequent checking. The steps involved in determining particle size distribution are listed below:

1. Select a representative sample (approximately 1/2 of a 6-inch long by 2.5-inch diameter sample liner).
2. Remove all particles larger than 3 inches from the sample. Estimate and record the percent by volume of these particles. Only the fraction of the sample smaller than 3 inches is classified.
3. Estimate and record the percentage of dry mass of gravel (less than 3 inches and greater than 1/4 inch).
4. Considering the rest of the sample, estimate, and record the percentage of dry mass of sand particles (about the smallest particle visible to the unaided eye).
5. Estimate and record the percentage of dry mass of fines in the sample (do not attempt to separate silts from clays).
6. Estimate percentages to the nearest 5 percent. If one of the components is present in a quantity considered less than 5 percent, indicate its presence by the term “trace”.
7. The percentages of gravel, sand, and fines must add up to 100 percent. “Trace” is not included in the 100 percent total.

8.1.2 Soil Dilatancy, Toughness, and Plasticity

8.1.2.1 Dilatancy

To evaluate dilatancy, follow these procedures:

[2] If the soil is estimated to have 15 percent to 25 percent sand or gravel, or both, the words “with sand” or “with gravel” (whichever predominates) shall be added to the group name (e.g., clay with sand, CL; or silt with gravel, ML). If the soil is estimated to have 30 percent or more sand or gravel, or both, the words “sandy” or “gravely” (whichever predominates) shall be added to the group name (e.g., sandy clay, CL). If the percentage of sand is equal to the percent gravel, use “sandy.”

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1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 millimeters [mm]) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
2. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 8-1. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Table 8-1: Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

8.1.2.2 Toughness

Following the completion of the dilatancy test, shape the test specimen into an elongated pat and roll it by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, spread it into a thin layer and allow it to lose some water by evaporation.) Fold the sample threads and re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble at a diameter of 1/8 inch when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, lump the pieces together and knead it until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 8-2.

Table 8-2: Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread near the plastic limit. The thread and the lump have very high stiffness.

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DEFINITION OF TERMS

MAJOR DIVISIONS			SYMBOLS	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More Than Half of Material is Larger Than No. 200 Sieve Size	GRAVELS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	CLEAN GRAVELS (Less than 6% Fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS With Fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	CLEAN SANDS (Less than 6% Fines)	SW	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SANDS With Fines	SM	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More Than Half of Material is Smaller Than No. 200 Sieve Size	SILTS AND CLAYS Liquid Limit is Less Than 50%		ML	Inorganic silts, rock flour, fine sandy silts or clays, and clayey silts with non- or slightly-plastic fines
			CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limit is Greater Than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, clayey silt
			CH	inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils

GRAIN SIZES

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

200 40 10 4 3/4" 3" 12"

U.S. STANDARD SERIES SIEVE — CLEAR SQUARE SIEVE OPENINGS

Figure8-1: Unclassified Soil Classification System (USCS)

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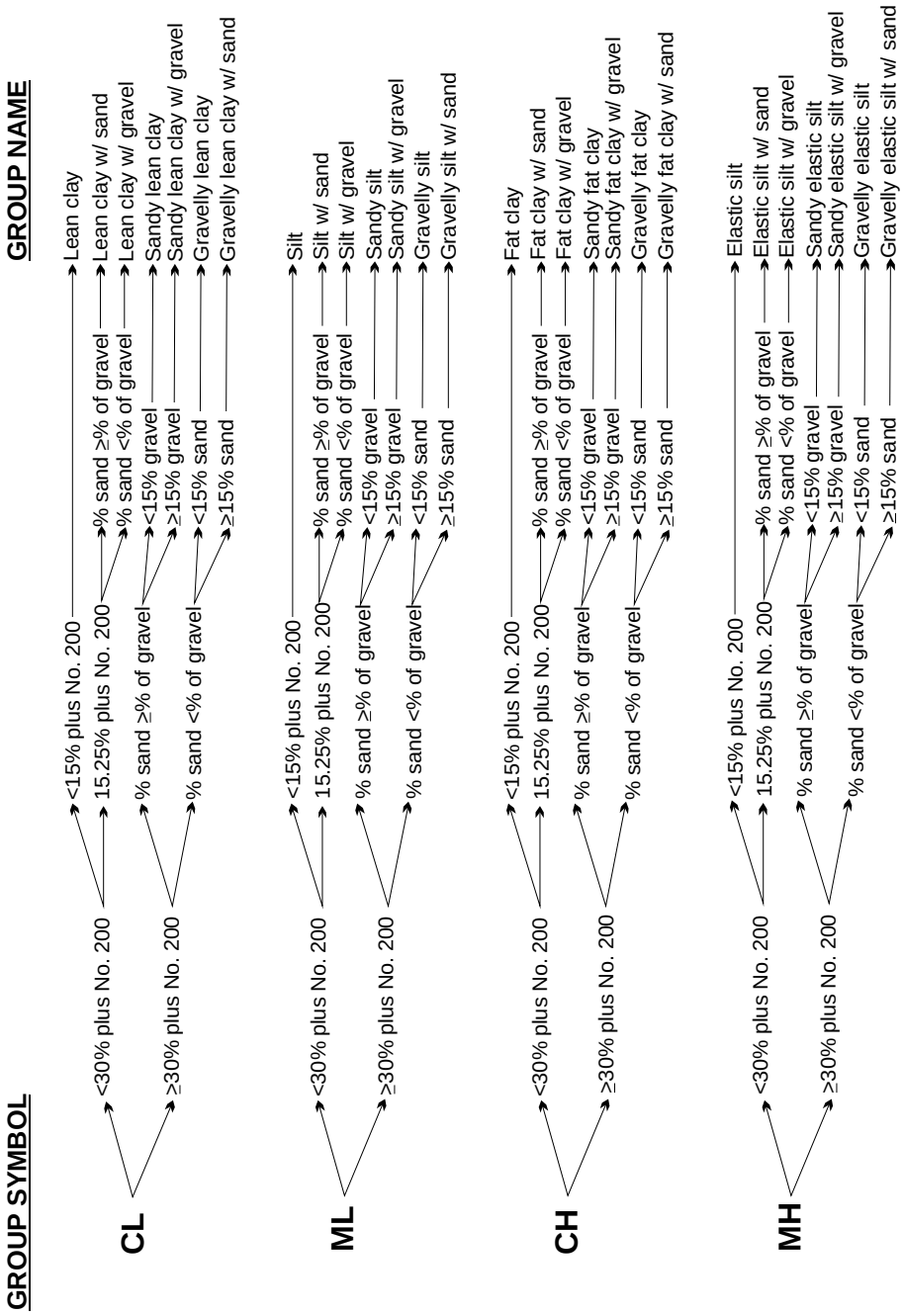

Figure 8-2: Flow Chart for Fine Grain Soil Classification

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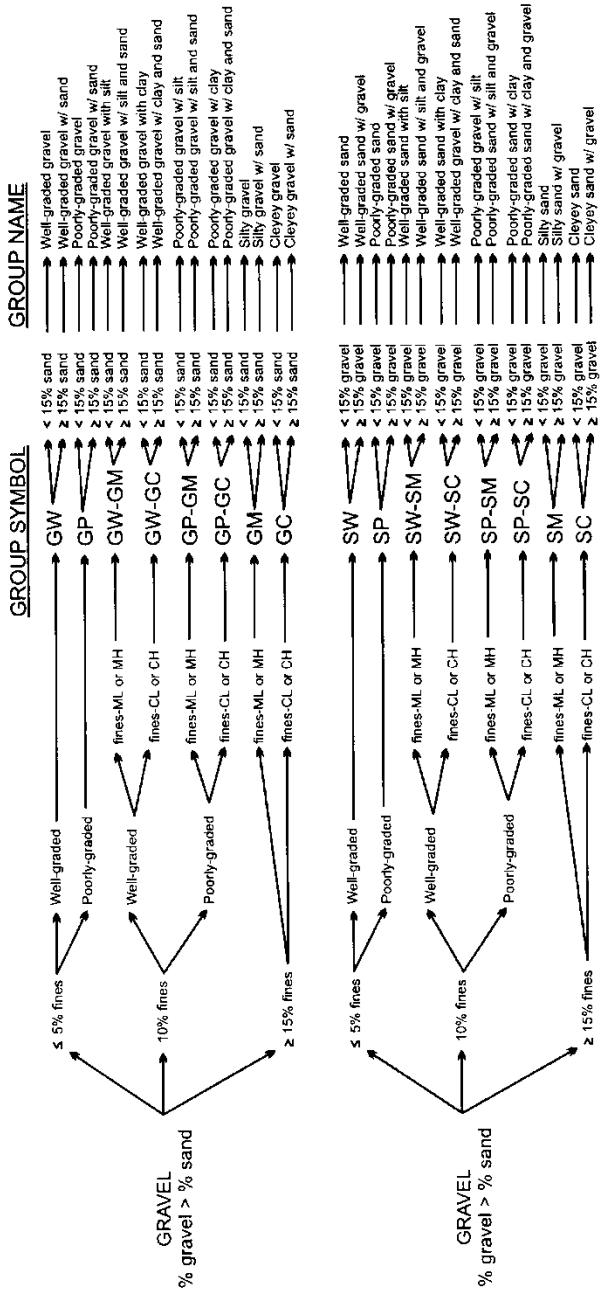

Figure 8-3: Flow Chart for Soil with Gravel

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8.1.2.3 Plasticity

The plasticity of a soil is defined by the ability of the soil to deform without cracking, the range of moisture content over which the soil remains in a plastic state, and the degree of cohesiveness at the plastic limit. The plasticity characteristic of clays and other cohesive materials is defined by the liquid limit and plastic limit. The liquid limit is defined as the soil moisture content at which soil passes from the liquid to the plastic state as moisture is removed. The test for the liquid limit is a laboratory, not a field, analysis.

The plastic limit is the soil moisture content at which a soil passes from the plastic to the semi-solid state as moisture is removed. The plastic limit test can be performed in the field and is indicated by the ability to roll a 1/8-inch (0.125-inch) diameter thread of fines, the time required to roll the thread, and the number of times the thread can be re-rolled when approaching the plastic limit.

The plasticity tests are not based on natural soil moisture content, but on soil that has been thoroughly mixed with water. If a soil sample is too dry in the field, add water prior to performing classification. If a soil sample is too sticky, spread the sample thin and allow it to lose some soil moisture.

Table 8-3 presents the criteria for describing plasticity in the field using the rolled thread method.

Table 8-3: Criteria for Describing Plasticity

Description	Criteria
Non-Plastic	A 1/8-inch thread cannot be rolled.
Low Plasticity	The thread can barely be rolled.
Medium Plasticity	The thread is easy to roll and not much time is required to reach the plastic limit.
High Plasticity	It takes considerable time rolling the thread to reach the plastic limit.

8.1.3 Angularity

The following criteria describe the angularity of the coarse sand and gravel particles:

- **Rounded** particles have smoothly-curved sides and no edges.
- **Subrounded** particles have nearly plane sides, but have well-rounded corners and edges.
- **Subangular** particles are similar to angular, but have somewhat rounded or smooth edges.
- **Angular** particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

8.1.4 Color, Moisture, and Odor

The natural moisture content of soil is very important. Table **8-4** shows the terms for describing the moisture condition and the criteria for each.

Table 8-4: Soil Moisture Content Qualifiers

Qualifier	Criteria
Dry	Absence of moisture, dry to the touch
Moist	Damp but no visible water
Wet	Visible water, usually soil is below water table

Color is described by hue and chroma using the Munsell Soil Color Chart (Munsell 2000). For uniformity, all site geologists shall utilize this chart for soil classification. Doing so will facilitate correlation of geologic units between boreholes logged by different geologists. The Munsell Color Chart is a small booklet of numbered color chips with names like “5YR 5/6, yellowish-red.” Note mottling or banding of colors. It is particularly important to note and describe staining because it may indicate contamination.

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In general, wear a respirator if strong organic odors are present. If odors are noted, describe them if they are unusual or suspected to result from contamination. An organic odor may have the distinctive smell of decaying vegetation. Unusual odors may be related to hydrocarbons, solvents, or other chemicals in the subsurface. An organic vapor analyzer may be used to detect the presence of volatile organic contaminants.

8.1.5 In-Place Conditions

Describe the conditions of undisturbed soil samples in terms of their density/consistency (i.e., compactness), cementation, and structure utilizing the following guidelines:

8.1.5.1 Density/Consistency

Density and consistency describe a physical property that reflects the relative resistance of a soil to penetration. The term “density” is commonly applied to coarse to medium-grained sediments (i.e., gravels, sands), whereas the term “consistency” is normally applied to fine-grained sediments (i.e., silts, clays). There are separate standards of measure for both density and consistency that are used to describe the properties of a soil.

The density or consistency of a soil is determined by observing the number of blows required to drive a 1 3/8-inch (35 mm) diameter split barrel sampler 18 inches using a drive hammer weighing 140 lbs (63.5 kilograms [kg]) dropped over a distance of 30 inches (0.76 meters). Record the number of blows required to penetrate each 6 inches of soil in the field boring log during sampling. The first 6 inches of penetration is considered to be a seating drive; therefore, the blow count associated with this seating drive is recorded, but not used in determining the soil density/consistency. The sum of the number of blows required for the second and third 6 inches of penetration is termed the “standard penetration resistance,” or the “N-value.” The observed number of blow counts must be corrected by an appropriate factor if a different type of sampling device (e.g., Modified California Sampler with liners) is used. For a 2 3/8-inch inner diameter (I.D.) Modified California Sampler equipped with brass or stainless steel liners and penetrating a cohesionless soil (sand/gravel), the N-value from the Modified California Sampler must be divided by 1.43 to provide data that can be compared to the 1 3/8-inch diameter sampler data.

For a cohesive soil (silt/clay), the N-value for the Modified California Sampler should be divided by a factor of 1.13 for comparison with 1 3/8-inch diameter sampler data.

Drive the sampler and record blow counts for each 6-inch increment of penetration until one of the following occurs:

- A total of 50 blows have been applied during any one of the three 6-inch increments; a 50-blow count occurrence shall be termed “refusal” and noted as such on the boring log.
- A total of 150 blows have been applied.
- The sampler is advanced the complete 18 inches without the limiting blow counts occurring, as described above.

If the sampler is driven less than 18 inches, record the number of blows per partial increment on the boring log. If refusal occurs during the first 6 inches of penetration, the number of blows will represent the N-value for this sampling interval. Table 8-5 and Table 8-6 present representative descriptions of soil density/consistency vs. N-values.

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Table 8-5: Measuring Soil Density with a California Sampler – Relative Density (Sands, Gravels)

Description	Field Criteria (N-Value)	
	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.43 factor
Very Loose	0–4	0–6
Loose	4–10	6–14
Medium Dense	10–30	14–43
Dense	30–50	43–71
Very Dense	> 50	> 71

Table 8-6: Measuring Soil Density with a California Sampler – Fine Grained Cohesive Soil

Description	Field Criteria (N-Value)	
	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.13 factor
Very Soft	0–2	0–2
Soft	2–4	2–4
Medium Stiff	4–8	4–9
Stiff	8–16	9–18
Very Stiff	16–32	18–36
Hard	> 32	> 36

For undisturbed fine-grained soil samples, it is also possible to measure consistency with a hand-held penetrometer. The measurement is made by placing the tip of the penetrometer against the surface of the soil contained within the sampling liner or shelby tube, pushing the penetrometer into the soil a distance specified by the penetrometer manufacturer, and recording the pressure resistance reading in pounds per square foot (psf). The values are as follows (Table 8-7):

Table 8-7: Measuring Soil Consistency with a Hand-Held Penetrometer

Description	Pocket Penetrometer Reading (psf)
Very Soft	0–250
Soft	250–500
Medium Stiff	500–1000
Stiff	1000–2000
Very Stiff	2000–4000
Hard	>4000

Consistency can also be estimated using thumb pressure using Table 8-8.

Table 8-8: Measuring Soil Consistency Using Thumb Pressure

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will penetrate soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

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8.1.5.2 *Cementation*

Cementation is used to describe the friability of a soil. Cements are chemical precipitates that provide important information as to conditions that prevailed at the time of deposition, or conversely, diagenetic effects that occurred following deposition. Seven types of chemical cements are recognized by Folk (1980). They are as follows:

- Quartz – siliceous
- Chert – chert-cemented or chalcedonic
- Opal – opaline
- Carbonate – calcitic, dolomitic, sideritic (if in doubt, calcareous should be used)
- Iron oxides – hematitic, limonitic (if in doubt, ferruginous should be used)
- Clay minerals – if the clay minerals are detrital or have formed by recrystallization of a previous clay matrix, they are not considered to be a cement. Only if they are chemical precipitates, filling previous pore space (usually in the form of accordion-like stacks or fringing radial crusts) should they be included as “kaolin-cemented,” “chlorite-cemented,” etc.
- Miscellaneous minerals – pyritic, collophane-cemented, glauconite-cemented, gypsiferous, anhydrite-cemented, baritic, feldspar-cemented, etc.

The degree of cementation of a soil is determined qualitatively by utilizing finger pressure on the soil in one of the sample liners to disrupt the gross soil fabric. The three cementation descriptors are as follows:

- Weak – friable; crumbles or breaks with handling or slight finger pressure
- Moderate – friable; crumbles or breaks with considerable finger pressure
- Strong – not friable; will not crumble or break with finger pressure

8.1.5.3 *Structure*

This variable is used to qualitatively describe physical characteristics of soil that are important to incorporate into hydrogeological and/or geotechnical descriptions of soil at a site. Appropriate soil structure descriptors are as follows:

- Granular – spherically shaped aggregates with faces that do not accommodate adjoining faces
- Stratified – alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness
- Laminated – alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness
- Blocky – cohesive soil that can be broken down into small angular or subangular lumps that resist further breakdown
- Lensed – inclusion of a small pocket of different soil, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soil are present, the soil being described can be termed homogeneous if the description of the lenses is included
- Prismatic or Columnar – particles arranged about a vertical line, ped is bounded by planar, vertical faces that accommodate adjoining faces; prismatic has a flat top; columnar has a rounded top
- Platy – particles are arranged about a horizontal plane

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8.1.5.4 Other Features

- Mottled – soil that appears to consist of material of two or more colors in blotchy distribution
- Fissured – breaks along definite planes of fracture with little resistance to fracturing (determined by applying moderate pressure to sample using thumb and index finger)
- Slickensided – fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)

8.1.6 **Development of Soil Description**

Develop standard soil descriptions according to the following examples. There are three principal categories under which all soil can be classified. They are described below.

8.1.6.1 Coarse-grained Soil

Coarse-grained soil is divided into sands and gravels. A soil is classified as a sand if over 50 percent of the coarse fraction is "sand-sized." It is classified as a gravel if over 50 percent of the coarse fraction is composed of "gravel-sized" particles.

The written description of a coarse-grained soil shall contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); grain size of coarse fraction; Munsell color and color number; moisture content; relative density; sorting; angularity; other features, such as stratification (sedimentary structures) and cementation, possible formational name, primary USCS classification, secondary USCS classification (when necessary), and approximate percentages of minor constituents (i.e., sand, gravel, shell fragments, rip-up clasts) in parentheses.

Example: <u>POORLY-SORTED SAND WITH SILT</u>, medium- to coarse-grained, light olive gray, 5Y 6/2, saturated, loose, poorly sorted, subrounded clasts, SW/SM (minor silt with approximately 20 percent coarse-grained sand-sized shell fragments, and 80 percent medium-grained quartz sand, and 5 percent to 15 percent ML).

8.1.6.2 Fine-grained Soil

Fine-grained soil is further subdivided into clays and silts according to its plasticity. Clays are rather plastic, while silts have little or no plasticity.

The written description of a fine-grained soil should contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); Munsell color; moisture content; consistency; plasticity; other features, such as stratification, possible formation name, primary USCS classification, secondary USCS classification (when necessary), and the percentage of minor constituents in parentheses.

Example: <u>SANDY LEAN CLAY</u>, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70 percent fines, 30 percent sand, with minor amounts of disarticulated bivalves [about 5 percent]).

8.1.6.3 Organic Soil

For highly organic soil, describe the types of organic materials present as well as the type of soil constituents present using the methods described above. Identify the soil as an organic soil, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soil usually has a dark brown to black color and may have an organic odor. Often, organic soils will change color, (e.g., from black to brown) when exposed to air. Some organic soils will lighten in color significantly when air-dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

8.2 Example: <u>ORGANIC CLAY</u>, black, 2.5Y, 2.5/1, wet, soft, low plasticity, organic odor, OL (100 percent fines), weak reaction to HCl.

8.3 Rock Classification

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The purpose of rock classification is to thoroughly describe the physical and mineralogical characteristics of a specimen and to classify it according to an established system. The generalized rock classification system described below was developed because, unlike the USCS for soils, there is no universally accepted rock classification system. In some instances, a more detailed and thorough rock classification system may be appropriate. Any modifications to this classification system, or the use of an alternate classification system should be considered during preparation of the site work plan. Both the CTO Manager and the QA Manager or Technical Director must approve any modifications to this classification system, or the use of another classification system.

Describing rock specimens on a common basis is essential so that rocks described by different site geologists are comparable. Site geologists describing rock specimens as a part of investigative activities must use the classification system described herein, or if necessary, another more detailed classification system. Use of a common classification system provides the most useful geologic database for all present and future subsurface investigations and remedial activities.

In order to provide a more consistent rock classification between geologists, a rock classification template has been designated as shown in **Error! Reference source not found.**. The template includes classification of rocks by origin and mineralogical composition. When classifying rocks, all site geologists shall use this template.

The site geologist shall describe the rock specimen and record the description in a boring log or logbook. The items essential for classification include (i.e., metamorphic foliated):

- Classification Name (i.e., schist)
- Color
- Mineralogical composition and percent
- Texture/Grain size (i.e., fine-grained, pegmatitic, aphlitic, glassy)
- Structure (i.e., foliated, fractured, lenticular)
- Rock Quality Designation (sum of all core pieces greater than two times the diameter of the core divided by the total length of the core run, expressed as a percentage)
- Classification symbol (i.e., MF)

Example: Metamorphic foliated schist: Olive gray, 5Y, 3/2, Garnet 25 percent, Quartz 45 percent, Chlorite 15 percent, Tourmaline 15 percent, Fine-grained with Pegmatite garnet, highly foliated, slightly wavy, MF.

9.0 Quality Control and Assurance

None

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DEFINITION OF TERMS				
PRIMARY DIVISIONS			SYMBOLS	SECONDARY DIVISIONS
SEDIMENTARY ROCKS	Clastic Sediments	CONGLOMERATE	CG	Coarse-grained Clastic Sedimentary Rock types including: Conglomerates and Breccias
		SANDSTONE	SS	Clastic Sedimentary Rock types including: Sandstone, Arkose and Greywacke
		SHALE	SH	Fine-grained Clastic Sedimentary Rock types including: Shale, Siltstone, Mudstone and Claystone
	Chemical Precipitates	CARBONATES	LS	Chemical Precipitates including: Limestone, Crystalline Limestone, Fossiliferous Limestone Micrite and Dolomite
		EVAPORITES	EV	Evaporites including: Anhydrite, Gypsum, Halite, Travertine and Caliche
IGNEOUS ROCKS		EXTRUSIVE (Volcanic)	IE	Volcanic Rock types including: Basalt, Andesite, Rhyolite, Volcanic Tuff, and Volcanic Breccia
		INTRUSIVE (Plutonic)	II	Plutonic Rock types including: Granite, Diorite and Gabbro
METAMORPHIC ROCKS		FOLIATED	MF	Foliated Rock types including: Slate, Phyllite, Schist and Gneiss
		NON-FOLIATED	MN	Non-foliated Rock types including: Metaconglomerate, Quartzite and Marble

Figure 8-4: Rock Classification System

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10.0 Data and Records Management

10.1 Document soil classification information collected during soil sampling onto the field boring logs, field trench logs, and into the field notebook. Copies of this information shall be sent to the **CTO Manager** for the project files.

10.2 Field notes will be kept during coring activities in accordance with SOP 3-03 – Recordkeeping, Sample Labeling, and Chain of Custody. The information pertinent to soil classification activities includes chronology of events, sample locations (x,y,z), time/date, sampler name, methods (including type of core liner/barrel, if applicable), sampler penetration and acceptability, sample observations, and the times and type of equipment decontamination. Deviations to the procedures detailed in the SOP should be recorded in the field logbook.

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Author	*Reviewer*	*Revisions (Technical or Editorial)*
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Surface and Subsurface Soil Sampling Procedures

Procedure 3-21

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the procedures for soil sampling. The procedure includes surface and subsurface sampling by various methods using hand auguring, test pit, direct-push, and split-spoon equipment.

1.2 The procedure includes soil sampling for volatile organic compounds (VOCs). For project specific information (e.g. sampling depths, equipment to be used, and frequency of sampling), refer to the Sampling and Analysis Plan (SAP), which takes precedence over these procedures. Surface soil sampling, typically considered to be up to two feet below ground surface by EPA standards, is typically accomplished using hand tools such as shovels or hand augers. Test pit samples are considered subsurface samples, although normally collected via hand tools similar to surface soil sampling or by excavation machinery. Direct-push and split-spoon sampling offer the benefit of collecting soil samples from a discrete or isolated subsurface interval, without the need of extracting excess material above the target depth. These methods dramatically reduce time and cost associated with disposal of material from soil cuttings when compared to test pit sampling. In addition, direct-push and split-spoon sampling methods can obtain samples at targeted intervals greater than 15 feet in depth, allowing for discrete depth soil sampling while speeding up the sampling process. Direct-push methods work best in medium to fine-grained cohesive materials such as medium to fine sands, silts, and silty clay soils. Split-spoon sampling works well in all types of soil, but is somewhat slower than direct-push methods. Samples are composited so that each sample contains a homogenized representative portion of the sample interval. Due to potential loss of analytes, samples for volatile analysis are not composited. Samples for chemical analysis can be collected by any of the above-mentioned sampling methods, as disturbed soil samples. Undisturbed samples are collected, sealed, and sent directly to the laboratory for analysis. For undisturbed samples, the samples are not homogenized.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Health and Safety Plan (HASP). In the absence of a HASP, work will be conducted according to the Contract Task Order (CTO) Work Plan (WP) and/or direction from the **Site Safety Officer (SSO)**.

2.2 Before soil sampling commences, appropriate entities (e.g. DigSafe, local public works departments, company facilities) must be contacted to assure the anticipated soil sampling locations are marked for utilities, including electrical, telecommunications, water, sewer, and gas.

3.0 Terms and Definitions

None.

4.0 Interferences

4.1 Low recovery of soil from sampling equipment will prevent an adequate representation of the soil profile and sufficient amount of soil sample. If low recovery is a problem, the hole may be offset and re-advanced, terminated, or continued using a larger diameter sampler.

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4.2 Asphalt in soil samples can cause false positive results for hydrocarbons. To ensure samples are free of asphalt, do not collect samples that may contain asphalt. If the collection of samples potentially containing asphalt is unavoidable, note the sampling depths at which the presence of asphalt are suspected.

4.3 Instrumentation interferences addressed in SOPs for Calibration of the Photoionization Detector (PID), Headspace Screening for Total Volatile Organics, and Equipment Decontamination must also be considered.

4.4 Cross contamination from sampling equipment must be prevented by using sampling equipment constructed of stainless steel that is adequately decontaminated between samples.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The CTO Manager is responsible for ensuring that soil sampling activities comply with this procedure. The CTO Manager is responsible for ensuring that all personnel involved in soil sampling shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The Program Quality Manager is responsible for ensuring overall compliance with this procedure.

5.2.3 The Field Manager is responsible for ensuring that all soil sampling activities are conducted according to this procedure.

5.2.4 All Field Personnel are responsible for the implementation of this procedure.

6.0 Equipment and Supplies

The depth at which samples will be collected and the anticipated method of sample collection (direct-push, split-spoon, hand auger, shovel, or test pits) will be presented in the SAP. The following details equipment typically needed for soil sampling, based on the various methods. See the SAP for specific detail of equipment and supply needs.

6.1 Depending on the nature of suspected contamination, field screening instrumentation may be used for direct sampling. Appropriate instrumentation and calibration standards should be available. If volatile organic contaminants are suspected and a PID will be used, refer to the equipment and instrumentation listed in SOP 3-20 Operation and Calibration of a Photoionization Detector. Equipment in this SOP includes but is not limited to:

- PID/FID;
- Calibration gas; and
- Tedlar® gas bags (for calibration).

6.2 If field screening methods include jar headspace screening for volatile organics, refer to the equipment and procedure in SOP 3-19 Headspace Screening for Total VOCs. Equipment in this SOP includes but is not limited to:

- Clean soil (“drillers jars”) jars; and
- Aluminium foil.

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6.3 Appropriate decontamination procedures must be followed for sampling equipment. Refer to SOP 3-06 Equipment Decontamination. Equipment in this SOP includes but is not limited to:

- Phosphate-free detergent;
- Isopropyl Alcohol;
- Tap water;
- Deionized Ultra-Filtered (DIUF) Water;
- Plastic buckets or washbasins;
- Brushes; and
- Polyethylene sheeting.

6.4 The following general equipment is needed for all soil sampling, regardless of method:

- Stainless steel bowls;
- Stainless steel trowels;
- Appropriate sample containers for laboratory analysis;
- Personal Protective Equipment (PPE);
- Logbook;
- Cooler and ice for preservation; and
- Stakes and flagging to document sampling location.

6.5 The following additional equipment is needed for volatile organic sampling:

- Electronic pan scale and weights for calibration; and
- Syringes or other discrete soil core samplers.

6.6 The following additional equipment may be needed for surface and test pit soil sampling:

- Hand Auger

6.7 The following additional equipment may be needed for soil sampling from direct push and/or split-spoon equipment:

- Tape measure or folding carpenter's rule for recording the length of soil recovered.

Note: All subsurface drilling equipment will be provided and maintained by the subcontractor.

7.0 Procedure

7.1 **General Soil Sampling Procedure for All Soil Sampling Methods**

7.1.1 Record the weather conditions and other relevant on-site conditions.

7.1.2 Select the soil sampling location, clear vegetation if necessary, and record the sampling location identification number and pertinent location details.

7.1.3 Verify that the sampling equipment is properly decontaminated, in working order, and situated at the intended sampling location.

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7.1.4 Place polyethylene sheeting on the ground and assemble all necessary sampling equipment on top of it. Cover surfaces onto which soils or sampling equipment will be placed (i.e. tables with polyethylene sheeting).

7.1.5 Follow the appropriate procedures listed below for either surface, split-spoon, direct push, or test pit sample collection (7.2, 7.3, 7.4, and 7.5 respectively).

7.1.6 Collect soil samples according to procedures listed in Section 7.6 depending on project specific analyses.

7.1.7 Record date/time, sample ID, and sample descriptions in the field logbook or field form. A sketch or description of the location may also be recorded so the sample location can be re-constructed, especially if the location will not be recorded using global positioning satellite (GPS) equipment.

7.1.8 Immediately label the sample containers and place them on ice, if required for preservation. Complete the chain-of-custody form(s) as soon as possible.

7.1.9 Dispose of all excess excavated soil in accordance with the SAP.

7.1.10 If required, mark the sample location with a clearly labelled wooden stake or pin flag. If the location is on a paved surface, the location may be marked with spray paint.

7.1.11 Decontaminate the sampling equipment according to SOP 3-06 Equipment Decontamination.

7.2 Surface Sampling

7.2.1 The criteria used for selecting surface soil locations for sampling may include the following:

- Visual observations (soil staining, fill materials);
- Other relevant soil characteristics;
- Site features;
- Screening results;
- Predetermined sampling approach (i.e. grid or random); and
- Sampling objectives as provided in the SAP.

7.2.2 The following procedures are to be used to collect surface soil samples. Surface soils are considered to be soils that are up to two feet below ground surface, though state regulations and project objectives may define surface soils differently; therefore, the SAP should be consulted for direction on the depth from which to collect the surface soil samples. Sampling and other pertinent data and information will be recorded in the field logbook and/or on field forms. Photographs may be taken as needed or as specified in the SAP.

1. Gently scrape any vegetative covering until soil is exposed. Completely remove any pavement.
2. Remove soil from the exposed sampling area with a trowel, hand auger, or shovel. Put soils within the sampling interval in a stainless steel bowl for homogenizing. Monitor the breathing zone and sampling area as required in the HASP.
3. For VOC analyses, collect representative soil samples directly from the recently-exposed soil using a syringe or other soil coring device (e.g., TerraCore®, EnCore®). Follow procedures in Section 7.6.1 for VOC sampling.
4. Collect sufficient soil to fill all remaining sample jars into a stainless steel bowl. Homogenize the soil samples to obtain a uniform soil composition which is representative of the total soil sample collected according to the following procedure:
   a) Remove all rocks and non-soil objects using a stainless steel spoon or scoop.

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b) Form a cone shaped mound with the sample material, then flatten the cone and split the sample into quarters.

c) Use the stainless steel spoon/scoop to mix the quarter samples that are opposite.

d) After mixing the opposite quarters, reform the cone shaped mound.

e) Repeat this procedure a minimum of five (5) times, removing any non-soil objects and breaking apart any clumps.

7.3 Split-Spoon Sampling

7.3.1 At each boring location, the frequency and depth of split-spoon samples will be determined from the SAP. Split-spoon samples may be collected continuously, intermittently, or from predetermined depths.

7.3.2 Split-spoon samplers shall be driven into undisturbed soil by driving the spoon ahead of the drill augers/casing. In cohesive soils, or soils where the borehole remains open (does not collapse), two split-spoon samples may be taken prior to advancing the augers/casing.

7.3.3 After split-spoons are retrieved, open the split-spoon and measure the recovery of soil. If a PID will be used for screening, immediately scan the recovered sample for VOCs using the PID. Scan the recovered soil boring by making a hole in the soil with a decontaminated trowel and placing the PID inlet very close to the hole. Be very careful not to get soil on the tip of the PID. Take PID readings every 6 inches along the split-spoon and/or in any areas of stained or disturbed soil. Record the highest PID reading and the depth at which it was observed along with all other pertinent observations. If required in the SAP, VOC and headspace samples should be collected (see Section 7.6.1) prior to logging the sample.

7.3.4 If headspace screening for VOCs is required in the SAP, collect a soil sample (as defined in the SAP) and perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.

7.3.5 Soils collected using the split-spoon sampler will be logged by the field representative using the procedure required in the SAP.

7.3.6 Collect the remainder of the sample volume required into a stainless steel bowl. Homogenize the soil so the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.

7.3.7 The SAP may specify that intervals to be sent to the laboratory be determined by visual observation and/or highest PID screening or headspace results, which can only be determined once the boring is complete. In this instance, a VOC sample should be collected at each interval. The remainder of the soil from that interval will be set aside in a clearly labelled stainless steel bowl covered with aluminium foil. Once the boring has been completed and the sample interval has been determined, the remainder of the soil can be homogenized according to Section 7.2 and submitted for laboratory analysis.

7.3.8 Once a boring is complete and all required samples have been collected, the boring must be completed as specified in the SAP (e.g., completed as a monitoring well, backfilled with bentonite, etc).

7.4 Direct Push Sampling

At each boring location, the frequency of direct-push samples will be determined from the SAP. Typically, samples with direct-push equipment are collected in 4 foot (ft) intervals, but smaller (e.g., 2 ft) and larger (e.g., 5 ft) intervals are also possible.

1. Sample using Macro-Core samplers with acetate liners to obtain discrete soil samples at the depths specified in the SAP.

2. Cut open the acetate liner. If required in the SAP, immediately scan the recovered soil boring for VOCs using a PID by making a hole in the soil with a decontaminated trowel and placing the PID inlet very close to the hole. Be very careful not to get soil on the tip of the PID. Take PID readings every 6 inches along the split-spoon and/or in any areas of stained or disturbed soil. Record the

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highest PID reading and the depth at which it was observed along with all other pertinent observations. VOC and headspace samples, if required in the SAP should be collected (see Section 7.6.1) prior to logging the sample.

3. If required in the SAP, collect a soil sample (as defined in the SAP) and perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.

4. Soils collected using the direct-push sampler will be logged by the by the field representative using the procedure required in the SAP.

5. Collect the remainder of the sample into a stainless steel bowl. Homogenize the soil collected so that the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.

6. Once a boring is complete and all required samples have been collected, the boring must be completed as specified in the SAP (e.g., completed as a monitoring well, backfilled with bentonite, etc).

7.5 Test Pit Sampling

7.5.1 Excavate the test pit to the desired depth.

7.5.2 Using the excavator bucket, collect soil samples as specified in the SAP. Collect a sample and perform screening analyses as required by the SAP. If VOCs contamination is suspected, perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.

7.5.3 Collect the sample from center of the bucket to avoid potential contamination from the bucket.

7.5.4 VOC samples should also be collected from an undisturbed section soil in the excavator bucket. The top layer of exposed soil should be scraped away just prior to collecting the VOC samples.

7.5.5 Collect the remainder of the sample volume required into a stainless steel bowl. Homogenize the soil so the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.

7.5.6 Dispose of all excavated soil according to the SAP.

7.6 Sample Collection Methods

7.6.1 Volatile Organics Sampling

For soils collected for analyses of volatile organics, including Volatile Petroleum Hydrocarbons (VPH) or other purgable compounds, a closed system is maintained. From collection through analysis, the sample bottles are not opened. The bottle kit for a routine field sample for these analyses will typically include three 40-mL VOA vials and one soil jar. Two 40-mL VOA vials will contain either 5 mL reagent water or 5 mL sodium bisulfate and magnetic stir bars (i.e., low level vials). The third VOA vial will contain 15 mL methanol with no magnetic stir bar (i.e., high level vial). These vials are usually provided by the laboratory and are pre-weighed, with the tare weight recorded on the affixed sample label. No additional sample labels are affixed to the VOA vials, as addition of a label would alter the vial weight. All information is recorded directly on the sample label using an indelible marker. The soil jar is provided for percent solids determination. For VOC or VPH analyses, samples are collected prior to sample homogenization. Collect the VOC sample in accordance with the procedure described below.

1. Determine the soil volume necessary for the required sample weight, typically 5 grams:

   a) Prepare a 5 mL sampling corer (e.g., Terra Core®) or cut-off plastic syringe.

   b) Tare the sampler by placing it on the scale, and zeroing the scale.

   c) Draw back the plunger to the 5 gram mark or 5mL (5cc) mark on cut-off syringe, and insert the open end of the sampler into an undisturbed area of soil with a twisting motion, filling the

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sampler with soil. Note the location of the plunger with respect to the milliliter (cc) or other graduation printed on the sampler.

d) Weigh the filled sampler, and remove or add soil until the desired weight is obtained. Note the location of the plunger which corresponds to this weight. Do not use this sample for laboratory analysis.

2. Once the required soil volume has been determined, pull the plunger back to this mark and hold it there while filling the syringe for each sample.

3. Collect 5 grams of soil using the cut-off syringe or Terra Core® sample device. Extrude the 5-grams of soil into one of the low level 40-mL VOA vials. Quickly wipe any soil from the threads of the VOA vial with a clean Kimwipe® and immediately close the vial. It is imperative that the threads be free from soil or other debris prior to replacing the cap on the vial in order to maintain the closed system necessary for the analysis.

4. Gently swirl the vial so that all of the soil is fully wetted with the preservative.

5. Fill the other low level 40 mL VOA vial in this manner.

6. Repeat the process for the high level VOA vials, only for the high level VOA vial three 5 gram aliquots (i.e., 15 grams total) should be extruded into the high level VOA vial.

   NOTE: Depending on the laboratory, some high level VOA vials only contain 5 mL or 10 mL of methanol. If this is the case, either 5 grams total or 10 grams total, respectively, should be extruded into the high level VOA vial. In other words, the mass of soil in grams should be identical to the volume of methanol in mL (i.e., 1:1 ratio of soil to methanol).

7. Collect any additional QC sample collected (e.g., field duplicate, MS, and MSD) in the same manner as above.

8. Fill the 4-oz glass jar with soil from the same area for percent moisture determination.

7.6.2 Soil Sampling Method (All other analyses except VOC/VPH)

When all the required soil for a sampling location has been obtained, the soil can be homogenized as described in section 7.2. Collect sufficient volume to fill all of the remaining sample containers at least ¾ full for all other analyses. Homogenize the soil in a decontaminated stainless steel bowl, removing rocks, sticks, or other non-soil objects and breaking apart any lumps of soil prior to filling the remaining sample containers.

NOTE: Soil samples must contain greater than 30% solids for the data to be considered valid.

8.0 Quality Control and Assurance

8.1 Sampling personnel should follow specific quality assurance guidelines as outlined in the SAP. Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements outlined in the SAP typically suggest the collection of a sufficient quantity of field duplicate, field blank, and other samples.

8.2 Quality control requirements are dependent on project-specific sampling objectives. The SAP will provide requirements for equipment decontamination (frequency and materials), sample preservation and holding times, sample container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

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9.0 Records, Data Analysis, Calculations

All data and information (e.g., sample collection method used) must be documented on field data sheets, boring logs, or within site logbooks with permanent ink. Data recorded may include the following:

- Weather conditions;
- Arrival and departure time of persons on site;
- Instrument type, lamp (PID), make, model and serial number;
- Calibration gas used;
- Date, time and results of instrument calibration and calibration checks;
- Sampling date and time;
- Sampling location;
- Samples collected;
- Sampling depth and soil type;
- Deviations from the procedure as written; and
- Readings obtained.

10.0 Attachments or References

SOP 3-06, *Equipment Decontamination*

SOP 3-19, *Headspace Screening for Total VOCs*

SOP 3-20, *Operation and Calibration of a Photoionization Detector*

Author	Reviewer	Revisions (Technical or Editorial)
Robert Shoemaker Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)

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Standard Operating Procedure SOP-3-24
Water Quality Parameter Testing for Groundwater Sampling

1.0 PURPOSE

This standard operating procedure (SOP) represents minimum standard of practice. State and federal requirements may vary, and this SOP does not replace state and federal requirements that must be consulted before work begins. Further, if a project-specific work plan has been created, the work plan should be considered the ruling document. This SOP may be modified to meet specific regulatory, client, or project specific criteria.

If there are procedures whether it be from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to water quality parameter testing, then those procedures may be added as an appendix to the project-specific Sampling and Analysis Plan (SAP).

2.0 SCOPE

This procedure provides guidance for expected sampling methods and protocols by all personnel related to the measurement of water quality parameters.

Field measurements of water quality parameters are commonly performed to evaluate surface water and groundwater. These tests are often performed to evaluate basic water quality parameters, to evaluate natural attenuation parameters, and to assess the presence of pore water entering a well.

As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

3.0 DEFINITIONS

3.1 Barometric Pressure (BP)

The density of the atmosphere, which varies according to altitude and weather conditions.

3.2 Conductivity/Specific Conductance

A measure of the ability of water to pass electrical current, which increases with the amount of dissolved ionic substances (i.e., salts). Conductivity is inversely related to the resistance of a solution and is measured in units of mhos per centimeter (mhos/cm) (inverse ohms/cm, Siemens/cm). The conductivity of water increases with increasing temperature.

Specific Conductance is corrected for 25 degrees Celsius (°C); for this reason, it is best to record Specific Conductance. If Conductivity is recorded, the temperature of the sample MUST recorded.

3.3 Dissolved Oxygen (DO)

The amount of oxygen present in water and available for respiration. DO is typically measured in milligrams per liter (mg/L). Oxygen is less soluble in warm and salty waters, so the instrument compensates the apparent percent saturation for changes in temperature and conductivity. Most probes measure the current resulting from the electrochemical reduction of oxygen (at a gold cathode) diffusing through a selective membrane. Because oxygen is being removed from the sample to perform the measurement, sample flow is required to prevent false low readings due to depletion of oxygen in the solution in front of the probe. Optical DO probes do not remove oxygen from the sample and are less affected by salts. The common range of DO in groundwater is 0.0 to 3.0 mg/L. Measurements outside of this range suggest that the meter may not be operating correctly.

3.4 Nephelometric Turbidity Unit (NTU)

The measurement of light passing through a sample based on the scattering of light caused by suspended particles.

3.5 pH

A measure of acidity and alkalinity of a solution using a logarithmic scale on which a value of 7 represents neutrality, lower numbers indicate increasing acidity, and higher numbers are increasingly basic.

3.6 Oxidation-Reduction Potential (ORP)

Also known as redox or eH, ORP is a measurement of the potential for a reaction to occur, which generally indicates the oxygen status of a sample. The probe consists of a platinum electrode, the potential of which is measured with respect to a reference electrode that rapidly equilibrates with the potential of the sample solution. A positive value indicates that oxygen is present. A negative value indicates an anaerobic environment or reducing condition. For this reason, negative ORP readings should be associated with DO readings of less than 0.5 mg/l; with negative ORP readings the water may exhibit a sulfur odor or gray color. Positive ORP readings should be associated with DO readings greater than 0.5 mg/L and lack of sulfur odors. Because of the complex relationship between ORP and temperature, no compensation is attempted; it is thus best to report both the ORP and temperature of a water sample.

3.7 Total Dissolved Solids

A measure of the quantity of materials in water that are either dissolved or too small to be filtered.

3.8 Turbidity

Measure of the clarity of water in NTUs. Potable water typically has NTU values between 0.0 and 0.3 NTUs, depending on the state or regulatory program.

4.0 RESPONSIBILITIES

The CTO Manager, or designee, is responsible for ensuring that these standard groundwater sampling activities are followed and shall review all groundwater sampling forms at the conclusion of a sampling event. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks. The QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure. The Field Manager is responsible for ensuring that all project field staff follows these procedures.

Field sampling personnel are responsible for the implementation of this procedure. Personnel are required to be knowledgeable of the procedures in this SOP. Training and familiarization with this SOP shall be documented in the training file for each employee. The field sampler and/or Field Manager is responsible for directly supervising the calibration procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the CTO Manager, QA Manager, or Technical Director and then documented in the field logbook and associated report or equivalent document.

5.0 PROCEDURES

5.1 Purpose

The procedures will vary depending on parameters being measured, method of sampling, and the method of measurement used. The information here is a general guidance and the site-specific documents and manufacturer manuals supersede these procedures.

5.2 Cautions

Improper use of water quality testing equipment could result in equipment damage or compromised sampling results. Personnel should be trained to operate the test equipment being used for a field operation and should be trained in the proper techniques for collecting and

logging water quality parameters. Personnel should also be able to recognize problems with test equipment and have someone available for basic troubleshooting and repair.

5.3 Interferences

During field testing, water quality data that is documented from field testing equipment may be influenced by certain outside factors that are unrelated to the actual site water quality. Such parameters and equipment include the following:

pH Meters

- Coatings of oils, greases, and particles may impair the electrode's response. Pat the electrode bulb dry with lint-free paper or cloth and rinse with de-ionized water. For cleaning hard-to-remove films, use isopropyl alcohol very sparingly so that the electronic surface is not damaged.

- Poorly buffered solutions with low specific conductance (less than 200 microsiemens per centimeter) may cause fluctuations in the pH readings. Equilibrate electrode by immersing in several aliquots of sample before taking pH.

Dissolved Oxygen

- Dissolved gases (e.g., hydrogen sulfide, halogens, sulfur dioxide) are a factor with the performance of DO probes. The effect is less pronounced on optical DO meters. Meter type and potential interferences should be considered based on potential sulfate/sulfide or nitrate/nitrite reducing environments.

- Exposure of the sample to the atmosphere will cause elevated DO measurements.

Turbidity Meter

- If the weather is warm and humidity is high, condensation may collect on the cuvet. To avoid this, allow the sample to warm and dry the outside of the cuvet before making the measurement. One method used to accomplish this is to place the cuvet against one's body (armpits work well).

Temperature

- Sample temperature will change rapidly when there are significant differences between the sample and ambient air.

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5.4 Apparatus and Materials

Field personnel shall consult the site work plan and SAP to review the equipment requirements for the sampling procedures to be followed during the sampling effort. The specific apparatus and materials required will depend on the water quality parameters being monitored. Table 1 shows the common equipment used in water quality parameter testing.

Table 1
Water Quality Parameter Testing — Common Equipment

Water Quality Parameter Instrument	Calibration Standards Required	Other Equipment
pH Meter	Yes - 2 or 3 Point Standards depending on groundwater range. Calibration must cover the range to be measured. If samples are above or below typical buffer standards (4, 7 and 10), special order buffers that fall outside groundwater pH range.	Container or flow thru cell for holding sample
Specific Conductance	Yes	Container or flow thru cell for holding sample
ORP Meter	Yes	Container or flow thru cell for holding sample
Turbidity Meter	Yes	Container or flow thru cell for holding sample
DO	No	Container or flow thru cell for holding sample
Thermometer	No	Container or flow thru cell for holding sample
Flow Rate	No	Calibrated Container

Notes:
ORP = Oxidation-Reduction Potential
DO = Dissolved Oxygen

5.5 Instrument or Method Calibration

Most monitoring instruments require calibration before use, and this calibration must be conducted in the field under the ambient climatic conditions that will be present during field sampling. Calibration of monitoring instruments shall be performed in accordance with the manufacturer's specifications and recorded in the provided form in Attachment 1. Site-specific instrument calibration requirements should be specified in the SAP. The following minimum calibration requirements apply to the various types of meters used to gather water quality measurements.

Initial Calibration (IC): Before use, the instrument or meter electronics are adjusted (manually or automatically) to a theoretical value (e.g., DO saturation) or a known value of a

calibration standard. An IC is performed in preparation for the first use of an instrument or if a calibration verification does not meet acceptance criteria.

Initial Calibration Verification (ICV): The instrument or meter calibration is checked or verified directly following IC by measuring a calibration standard of known value as if it were a sample and comparing the measured result to the calibration acceptance criteria for the instrument/parameter. If an ICV fails to meet acceptance criteria, immediately recalibrate the instrument using the applicable initial calibration procedure or remove it from service.

Continuing Calibration Verification (CCV): After use, the instrument or meter calibration is checked or verified by measuring a calibration standard of known value as if it were a sample and comparing the measured result to the calibration acceptance criteria for the instrument/parameter.

5.5.1 Calibration Checks

Calibration checks are conducted by measuring a known standard. They must be completed after calibration and should be performed at least one other time (i.e., after lunch) and anytime suspect measurements are encountered. Table 2 provides general acceptance ranges to be used during calibration checks. If a meter is found to be outside of the acceptance range, the meter **must** be recalibrated. If the meter remains out of range, the project manager and/or the supplier of the meter should be contacted to determine alternative measures.

Table 2
Calibration Check Acceptance Limits

Parameter	Acceptance Criteria
Dissolved Oxygen	±0.3 mg/L of the theoretical oxygen solubility
Oxidation-Reduction Potential	±10 mv from the theoretical standard value at that temperature
pH	±0.2 Standard pH Units
Specific Conductance	±5% of the standard
Turbidity	0.1 to 10 NTU: ±10% of the standard 11 to 40 NTU: ±8% of the standard 41 to 100 NTU: ±6.5% of the standard

Notes:
mg/L = milligrams per liter
mv = millivolts
NTU = nephelometric turbidity units

5.5.2 Possible and Suspected Ranges

The concentration for each parameter range should be known so that concentrations outside of the range can be noted. Table 3 presents the maximum range of the parameter in groundwater. The table also presents the suspected range. Measurements outside of the maximum/minimum range should be considered in error and the measurement method should be checked. Concentrations outside the normal range should be treated as suspect but may be the result of contaminant impact. For example, a pH of 2.0 would be out of the normally suspected range for groundwater but not at a site impacted with an acid.

Table 3
Minimum and Maximum Result Ranges

Parameter	Units	Possible Min	Possible Max	Normal Min	Normal Max	Notes
Dissolved Oxygen	mg/L	0.0	14.6 (0°C) 10.1 (15°C) 8.3 (2°C)	0.0	5	The colder the sample, the higher the DO reading. DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron and/or gray color. DO less than 1 mg/L, ORP negative, may have sulfur odor, sulfide, ferrous iron and/or gray color.
pH	SU	0	14	5	9	pH values exceeding 10 could indicate grout contamination
ORP	mv					DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron and/or gray color. DO less than 1 mg/L, ORP negative, may have sulfur odor, sulfide, ferrous iron and/or gray color.
Specific Conductance	µS/cm			varies	varies	
Temperature	°C	0	100	5	30	
Turbidity	NTU	0	Greater than 1,000	0	Greater than 1,000	50 NTU or greater suggests cloudiness.

Notes:

mg/L = milligrams per liter
°C = degrees Celsius
DO = dissolved oxygen
SU = standard units
ORP = oxidation reduction potential
mv = millivolts
mS/cm = micro Siemens per cm
NTU = nephelometric turbidity units

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5.5.3 Field Instruments and Calibration Criteria

The calibration acceptance criteria for each instrument are summarized in Table 4 along with special considerations related to each field instrument.

Table 4
Calibration Check Acceptance Limits

Parameter	Acceptance Criteria
Dissolved Oxygen	±0.3 mg/L of the theoretical oxygen solubility.
Oxidation-Reduction Potential	±10 mv from the theoretical standard value at that temperature.
pH	±0.2 Standard pH Units
Specific Conductance	±5% of the standard
Turbidity	0.1 to 10 NTU: ±10% of the standard 11 to 40 NTU: ±8% of the standard 41 to 100 NTU: ±6.5% of the standard

Notes:
mg/L = milligrams per liter
mv = millivolts
NTU = nephelometric turbidity units

pH Meters

- For the most accurate of pH measurements, pH meters should receive a three-point calibration. However, if a two-point calibration will bracket the groundwater pH of the site, a two-point calibration is acceptable. Three-point calibrations typically include calibrating to solutions of pH 7.00, 4.00, and 10.00. If groundwater pH is outside the calibration range of the solution standards, special buffers must be ordered to bracket the pH. Some meters will report the slope of the calibration and this may be used in checking the meter calibration (refer to the meter's manual). When performing an ICV, the result must be within +/- 0.2 pH units of the stated buffer value.

- pH meters should be calibrated across the range of values to be measured. The maximum and minimum calibration solutions shall be outside the range of anticipated values. For example, if the expected range is between 7.50 and 9.00, the 7.00 and the 10.00 standard should be used for calibration. Perform the IC using at least two buffers, and always use the pH 7.00 buffer first. A reading that is above the maximum (or below the minimum) calibration standard is an estimate only and is not valid. This condition requires obtaining a new standard that is above (or below) the reported value, depending on the measurement.

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- A percent slope of less than 90 percent indicates a bad electrode that must be changed or repaired. If percent slope cannot be determined, or the manufacturer's optimum specifications are different, follow the manufacturer's recommendation for maintaining optimum meter performance.

Specific Conductivity Meters

- For IC, when the sample measurements are expected to be 100 microsiemens per centimeter (µS/cm) or greater, use two standard potassium chloride (KCl) solutions that bracket the range of expected sample conductivities. Calibrate the instrument with the first standard. Verify the calibration of the instrument with the second standard, bracketing the range of expected sample values.

- If the instrument can be calibrated with more than one standard, choose additional calibration standards within the range of expected sample values.

- When the sample measurements are expected to be less than 100 µS/cm, a lower bracket is not required, but one standard (KCl) solution that is within the range of expected measurements must be used for the IC and the ICV.

- Accept the calibration if the meter reads within +/- 5 percent of the value of any calibration standard used to verify the calibration.

- Most field instruments read conductivity directly. Record all readings and calculations in the calibration records.

- For CCV, check the meter with at least one KCl standard with a specific conductance in the range of conductivity measured in environmental samples. The reading for the calibration verification must also be within +/- 5 percent of the standard value.

- If new environmental samples are encountered outside the range of the IC, verify the instrument calibration with two standards bracketing the range of sample values. If these calibration verifications fail, recalibrate the instrument.

Dissolved Oxygen Meters

- Before calibrating, check the probe membrane for bubbles, tears, or wrinkles. These conditions require replacement of the membrane in accordance with the manufacturer's directions.

- If the meter provides readings that are off-scale, will not calibrate, or drift, check the leads, contacts, etc., for corrosion and/or short circuits. These conditions require replacement maintenance in accordance with the manufacturer's directions.
- Most DO meters must be calibrated based on an environment of 100 percent humidity and a known elevation and barometric pressure (BP).

- For 100 percent humidity, place the probe in the calibration container with a moist towel and allow the probe to remain, undisturbed, for 10 to 20 minutes.

- The IC is an air calibration at 100% saturation. Before use, verify the meter calibration in water-saturated air to make sure it is properly calibrated and operating correctly. Make a similar verification at the end of the day or sampling event. Follow the manufacturer's instructions for your specific instrument. Allow an appropriate warm up period before IC. Wet the inside of the calibration chamber with water, pour out the excess water (leave a few drops), wipe any droplets off the membrane/sensor and insert the sensor into the chamber (this ensures 100 percent humidity). Allow adequate time for the DO sensor and the air inside the calibration chamber to equilibrate. Once the probe/calibration chamber is stable at ambient temperature, check the air temperature and determine, from the DO versus temperature table (see Attachment 2) what DO should measure. The acceptance criterion for DO ICV is +/- 0.3 mg/L.

- Use the same procedure as above for CCV.

ORP Meters

- Verify electrode response before use in the field.

- Equilibrate the standard solution to the temperature of the sample. The standard solution is based on a 25°C temperature; however, the calibration solution standard's value will require adjustment based on the temperature.

- Immerse the electrodes and gently stir the standard solution in a beaker (or flow cell). Turn the meter on, placing the function switch in the millivolt (mv) mode.

- Let the electrode equilibrate and record the reading to the nearest millivolt. The reading must be within ±10 mv from the theoretical redox standard value at that temperature. If not, determine the problem and correct it before proceeding. Switch to temperature display and read the value.

- Record the mv reading and temperature in the field notebook or in form. Rinse the electrode with distilled water and proceed with the sample measurement, unless using a flow cell. If a flow cell is used, rinse between sample locations.

Turbidity Meters

- Perform an initial calibration using at least two primary standards.

- If the instrument cannot be calibrated with two standards, calibrate the instrument with one standard and verify with a second standard.

- Perform an ICV by reading at least one primary standard as a sample. The acceptance criterion for the ICV depends on the range of turbidity of the standard value:

  1. Standard Value = 0.1 to 10 NTU: the response must be within 10 percent of the standard;

  2. Standard Value = 11 to 40 NTU: the response must be within 8 percent of the standard;

  3. Standard Value = 41 to 100 NTU: the response must be within 6.5 percent of the standard; and

  4. Standard Value greater than 100 NTU: the response must be within 5 percent of the standard.

- Determining the Values of Secondary Standards: Use only those certified by the manufacturer for a specific instrument. Secondary standards may be used for CCVs.

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To initially determine the value of a secondary standard, assign the value that is determined immediately after an ICV or verification with primary standards. This is done by reading the secondary standard as a sample. This result must be within the manufacturer's stated tolerance range and +/- 10 percent of the assigned standard value. If the +/- 10 percent criterion is not met, assign this reading as the value of the standard. If the reading is outside the manufacturer's stated tolerance range, discard the secondary standard.

- CCV: Perform a CCV using at least one primary or secondary standard. The calibration acceptance criteria are the same as those for an ICV.

5.6 Direct Measurements

Direct measurements with meters are the most common methods and can be accomplished by placing a sample in a container with the probe or by allowing the water to flow past the probe in a flow cell. The use of a flow-through cell improves measurement quality by allowing the constant flow of water over the probes and reduces interaction of the sample with the atmosphere. Sample cups should be avoided. The quantity of samples, timing, and methodology should be described in the project SAP.

Following calibration of required probes, connect the bottom flow-cell port to the discharge line of the pump. Connect the top port to a discharge line directed to a bucket to collect the purge water. Allow the flow cell to completely fill. As the water flows over the probe, record the measurements. Continue to record the measurements at regular intervals, as specified in the SAP.

When the ambient air temperatures are much higher or lower than the temperature of the water sample, it is best to keep the length of tubing between the wellhead and the flow cell as short as possible to prevent heating or cooling of the water. Tubing and flow-through cell should not be exposed to direct sunlight, particularly in the summer, if at all possible, to avoid heating of water samples.

5.7 Data Acquisitions, Calculations, and Data Reduction

5.7.1 Specific Conductivity Correction Factions

If the meter does not automatically correct for temperature (i.e., read Specific Conductivity) record Conductivity and adjust for temperature upon returning to the office. The following equation can be used to convert Conductivity to Specific Conductivity.

$$K = \frac{(Km)(C))}{1 + 0.0191(\mathrm{T} - 25)}$$

Where:

K	=	Conductivity in μmhos/cm at 25°C
Km	=	Measured conductivity in μmhos/cm at T degrees Celsius
C	=	Cell constant
T	=	Measured temperature of the sample in degrees Celsius;

If the cell constant is 1, the formula for determining conductivity becomes:

$$K = \frac{(Km)}{1 + 0.0191(\mathrm{T} - 25)}$$

5.7.2 Percentage Difference Calculation

For evaluating slope of readings from either a flow cell or a sample cup.

$$\%Difference = \frac{(Highest\ Value - Lowest\ Value)}{(Highest\ Value)}\ x\ 100$$

5.7.3 Convert mm mercury (mmHG) to inches mercury (inHG)

$$mmHG = inHG\ x\ 25.4$$

5.7.4 True Barometric Pressure

For converting BP obtained from a public domain source that is expressed in BP at sea level to BP at the subject site.

$$TrueBP = (BP) - \frac{(2.5\ x\ [Local\ Altitude])}{100}$$

Where: BP is in mmHG and Local Altitude is in feet

Example: BP at site A is 30.49 inHg and elevation is 544 feet, calculate TrueBP

Convert inHG to mmgHG:

mmHg = 30.49 inHg x 25.4 = 774.4 mmHg

Calculate True BP:

TrueBP = (774.4 mmHg) – [2.5 * (544 /100)] = 774.4-13.6 = 760.8 mmHg

6.0 RECORDS

Data will be recorded promptly, legibly, and in indelible ink on the appropriate logbooks and forms. At the completion of a field effort, all logbooks, field data forms, and calibration logs shall be scanned and made electronically available to the project team. The original field forms, calibrations logs, and log book will be maintained in the project file.

7.0 HEALTH AND SAFETY

Detailed Health and Safety requirements can be found in the site specific Health and Safety Plan. Ensure that a Safe Work Assessment and Permit form is filled out daily prior to any work in the field and reviewed with all project personnel in a daily safety brief.

Safety glasses with side shields or goggles and disposable gloves shall be worn during calibration activities.

8.0 REFERENCES

None

9.0 ATTACHMENTS

Attachment 1: Example Field Instrument Calibration Form
Attachment 2: Solubility of Oxygen at Given Temperatures
Attachment 3: Example Field Data Form

Attachment 1

Example Field Instrument Calibration Form

Field Instrument Calibration Form

Calibrated by: _____ Equipment (Make/Model/Serial#): _____

Date: _____ Equipment (Make/Model/Serial#): _____

pH (su) — Standard: ± 0.2 standard units

Initial Calibration / Initial Calibration Verification

	Hach SL	Reading	Pine SL	Reading
pH7				
pH4				

Continuing Calibration Verification

	Hach SL	Reading	Deviation	Acceptable Variance (Y/N)
pH7				
pH4				

DO (mg/L) — Standard: ± 0.3 mg/L of theoretical*

IC (Temp:)		ICV (Temp:)	
Saturation (%)	Reading (%)	Theoretical (mg/L)	Reading (mg/L)
100			

CCV (Temp:)

Saturation (%)	Reading (%)	Deviation	Acceptable Variance (Y/N)
100			

Theoretical (mg/L)	Reading (mg/L)	Deviation	Acceptable Variance (Y/N)

ORP (mV) — Standard: NA

IC (Zobell SL:)		ICV (Pine SL:)	
TCS (Std/Temp)	Reading	TCS (Std/Temp)	Reading

CCV (Zobell SL:)

TCS (Std/Temp)	Reading	Deviation	Acceptable Variance (Y/N)

Turbidity (ntu) — Standard: ±10% of Standard

Initial Calibration

Standard	Reading

Continuing Calibration Verification

Standard	Reading	Deviation	Acceptable Variance (Y/N)

Conductivity (ms^{C}/cm) — Standard: ± 5% of standard value

IC (YSI SL:)		ICV (Pine SL:)	
Standard	Reading	Standard	Reading

CCV (YSI SL:)

Standard	Reading	Deviation	Acceptable Variance (Y/N)

Comments:

Notes:

SL	solution lot	su	standard units	ntu	Nephelometric Turbidity Units
TCS	temperature corrected standard	mV	millivolts	°C	degrees Celsius
Std	standard	%	percent	ms°/cm	millisiemens per centimeter (temperature corrected)
Temp	temperature	mg/L	milligrams per liter	*	Theoretical value

Attachment 2

Solubility of Oxygen at Given Temperatures

Field Measurement of Dissolved Oxygen

Solubility of Oxygen in Water at Atmospheric Pressure			
Temperature	**Oxygen Solubility**	**Temperature**	**Oxygen Solubility**
°C	**mg/L**	**°C**	**mg/L**
0.0	14.621	26.0	8.113
1.0	14.216	27.0	7.968
2.0	13.829	28.0	7.827
3.0	13.460	29.0	7.691
4.0	13.107	30.0	7.559
5.0	12.770	31.0	7.430
6.0	12.447	32.0	7.305
7.0	12.139	33.0	7.183
8.0	11.843	34.0	7.065
9.0	11.559	35.0	6.950
10.0	11.288	36.0	6.837
11.0	11.027	37.0	6.727
12.0	10.777	38.0	6.620
13.0	10.537	39.0	6.515
14.0	10.306	40.0	6.412
15.0	10.084	41.0	6.312
16.0	9.870	42.0	6.213
17.0	9.665	43.0	6.116
18.0	9.467	44.0	6.021
19.0	9.276	45.0	5.927
20.0	9.092	46.0	5.835
21.0	8.915	47.0	5.744
22.0	8.743	48.0	5.654
23.0	8.578	49.0	5.565
24.0	8.418	50.0	5.477
25.0	8.263		

Notes:

The table provides three decimals to aid interpolation

Under equilibrium conditions, the partial pressure of oxygen in air-saturated water is equal to that of the oxygen in water saturated

°C = degrees Celsius

mg/L = milligrams per liter

Attachment 3
Example Field Data Form

WELL DEVELOPMENT & GROUNDWATER SAMPLING FORM

DATE:	JOB NUMBER:	EQUIPMENT (Make/Model #/Serial #):
PROJECT:	EVENT:	/ /
WELL ID:	LOCATION:	/ /
WEATHER CONDITIONS:	AMBIENT TEMP:	/ /
REVIEWED BY:	PERSONNEL:	/ /

WELL DIA:	**WELL DEVELOPMENT**	
TOTAL DEPTH from TOC (ft.):	START:	FINISH:
DEPTH TO WATER from TOC (ft.):	VOLUME PURGED (gal):	
LENGTH OF WATER COL. (ft.):	**GROUNDWATER SAMPLING**	
1 VOLUME OF WATER (gal):	START:	FINISH:
3 VOLUMES OF WATER (gal):	VOLUME PURGED (gal):	
	ANALYSIS:	

WELL DEVELOPMENT PARAMETERS		GW SAMPLING PARAMETERS	
Temperature:	± 1.0° C	Temperature:	± 0.2° C
pH:	± 0.5 standard units	pH:	± 0.2 standard units
Specific Conductance:	± 10% of the past measurement	Specific Conductance:	± 5% of the past measurement
Turbidity:	relatively stable	DO:	≤ 20% saturation
		ORP:	± 10 millivolts
		Turbidity:	≤ 10 NTU

IN-SITU TESTING

Circle one: DEVELOPMENT SAMPLING ☐ Bailer ☐ Pump Description:

Time (hh:mm):												
pH (units):												
Conductivity (mS/cm):												
Turbidity (NTU):												
DO (mg/L): YSI 556												
DO (mg/L): YSI 550												
Temperature (C°):												
ORP (mV):												
Volume Purged (gal):												
Depth to Water (ft):												
								Well Goes Dry While Purging ☐				

SAMPLE DATA

☐ Bailer ☐ Pump Description:

Sample ID	Date (m/d/y)	Time (hh:mm)	Bottles (total to lab)	Filtered (0.45 µm)	Remarks
Purging/Sampling Device Decon Process:					

COMMENTS:

Purge water placed in drum#_____

Page __ of __

Subsurface Soil Sampling by Split Spoon

Procedure 3-33

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the methods used in obtaining subsurface soil samples using a split spoon for physical and/or chemical analysis. Subsurface soil samples are obtained in conjunction with soil boring programs and provide information as to the physical and/or chemical makeup of the subsurface environment. Specific information regarding sampling locations can be found in the associated Sampling and Analysis Plan (SAP).

1.2 The purpose of this SOP is to provide a description of a specific method or procedure to be used in the collection of subsurface soil samples. Subsurface soil is defined as unconsolidated material which may consist of one or a mixture of the following materials: sand, gravel, silt, clay, peat (or other organic soils), and fill material. Subsurface soil sampling, conducted in accordance with this SOP will promote consistency in sampling and provide a basis for sample representativeness.

1.3 This SOP covers subsurface soil sampling by split-spoon only, as this is the means most often used for obtained samples of unconsolidated deposits. Other types of equipment are available for use in subsurface soil sampling, including thin-wall tube samplers (Shelby tubes), piston samplers, and continuous core barrel samplers. Information on the use of these other sampling devices may be found in several available drilling handbooks and respective state and/or federal agency technical guidance documents. The American Society for Testing and Materials (ASTM) also provides procedures for use of split-spoon and other sampling devices.

1.4 Split-spoon subsurface soil sampling generally requires use of a drilling rig and typically the hollow-stem auger (HSA) or other common drilling method to generate a borehole in which to use the split-spoon sampler. The split-spoon sampler is inserted through the augers (or other type of drill casing) then is driven into the subsurface soil with a weighted hammer. The sampler is then retrieved and opened to reveal the recovered soil sample. Soil samples may be collected at a continuous interval or at pre-selected vertically spaced intervals within the borehole.

1.5 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).

1.6 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review. If there are procedures whether it be from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to surface water sampling then those procedures may be added as an appendix to the project specific SAP.

1.7 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Program Quality Manager. Deviations to this SOP will be documented in the field records.

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2.0 Safety

2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first location. All **field sampling personnel** responsible for sampling activities must review the project-specific health and safety plan (HASP) paying particular attention to the control measures planned for the sampling tasks. Conduct preliminary area monitoring to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor and liquid phase through the use of respirators and disposable clothing.

2.2 In addition, observe standard health and safety practices according to the project-specific HASP. Suggested minimum protection during well sampling activities includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves, rubberized steel-toed boots, and an American National Standards Institute-standard hard hat. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations, and shall always be available on site.

2.3 Daily safety briefs will be conducted at the start of each working day before any work commences. These daily briefs will be facilitated by the **Site Safety Officer (SSO)** or designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the HASP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.

2.4 The health and safety considerations for the work associated with split spoon sampling include:

- To avoid lifting injuries associated with carrying split spoons and associated drilling/sampling equipment, use large muscles of the legs, not the back.
- Stay clear of all moving equipment, and avoid wearing loose fitting clothing.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and in case of extreme cold, wear fitted insulated clothing.
- Be aware of restricted mobility due to PPE.
- At no point should soil samples be put into the mouth.

3.0 Terms and Definitions

None.

4.0 Interference

Potential interferences could result from cross-contamination between samples or sample locations. Minimization of the cross contamination will occur through the following:

- The use of clean sampling tools at each location as necessary.
- Avoidance of material that is not representative of the media to be sampled.
- Extreme temperatures or humidity can affect the reliability of certain field screening equipment, such as photoionization detectors (PID).
- If screening soil samples for headspace readings in extreme cold temperatures, samples may need to be warmed slightly prior to screening.

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5.0 Training and Qualifications

5.1 Qualifications and Training

5.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **Contract Task Order (CTO) Manager** is responsible for ensuring that split spoon sampling activities comply with this procedure. The **CTO Manager** is responsible for ensuring that all field sampling personnel involved in split spoon sampling shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Field Manager** (FM) is responsible for ensuring that all field sampling personnel follow these procedures.

5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure. Minimum qualifications for field sampling personnel require that one individual on the field team shall have a minimum of 6 months of experience with split spoon sampling.

5.2.5 The **field sampler and/or task manager** is responsible for conducting split spoon soil sampling in a manner which is consistent with this SOP. The field sampler or designee will observe all activities pertaining to split spoon soil sampling to ensure that the SOP is followed, and to record all pertinent data onto a boring log. It is also the responsibility of the field sampler or designee to indicate the specific targeted sampling depth or sampling interval to the drilling subcontractor. The field sampler or designee is also responsible for the collection of representative environmental or stratigraphic characterization samples once the sampling device has been retrieved and opened. Additional sample collection responsibilities include labelling, handling, and storage of samples until further chain-of-custody procedures are implemented**.** If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the Program Quality Manager and then documented in the field logbook and associated report or equivalent document.

5.2.6 It will be the responsibility of the **drilling subcontractor** to provide the necessary materials for obtaining subsurface soil samples. This generally includes one or more split-spoon samplers in good operating condition and sample containers used for stratigraphic characterization samples (sample containers for environmental samples should be provided by the designated analytical laboratory). It is the drilling subcontractor's responsibility to provide and maintain their own boring logs if desired. Equipment decontamination materials should also be supplied by the subcontractor and should meet project specifications.

5.2.7 Sampling personnel will also be health and safety trained and certified as specified in the HASP.

6.0 Equipment and Supplies

In addition to those materials provided by the subcontractor, the following equipment list contains materials which may be needed in carrying out the procedures outlined in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- SAP and HASP
- Personal protective equipment (PPE) and other safety equipment, as required by the HASP
- Boring logs
- Teaspoon or spatula (stainless steel is recommended)

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- Sample kit (bottles, labels, custody records and tape, cooler with ice)
- Folding rule or tape measure
- Equipment decontamination materials
- Geologist Table
- Field logbook and pen with indelible ink

7.0 Calibration or Standardization

Field screening instruments (eg. PIDs) should be calibrated following manufacturer's instructions prior to the start of work and as a set time interval throughout the day. Calibration information should be recorded in the field log book or on a calibration log form.

8.0 Procedure

8.1 General Method Description

Split-spoon sampling devices are typically constructed of steel and are most commonly available in lengths of 18 and 24 inches and diameters of 1.5 to 3 inches. The split-spoon consists of a tubular body with two halves that split apart lengthwise, a drive head on the upper end with a ball-check valve for venting, and a hardened steel cutting shoe at the bottom. The soil sample enters the split-spoon through the cutting shoe as the device is driven into the ground. A replaceable plastic or metal basket is often inserted into the shoe to assist with retaining samples. Once the sampler is retrieved, the drive head and cutting shoes are removed and the split-spoon halves are then separated, revealing the sample.

Sample depth intervals are usually defined on a project-specific basis with these requirements specified in the project sampling plan. Sampling intervals typically range from one (1) sample per five (5) feet of drilling to continuous sampling where the entire drilled interval is sampled.

Subsurface soil sampling is usually accomplished as part of a drilling program where a soil boring is advanced with drilling equipment to the designated depth prior to collection of a representative sample. The general procedures outlined briefly in the following section provide requirements for advancing drill casing/augers in preparation for sampling.

8.2 General Procedures - Borehole Preparation

8.2.1 Advancing Casing/Augers

Soil borings that are completed for soil sampling purposes are typically advanced using hollow-stem augers and sometimes drive-and-wash or other casing methods. The casing/augers must be of sufficient diameter to allow for soil sampling at a minimum. The casing/augers will be advanced according to project requirements to the required depth for sampling. If hollow-stem augers are used, a temporary plug shall be used in the lead auger to prevent the auger from becoming filled with drill cuttings while drilling is in progress.

8.2.2 Obstructions

For those borings which encounter obstructions, the casing/augers will be advanced past or through the obstruction if possible. Caution should be exercised when obstructions are encountered and an effort made to identify the obstruction before drilling is continued. If the obstruction is not easily drilled through or removed, the boring should be relocated to an adjacent location.

8.2.3 Use of Added Water

The use of added or recirculated water during drilling is permitted when necessary. Use of extraneous water should be minimized or avoided if possible as it may impact sample quality. Water usage should be documented in the field notebook. Sampling and analysis of added or recirculated water may be

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required for quality assurance purposes (refer to SAP). If a well is installed within the completed borehole, removal of the added water may be required. State and/or local permitting may be required for adding water to the subsurface.

8.3 Sampling Procedure

8.3.1 Equipment Decontamination

Each split-spoon must be decontaminated prior to its initial use and following collection of each soil sample. Equipment decontamination procedures should be performed in accordance with SOP 3-06 – Equipment Decontamination. Any additional site-specific requirements for equipment decontamination will be outlined in the SAP.

8.3.2 Standard Penetration Test

The drilling subcontractor will lower the split-spoon into the borehole. Samples are generally obtained using the Standard Penetration Test (SPT) in accordance with ASTM standards (ASTM D 1586-84). Following this method, the sampler will be driven using the 140-pound hammer with a vertical free drop of 30 inches using two turns of the rope on the cathead. The number of hammer blows required for every 6 inches of penetration will be recorded on the boring log. Blowcount information is used as an indicator of soil density for geotechnical as well as stratigraphic logging purposes. Once the split-spoon has been driven to its fullest extent, or to refusal, it will be removed from the borehole.

8.3.3 Sample Recovery

The split-spoon will be immediately opened upon removal from the casing/auger. The open sampler should be screened for volatile organics with a photoionization device (PID) if required by the SAP. If the SAP also requires individual soil sample headspace screening for volatile organic compounds (VOCs), the procedure should be performed according to SOP 3-19 Headspace Screening for VOCs.

Sample recovery will be determined by the project geologist or designee who will examine the soil core once the sampler is opened. The length of sample shall then be measured with a folding rule or tape measure. Any portion of the split-spoon contents which are not considered part of the true sample (i.e., heaved soils) will be discarded. If the sample recovery is considered inadequate for sample characterization or analytical testing purposes, another sample should be collected from the next vertical interval if possible before drilling is reinitiated.

Adequate sample recovery for stratigraphic logging and/or headspace screening for VOCs purposes should be approximately 6 inches. Adequate sample recovery for analytical testing purposes should be a minimum of 12 inches and is somewhat dependent on the type of analytical testing required. In some cases, continuous sampling over a short interval, and compositing of the sample, may be required to satisfy analytical testing requirements. Larger diameter samplers may be used if large volumes of soil are required for analytical testing.

8.3.4 Sample Containment - General

Once retrieved, the sample will be removed from the split-spoon with a teaspoon or spatula and placed into the appropriate sample container. The sample will be split if necessary to meet sampling program requirements. Sample splitting may be necessary to provide individual samples for headspace testing, visual characterization, physical testing, analytical testing, or simply for archiving purposes. In general, most sampling programs are structured around environmental characterization needs; therefore, sample portions required for analytical testing should be collected first. The SAP will provide specific sample container requirements for each type of sample and should be referred to for guidance.

Once filled, the sample containers should be properly capped, cleaned, and labeled, and chain-of-custody and sample preservation procedures initiated. Sampling equipment should then be properly decontaminated.

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8.3.5 Sample Containment - Volatile Organic Analyses

Collection of subsurface soil samples for VOCs is more complex than collection of samples for other routine chemical or physical testing primarily because of the concern for the potential loss of volatiles during the sample collection procedure. To limit the potential for loss of volatiles, the soil sample needs to be obtained as quickly and as directly as possible from the split-spoon. This generally means that the VOC sample is collected and placed into the appropriate sample container first. The VOC sample should also be obtained from a discrete portion of the entire sample interval and not composited or homogenized. The remainder of the recovered sample can then be composited, homogenized or split to meet the other testing requirements. The boring log and/or sample logbook should be filled out to indicate actual sample collection depths for both VOA samples and other portions of the sample which may have been composited over a larger vertical interval.

9.0 Quality Control and Assurance

9.1 Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific SAP. Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements outlined in the SAP typically suggest the collection of a sufficient quantity of field duplicate, field blank, and other samples.

9.2 Quality control requirements are dependent on project-specific sampling objectives. The SAP will provide requirements for sample preservation and holding times, sample container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

10.0 Data Records and Management

10.1 Records will be maintained in accordance with SOP 3-03 Recordkeeping, Sample Labelling, and Chain-of-Custody. Various forms are required to ensure that adequate documentation is made of sample collection activities. These forms include:

- Boring logs and/or electronic data collection devices
- Field log books
- Chain-of-custody records
- Shipping labels

Original copies of these records should be maintained in the appropriate project files.

10.2 Boring logs (Attachment 1) will provide visual and descriptive information for each sample collected and are often the most critical form of documentation generated during a sampling program. Field electronic data collection devices (e.g., Yuma Tablet, Toughbook Laptop) with data collection software may also be used to record boring log information.

10.3 The field log book is kept as a general log of activities.

10.4 Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes.

10.5 Shipping labels are required if sample coolers are to be transported to the laboratory by a third party (courier service).

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11.0 Attachments or References

Attachment 1 – Boring Log

ASTM D 1586-84 Subsurface Exploration Using the Standard Penetration Test and the Cone Penetrometer Test

SOP 3-03 Recordkeeping, Sample Labeling, and Chain-of-Custody

SOP 3-06 Equipment Decontamination

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Robert Shoemaker Senior Scientist	Naomi Ouellette, Project Manager	Rev 0 – Initial Issue

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Attachment 1
Boring Log

RESOLUTION CONSULTANTS	Client:				Boring ID:
	Project Number:				
	Site Location:				
	Coordinates:		Elevation:		Sheet: 1 of 1
	Drilling Method:				Monitoring Well Installed:
	Sample Type(s):		Boring Diameter:		Screened Interval:
Weather:		Logged By:	Date/Time Started:		Depth of Boring:
Drilling Contractor:		Ground Elevation:	Date/Time Finished:		Water Level:

Depth (ft)	Geologic sample ID	Sample Depth (ft)	Blows per 6"	Recovery (inches)	Headspace (ppm)	U.S.C.S	MATERIALS: Color, size, range, MAIN COMPONENT, minor component(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)	Lab Sample ID	Lab Sample Depth (Ft.)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

NOTES:

Date	Time	Depth to groundwater while drilling

Checked by _____ Date:

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U.S. ENVIRONMENTAL PROTECTION AGENCY REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

Quality Assurance Unit
U.S. Environmental Protection Agency – Region 1
11 Technology Drive
North Chelmsford, MA 01863

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Prepared by: Charles Porfert 1/19/10
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(Gerard Sotolongo, Quality Assurance Unit) Date

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USE OF TERMS

Equipment blank: The equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank needs only to include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after sampling from contaminated wells and not after background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation/reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates: Used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Poteniometric Surface: The level to which water rises in a tightly cased well constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan

SOP: Standard operating procedure

Stabilization: A condition that is achieved when all indicator field parameter measurements are sufficiently stable (as described in the "Monitoring Indicator Field Parameters" section) to allow sample collection to begin.

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): Trip blank is a sample of analyte-free water taken to the sampling site and returned to the laboratory. The trip blanks (one pair) are added to each sample cooler that contains VOC samples.

SCOPE & APPLICATION

The goal of this groundwater sampling procedure is to collect water samples that reflect the total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions, with minimal physical and chemical alterations from sampling operations. This standard operating procedure (SOP) for collecting groundwater samples will help ensure that the project's data quality objectives (DQOs) are met under certain low-flow conditions.

The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations. Indicator field parameters (e.g., dissolved oxygen, pH, etc.) are monitored during purging in order to determine when sample collection may begin. Samples properly collected using this SOP are suitable for analysis of groundwater contaminants (volatile and semi-volatile organic analytes, dissolved gases, pesticides, PCBs, metals and other inorganics), or naturally occurring analytes. This SOP is based on Puls, and Barcelona (1996).

This procedure is designed for monitoring wells with an inside diameter (1.5-inches or greater) that can accommodate a positive lift pump with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval (Hereafter, the "screen or open interval" will be referred to only as "screen interval"). This SOP is not applicable to other well-sampling conditions.

While the use of dedicated sampling equipment is not mandatory, dedicated pumps and tubing can reduce sampling costs significantly by streamlining sampling activities and thereby reducing the overall field costs.

The goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help to minimize sampling variability.

This procedure describes a general framework for groundwater sampling. Other site specific information (hydrogeological context, conceptual site model (CSM), DQOs, etc.) coupled with systematic planning must be added to the procedure in order to develop an appropriate site specific SAP/QAPP. In addition, the site specific SAP/QAPP must identify the specific equipment that will be used to collect the groundwater samples.

This procedure does not address the collection of water or free product samples from wells containing free phase LNAPLs and/or DNAPLs (light or dense non-aqueous phase

liquids). For this type of situation, the reader may wish to check: Cohen, and Mercer (1993) or other pertinent documents.

This SOP is to be used when collecting groundwater samples from monitoring wells at all Superfund, Federal Facility and RCRA sites in Region 1 under the conditions described herein. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. All changes and modifications must be approved and included in a revised SAP/QAPP before implementation in field.

BACKGROUND FOR IMPLEMENTATION

It is expected that the monitoring well screen has been properly located (both laterally and vertically) to intercept existing contaminant plume(s) or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, and operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable, for all wells to be sampled, efforts to build a sampling history should commence with the next sampling event.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. For new wells, or for wells without pump intake depth information, the site's SAP/QAPP must provide clear reasons and instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected. If the depths to top and bottom of the well screen are not known, the SAP/QAPP will need to describe how the sampling depth will be determined and how the data can be used.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU, and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection

may still take place provided the indicator field parameter criteria in this procedure are met. If after 2 hours of purging indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event).

It is recommended that low-flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the data quality objectives, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be developed. Ice formation in the flow-through-cell will cause the monitoring probes to act erratically. A transparent flow-through-cell needs to be used to observe if ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All proper personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples should be handled with suitable protection to skin, eyes, etc.

CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the below conditions occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethene, ethane, dissolved oxygen, etc.) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in

the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem when using a centrifugal pump or peristaltic pump.

Direct sun light and hot ambient air temperatures may cause the groundwater in the tubing and flow-through-cell to heat up. This may cause the groundwater to degas which will result in loss of VOCs and dissolved gases. When sampling under these conditions, the sampler will need to shade the equipment from the sunlight (e.g., umbrella, tent, etc.). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sun light or ambient air from heating up the groundwater.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water which is denser than warm water sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convention cell. "During low-flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low-flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., dissolved oxygen meter, etc.) can result in faulty data being collected.

Interferences may result from using contaminated equipment, cleaning materials, sample containers, or uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning to avoid ambient air interferences. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely checked to be free from contaminants and equipment blanks collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected and they are a concern, then a more vigorous cleaning procedure will be needed.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. OSHA regulations may require the sampler to take the 40 hour OSHA health and safety training course and a refresher course prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team needs to read, and be familiar with, the site Health and Safety Plan, all relevant SOPs, and SAP/QAPP (and the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest to the understanding of these site documents and that it is recorded.

EQUIPMENT AND SUPPLIES

A. Informational materials for sampling event

A copy of the current Health and Safety Plan, SAP/QAPP, monitoring well construction data, location map(s), field data from last sampling event, manuals for sampling, and the monitoring instruments' operation, maintenance, and calibration manuals should be brought to the site.

B. Well keys.

C. Extraction device

Adjustable rate, submersible pumps (e.g., centrifugal, bladder, etc.) which are constructed of stainless steel or Teflon are preferred. Note: if extraction devices constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. This is not mandatory, but is considered a "best practice". For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence value should be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

Adjustable rate, peristaltic pumps (suction) are to be used with caution when collecting samples for VOCs and dissolved gases (e.g., methane, carbon dioxide, etc.) analyses. Additional information on the use of peristaltic pumps can be found in Appendix A. If peristaltic pumps are used, the inside diameter of the rotor head tubing needs to match the inside diameter of the tubing installed in the monitoring well.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling, and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

D. Tubing

Teflon or Teflon-lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. Note: if tubing constructed of other materials is to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for metal and other inorganics analyses.

The use of 1/4 inch or 3/8 inch (inside diameter) tubing is recommended. This will help ensure that the tubing remains liquid filled when operating at very low pumping rates when using centrifugal and peristaltic pumps.

Silastic tubing should be used for the section around the rotor head of a peristaltic pump. It should be less than a foot in length. The inside diameter of the tubing used at the pump rotor head must be the same as the inside diameter of tubing placed in the well. A tubing connector is used to connect the pump rotor head tubing to the well tubing. Alternatively, the two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing. The tubing must not be reused.

E. The water level measuring device

Electronic "tape", pressure transducer, water level sounder/level indicator, etc. should be capable of measuring to 0.01 foot accuracy. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each sampling event.

F. Flow measurement supplies

Graduated cylinder (size according to flow rate) and stopwatch usually will suffice.

Large graduated bucket used to record total water purged from the well.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL, or DNAPL) before purging begins (as needed).

H. Power source (generator, nitrogen tank, battery, etc.)

When a gasoline generator is used, locate it downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate samples.

I. Indicator field parameter monitoring instruments

Use of a multi-parameter instrument capable of measuring pH, oxidation/reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and coupled with a flow-through-cell is required when measuring all indicator field parameters, except turbidity. Turbidity is collected using a separate instrument. Record equipment/instrument identification (manufacturer, and model number).

Transparent, small volume flow-through-cells (e.g., 250 mLs or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.

Turbidity samples are collected before the flow-through-cell. A "T" connector coupled with a valve is connected between the pump's tubing and flow-through-cell. When a turbidity measurement is required, the valve is opened to allow the groundwater to flow into a container. The valve is closed and the container sample is then placed in the turbidimeter.

Standards are necessary to perform field calibration of instruments. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP which use a Zobell solution as a standard. For dissolved oxygen, a wet sponge used for the 100% saturation and a zero dissolved oxygen solution are used for the calibration.

Barometer (used in the calibration of the Dissolved Oxygen probe) and the conversion formula to convert the barometric pressure into the units of measure used by the Dissolved Oxygen meter are needed.

J. Decontamination supplies

Includes (for example) non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.

K. Record keeping supplies

Logbook(s), well purging forms, chain-of-custody forms, field instrument calibration forms, etc.

L. Sample bottles

M. Sample preservation supplies (as required by the analytical methods)

N. Sample tags or labels

O. PID or FID instrument

If appropriate, to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

P. Miscellaneous Equipment

Equipment to keep the sampling apparatus shaded in the summer (e.g., umbrella) and from freezing in the winter. If the pump's tubing is allowed to heat up in the warm weather, the cold groundwater may degas as it is warmed in the tubing.

EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field.

Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments are calibrated using U.S Environmental Protection Agency Region 1 *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* January 19, 2010, or latest version or from one of the methods listed in 40CFR136, 40CFR141 and SW-846.

The instruments shall be calibrated at the beginning of each day. If the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is highly recommended to ensure that the instruments did not drift out of calibration. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be qualified or rejected.

PRELIMINARY SITE ACTIVITIES (as applicable)

Check the well for security (damage, evidence of tampering, missing lock, etc.) and record pertinent observations (include photograph as warranted).

If needed lay out sheet of clean polyethylene for monitoring and sampling equipment, unless equipment is elevated above the ground (e.g., on a table, etc.).

Remove well cap and if appropriate measure VOCs at the rim of the well with a PID or FID instrument and record reading in field logbook or on the well purge form.

If the well casing does not have an established reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the altitude of this point should be determined using techniques that are appropriate to site's DQOs.

If water-table or potentiometric surface map(s) are to be constructed for the sampling event, perform synoptic water level measurement round (in the shortest possible time) before any purging and sampling activities begin. If possible, measure water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) the day before sampling begins, in order to allow for re-settlement of any particulates in the water column. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made the day before, it should be measured after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe may not be necessary unless analytical data or field analysis signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternate sampling method. All project modifications must be approved and documented prior to implementation.

If available check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the intake depth or extraction rate(s) used during previous sampling event(s), for either portable or dedicated extraction devices, record new values, and explain reasons for the changes in the field logbook.

PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) are preferred.

The use of dedicated pumps is recommended to minimize artificial mobilization and entrainment of particulates each time the well is sampled. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each

sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

A. Initial Water Level

Measure the water level in the well before installing the pump if a non-dedicated pump is being used. The initial water level is recorded on the purge form or in the field logbook.

B. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the appropriate depth (may not be the mid-point of the screen/open interval). The Sampling and Analysis Plan/Quality Assurance Project Plan should specify the sampling depth (used previously), or provide criteria for selection of intake depth for each new well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Pump tubing lengths, above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

C. Measure Water Level

Before starting pump, measure water level. Install recording pressure transducer, if used to track drawdowns, to initialize starting condition.

D. Purge Well

From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged. This information is recorded on the purge form or in the field logbook.

Start the pump at low speed and slowly increase the speed until discharge occurs. Check water level. Check equipment for water leaks and if present fix or replace the affected equipment. Try to match pumping rate used during previous sampling event(s). Otherwise, adjust pump speed until there is little or no water level drawdown. If the minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging.

Monitor and record the water level and pumping rate every five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" somewhat as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. If the initial water level is above the top of the screen do not allow the water level to fall into the well screen. The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.

Note: the flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (e.g., bladder, peristaltic), and/or the use of dedicated equipment. For new monitoring wells, or wells where the following situation has not occurred before, if the recovery rate to the well is less than 50 mL/min., or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. The project manager or field team leader will need to make the decision when samples should be collected, how the sample is to be collected, and the reasons recorded on the purge form or in the field logbook. A water level measurement needs to be performed and recorded before samples are collected. If the project manager decides to collect the samples using the pump, it is best during this recovery period that the pump intake tubing not be removed, since this will aggravate any turbidity problems. Samples in this specific situation may be collected without stabilization of indicator field parameters. Note that field conditions and efforts to overcome problematic situations must be recorded in order to support field decisions to deviate from normal procedures described in this SOP. If this type of problematic situation persists in a well, then water sample collection should be changed to a passive or no-purge method, if consistent with the site's DQOs, or have a new well installed.

E. Monitor Indicator Field Parameters

After the water level has stabilized, connect the "T" connector with a valve and the flow-through-cell to monitor the indicator field parameters. If excessive turbidity is anticipated or encountered with the pump startup, the well may be purged for a while without connecting up the flow-through-cell, in order to minimize particulate buildup in the cell (This is a judgment call made by the sampler). Water level drawdown measurements should be made as usual. If possible, the pump may be installed the day before purging to allow particulates that were disturbed during pump insertion to settle.

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, ORP, DO) at a frequency of five minute intervals or greater. The pump's flow rate must be able to "turn over" at least one flow-through-cell volume between measurements (for a 250 mL flow-through-cell with a flow rate of 50 mLs/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through-cell it would be every ten minutes). If the cell volume cannot be replaced in the five minute interval, then the time between measurements must be increased accordingly. Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments followed by stabilization of indicator parameters. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings are within the following limits:

Turbidity (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Samples for turbidity measurements are obtained before water enters the flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities. Record start and stop times and give a brief description of cleaning activities.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45 degree angle with the port facing upward can help remove bubbles from the flow-through-cell (see Appendix B Low-Flow Setup Diagram). All during the measurement process, the flow-through-cell must remain free of any gas bubbles. Otherwise, the monitoring probes may act erratically. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must remain submerged in water at all times.

F. Collect Water Samples

When samples are collected for laboratory analyses, the pump's tubing is disconnected from the "T" connector with a valve and the flow-through-cell. The samples are collected directly from the pump's tubing. Samples must not be collected from the flow-through-cell or from the "T" connector with a valve.

VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the pump's flow rate is too high to collect the VOC/dissolved gases samples, collect the other samples first. Lower the pump's flow rate to a reasonable rate and collect the VOC/dissolved gases samples and record the new flow rate.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use the following procedure to collect samples: collect non-VOC/dissolved gases samples first, then increase flow rate slightly until the water completely fills the tubing, collect the VOC/dissolved gases samples, and record new drawdown depth and flow rate.

For bladder pumps that will be used to collect VOC or dissolved gas samples, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL VOC vial.

Use pre-preserved sample containers or add preservative, as required by analytical methods, to the samples immediately after they are collected. Check the analytical methods (e.g. EPA SW-846, 40 CFR 136, water supply, etc.) for additional information on preservation.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter (transparent housing preferred) is required, and the filter size (0.45 μm is commonly used) should be based on the sampling objective. Pre-rinse the filter with groundwater prior to sample collection. Make sure the filter is free of air bubbles before samples are collected. Preserve the filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

Label each sample as collected. Samples requiring cooling will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

G. Post Sampling Activities

If a recording pressure transducer is used to track drawdown, re-measure water level with tape.

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

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth annually is usually sufficient after the initial low stress sampling event. However, a greater frequency may be needed if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and then following sampling of each well. Pumps should not be removed between purging and sampling operations. The pump, tubing, support cable and electrical wires which were in contact with the well should be decontaminated by one of the procedures listed below.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps and tubing are used, only the initial sampling event will require decontamination of the pump and tubing.

Note if the previous equipment blank data showed that contaminant(s) were present after using the below procedure or the one described in the SAP/QAPP, a more vigorous procedure may be needed.

Procedure 1

Decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump and tubing. The pump may be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Optional - flush with isopropyl alcohol (pesticide grade; must be free of ketones {e.g., acetone}) or with methanol. This step may be required if the well is highly contaminated or if the equipment blank data from the previous sampling event show that the level of contaminants is significant.

Flush with distilled/deionized water. This step must remove all traces of alcohol (if used) from the equipment. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, matrix spike/matrix spike duplicates, trip blanks (VOCs), and temperature blanks.

FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities (see Appendix C, example table), and record the following for each well:

Site name, municipality, state.

Well identifier, latitude-longitude or state grid coordinates.

Measuring point description (e.g., north side of PVC pipe).

Well depth, and measurement technique.

Well screen length.

Pump depth.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, calculated or measured total volume pumped, and clock time of each set of measurements.

Type of tubing used and its length.

Type of pump used.

Clock time of start and end of purging and sampling activity.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analyses.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions, including approximate ambient air temperature.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling/monitoring equipment used, including trade names, model number, instrument identification number, diameters, material composition, etc.

DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, field indicator parameters measured during purging, field instrument calibration information, and whatever other field logbook information is needed to allow for a full evaluation of data usability.

Note: the use of trade, product, or firm names in this sampling procedure is for descriptive purposes only and does not constitute endorsement by the U.S. EPA.

REFERENCES

Cohen, R.M. and J.W. Mercer, 1993, *DNAPL Site Evaluation*; C.K. Smoley (CRC Press), Boca Raton, Florida.

Robert W. Puls and Michael J. Barcelona, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, April 1996 (EPA/540/S-95/504).

U.S. Environmental Protection Agency, 1992, *RCRA Ground-Water Monitoring: Draft Technical Guidance*; Washington, DC (EPA/530-R-93-001).

U.S. Environmental Protection Agency, 1987, *A Compendium of Superfund Field Operations Methods*; Washington, DC (EPA/540/P-87/001).

U.S Environmental Protection Agency, Region 1, *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* January 19, 2010 or latest version.

U.S Environmental Protection Agency, EPA SW-846.

U.S Environmental Protection Agency, 40 CFR 136.

U.S Environmental Protection Agency, 40 CFR 141.

Vroblesky, Don A., Clifton C. Casey, and Mark A. Lowery, Summer 2007, Influence of Dissolved Oxygen Convection on Well Sampling, *Ground Water Monitoring & Remediation* 27, no. 3: 49-58.

APPENDIX A
PERISTALTIC PUMPS

Before selecting a peristaltic pump to collect groundwater samples for VOCs and/or dissolved gases (e.g., methane, carbon dioxide, etc.) consideration should be given to the following:

- The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data.
- If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable.
- If minor differences in the groundwater concentrations could effect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device should NOT be used for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

EPA and USGS have documented their concerns with the use of the peristaltic pumps to collect water sample in the below documents.

- "Suction Pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987.
- "The agency does not recommend the use of peristaltic pumps to sample ground water particularly for volatile organic analytes" *RCRA Ground-Water Monitoring Draft Technical Guidance*, EPA Office of Solid Waste, November 1992.
- "The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and volatiles loss", *Low-flow (Minimal drawdown) Ground-Water Sampling Procedures*, by Robert Puls & Michael Barcelona, April 1996, EPA/540/S-95/504.
- "Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in the loss of volatile analytes", USGS Book 9 Techniques of Water-Resources Investigation, Chapter A4. (Version 2.0, 9/2006).

APPENDIX B

SUMMARY OF SAMPLING INSTRUCTIONS

These instructions are for using an adjustable rate, submersible pump or a peristaltic pump with the pump's intake placed at the midpoint of a 10 foot or less well screen or an open interval. The water level in the monitoring well is above the top of the well screen or open interval, the ambient temperature is above 32°F, and the equipment is not dedicated. Field instruments are already calibrated. The equipment is setup according to the diagram at the end of these instructions.

1. Review well installation information. Record well depth, length of screen or open interval, and depth to top of the well screen. Determine the pump's intake depth (e.g., mid-point of screen/open interval).

2. On the day of sampling, check security of the well casing, perform any safety checks needed for the site, lay out a sheet of polyethylene around the well (if necessary), and setup the equipment. If necessary a canopy or an equivalent item can be setup to shade the pump's tubing and flow-through-cell from the sun light to prevent the sun light from heating the groundwater.

3. Check well casing for a reference mark. If missing, make a reference mark. Measure the water level (initial) to 0.01 ft. and record this information.

4. Install the pump's intake to the appropriate depth (e.g., midpoint) of the well screen or open interval. Do not turn-on the pump at this time.

5. Measure water level and record this information.

6. Turn-on the pump and discharge the groundwater into a graduated waste bucket. Slowly increase the flow rate until the water level starts to drop. Reduce the flow rate slightly so the water level stabilizes. Record the pump's settings. Calculate the flow rate using a graduated container and a stop watch. Record the flow rate. Do not let the water level drop below the top of the well screen.

If the groundwater is highly turbid or colored, continue to discharge the water into the bucket until the water clears (visual observation); this usually takes a few minutes. The turbid or colored water is usually from the well being disturbed during the pump installation. If the water does not clear, then you need to make a choice whether to continue purging the well (hoping that it will clear after a reasonable time) or continue to

the next step. Note, it is sometimes helpful to install the pump the day before the sampling event so that the disturbed materials in the well can settle out.

If the water level drops to the top of the well screen during the purging of the well, stop purging the well, and do the following:

> Wait for the well to recharge to a sufficient volume so samples can be collected. This may take awhile (pump maybe removed from well, if turbidity is not a problem). The project manager will need to make the decision when samples should be collected and the reasons recorded in the site's log book. A water level measurement needs to be performed and recorded before samples are collected. When samples are being collected, the water level must not drop below the top of the screen or open interval. Collect the samples from the pump's tubing. Always collect the VOCs and dissolved gases samples first. Normally, the samples requiring a small volume are collected before the large volume samples are collected just in case there is not sufficient water in the well to fill all the sample containers. All samples must be collected, preserved, and stored according to the analytical method. Remove the pump from the well and decontaminate the sampling equipment.

If the water level has dropped 0.3 feet or less from the initial water level (water level measure before the pump was installed); proceed to Step 7. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are be collected.

7. Attach the pump's tubing to the "T" connector with a valve (or a three-way stop cock). The pump's tubing from the well casing to the "T" connector must be as short as possible to prevent the groundwater in the tubing from heating up from the sun light or from the ambient air. Attach a short piece of tubing to the other end of the end of the "T" connector to serve as a sampling port for the turbidity samples. Attach the remaining end of the "T" connector to a short piece of tubing and connect the tubing to the flow-through-cell bottom port. To the top port, attach a small piece of tubing to direct the water into a calibrated waste bucket. Fill the cell with the groundwater and remove all gas bubbles from the cell. Position the flow-through-cell in such a way that if gas bubbles enter the cell they can easily exit the cell. If the ports are on the same side of the cell and the cell is cylindrical shape, the cell can be placed at a 45-degree angle with the ports facing upwards; this position should keep any gas bubbles entering the cell away from the monitoring probes and allow the gas bubbles to exit the cell easily (see Low-Flow Setup Diagram). Note,

make sure there are no gas bubbles caught in the probes' protective guard; you may need to shake the cell to remove these bubbles.

8. Turn-on the monitoring probes and turbidity meter.

9. Record the temperature, pH, dissolved oxygen, specific conductance, and oxidation/reduction potential measurements. Open the valve on the "T" connector to collect a sample for the turbidity measurement, close the valve, do the measurement, and record this measurement. Calculate the pump's flow rate from the water exiting the flow-through-cell using a graduated container and a stop watch, and record the measurement. Measure and record the water level. Check flow-through-cell for gas bubbles and sediment; if present, remove them.

10. Repeat Step 9 every 5 minutes or as appropriate until monitoring parameters stabilized. Note at least one flow-through-cell volume must be exchanged between readings. If not, the time interval between readings will need to be increased. Stabilization is achieved when three consecutive measurements are within the following limits:

Turbidity (10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

If these stabilization requirements do not stabilize in a reasonable time, the probes may have been coated from the materials in the groundwater, from a buildup of sediment in the flow-through-cell, or a gas bubble is lodged in the probe. The cell and the probes will need to be cleaned. Turn-off the probes (not the pump), disconnect the cell from the "T" connector and continue to purge the well. Disassemble the cell, remove the sediment, and clean the probes according to the manufacturer's instructions. Reassemble the cell and connect the cell to the "T" connector. Remove all gas bubbles from the cell, turn-on the probes, and continue the measurements. Record that the time the cell was cleaned.

11. When it is time to collect the groundwater samples, turn-off the monitoring probes, and disconnect the pump's tubing from the "T" connector. If you are using a centrifugal or peristaltic pump check the pump's tubing to determine if the tubing is completely filled with water (no air space).

All samples must be collected and preserved according to the analytical method. VOCs and dissolved gases samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

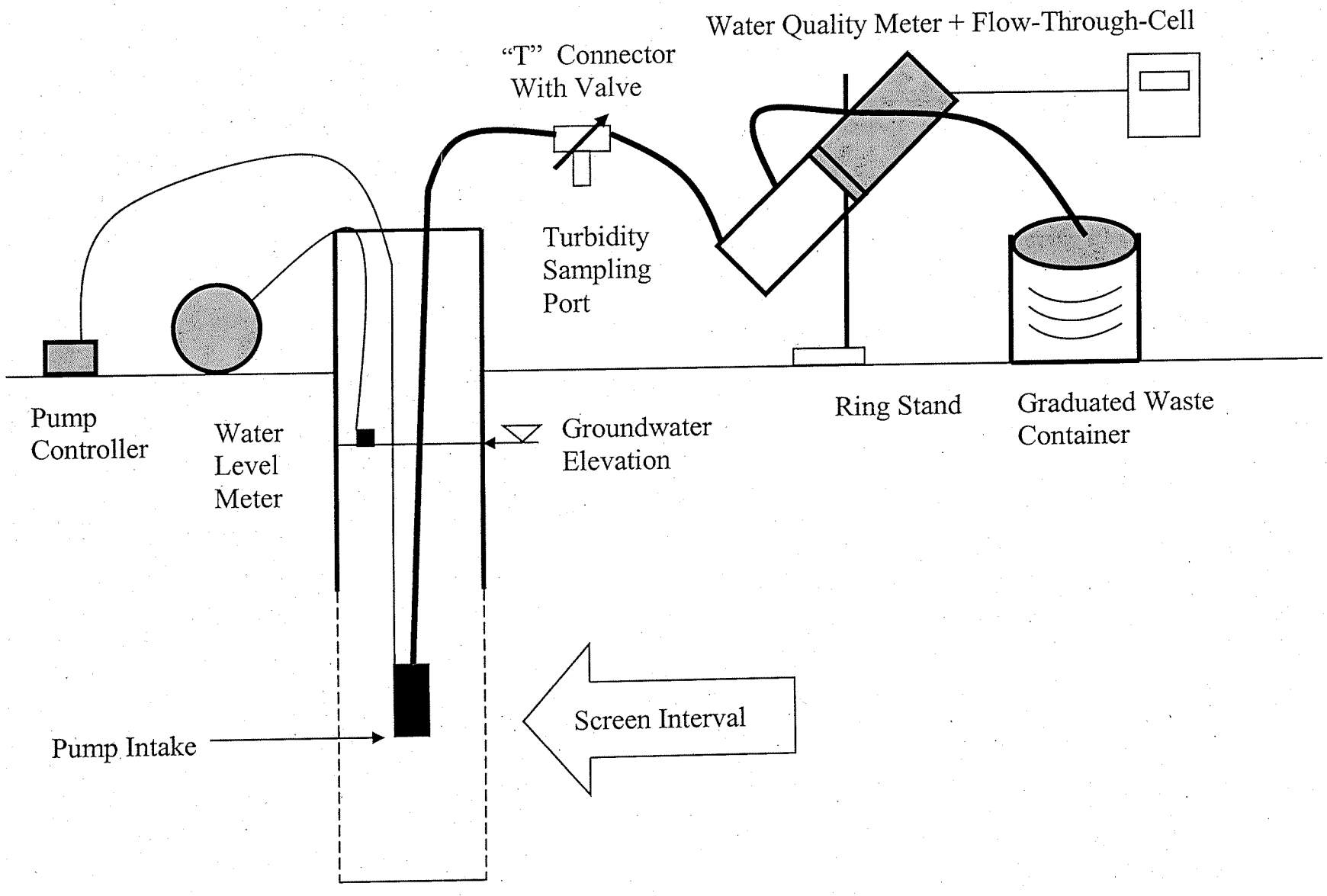
If the pump's tubing is not completely filled with water and the samples are being collected for VOCs and/or dissolved gases analyses using a centrifugal or peristaltic pump, do the following:

> All samples must be collected and preserved according to the analytical method. The VOCs and the dissolved gases (e.g., methane, ethane, ethene, and carbon dioxide) samples are collected last. When it becomes time to collect these samples increase the pump's flow rate until the tubing is completely filled. Collect the samples and record the new flow rate.

12. Store the samples according to the analytical method.

13. Record the total purged volume (graduated waste bucket). Remove the pump from the well and decontaminate the sampling equipment.

Low-Flow Setup Diagram



APPENDIX C
EXAMPLE (Minimum Requirements)
WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)_____
Well Number_____ Date_____
Field Personnel_____
Sampling Organization_____
Identify MP_____

Depth to _____/_____ of screen
(below MP) top bottom
Pump Intake at (ft. below MP)_____
Purging Device; (pump type)_____
Total Volume Purged _____

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Turb-idity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	± 10 mv	10%	10%	

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25 °C.
3. Oxidation reduction potential (ORP)

Appendix B

Laboratory Accreditation Certificates

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

TESTAMERICA DENVER
4955 Yarrow Street
Arvada, CO 80002
Margaret S. Sleevi Phone: 303-736-0100
www.testamericainc.com

ENVIRONMENTAL

Valid To: November 30, 2015 Certificate Number: 2907.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 4.2 of the DoD Quality Systems Manual for Environmental Laboratories), and for the test methods applicable to the Wyoming Storage Tank Remediation Laboratory Accreditation Program, accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

Atomic Absorption/ICP-AES Spectrometry, ICP/MS, Gas Chromatography, Gas Chromatography/Mass Spectrometry, Gravimetry, High Performance Liquid Chromatography, Ion Chromatography, Misc.- Electronic Probes (pH, O_2), Oxygen Demand, Hazardous Waste Characteristics Tests, Spectrophotometry (Visible), Spectrophotometry (Automated), Titrimetry, Total Organic Carbon, Total Organic Halide

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Metals				
Aluminum	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Antimony	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Arsenic	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Barium	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Beryllium	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Boron	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Cadmium	EPA 6010C	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Calcium	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Chromium	EPA 6010C	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Cobalt	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Copper	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Iron	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Lead	EPA 6010C	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Lithium	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Magnesium	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Manganese	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Mercury	----------	----------	EPA 7470A	EPA 7471A / 7471B
Molybdenum	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Nickel	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Potassium	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Selenium	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Silica	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Silicon	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Silver	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Sodium	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Strontium	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Thallium	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Tin	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Titanium	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Vanadium	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Zinc	----------	----------	EPA 6010B / 6010C / 6020 / 6020A	EPA 6010B / 6010C / 6020 / 6020A
Nutrients				
Nitrate (as N)	----------	By calculation	By calculation / EPA 9056 / 9056A	By calculation / EPA 9056 / 9056A
Nitrate-nitrite (as N)	----------	EPA 353.2	EPA 353.2 / 9056 / 9056A	EPA 9056 / 9056A
Nitrite (as N)	----------	SM 4500-NO2 B	SM 4500-NO2 B; EPA 9056 / 9056A	EPA 9056 / 9056A
Orthophosphate (as P)	----------	----------	EPA 9056 / 9056A	EPA 9056 / 9056A
Total phosphorus	----------	----------	EPA 6010B / 6010C	EPA 6010B / 6010C
Demands				
Total Organic Carbon	----------	----------	EPA 9060 / 9060A	EPA 9060 / 9060A
Total Organic Halides	----------	----------	EPA 9020B	----------
Wet Chemistry				----------
Alkalinity (Total Bicarbonate, Carbonate, and Hydroxide Alkalinty)	----------	SM 2320 B_1997	SM 2320 B	SM 2320 B
Ammonia	----------	EPA 350.1	EPA 350.1	----------
Biological Oxygen Demand	----------	SM 5210B	SM 5210B	----------
Bromide	----------	----------	EPA 9056 / 9056A	EPA 9056 / 9056A
Chloride	----------	----------	EPA 9056 / 9056A	EPA 9056 / 9056A
Chemical Oxygen Demand	----------	EPA 410.4	EPA 410.4	----------
Conductivity	----------	----------	EPA 9050 / 9050A	EPA 9050 / 9050A
Cyanide	----------	----------	9012A / 9012B	9012A / 9012B
Ferrous Iron	----------	SM 3500 Fe B, D	SM 3500 Fe B, D	----------
Fluoride	----------	----------	EPA 9056 / 9056A	EPA 9056 / 9056A
Hexavalent Chromium	EPA 7196A	----------	EPA 7196A	----------
pH	----------	----------	EPA 9040B / 9045C	EPA 9045C / 9045D
Oil and Grease (HEM and SGT-HEM)	----------	----------	EPA 1664A/ 1664B	9071B
Percent Moisture	----------	----------	----------	ASTM D2216
Perchlorate	----------	----------	EPA 6860	EPA 6860
Phenols	----------	----------	EPA 9066	EPA 9066
Solids, Total	----------	SM 2540 B	SM 2540 B	SM 2540 B
Solids, Total Suspended	----------	SM 2540 D	SM 2540 D	SM 2540 D
Solids, Total Dissolved	----------	SM 2540 C	SM 2540 C	SM 2540 C
Sulfate	----------	----------	EPA 9056 / 9056A	EPA 9056 / 9056A
Sulfide, Total	----------	----------	EPA 9034	EPA 9034
Sulfide	----------	----------	EPA 9030B	EPA 9030B
Total Kjeldahl Nitrogen	----------	----------	EPA 351.2	----------

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Purgeable Organics (volatiles)				----------
Acetone	----------	----------	EPA 8260B	EPA 8260B
Acetonitrile	----------	----------	EPA 8260B	EPA 8260B
Acrolein	----------	----------	EPA 8260B	EPA 8260B
Acrylonitrile	----------	----------	EPA 8260B	EPA 8260B
Allyl Chloride	----------	----------	EPA 8260B	EPA 8260B
tert-Amyl Methyl Ether	EPA 8260B			
Benzene	EPA 8260B / 8021B	----------	EPA 8260B / 8021B / AK101/ OK DEQ GRO/ 8260B SIM	EPA 8260B / 8021B / AK101/ OK DEQ GRO
Bromobenzene	----------	----------	EPA 8260B	EPA 8260B
Bromochloromethane	----------	----------	EPA 8260B	EPA 8260B
Bromodichloromethane	----------	----------	EPA 8260B	EPA 8260B
Bromoform	----------	----------	EPA 8260B	EPA 8260B
Bromomethane	----------	----------	EPA 8260B	EPA 8260B
2-Butanone	----------	----------	EPA 8260B	EPA 8260B
n-Butyl alcohol	----------	----------	EPA 8260B / 8015B / 8015C	EPA 8260B / 8015B / 8015C
tert-Butyl alcohol (2-Methyl-2-Propanol)	EPA 8260B		EPA 8260B / 8260B SIM	EPA 8260B
n-Butylbenzene	----------	----------	EPA 8260B	EPA 8260B
sec-Butylbenzene	----------	----------	EPA 8260B	EPA 8260B
tert-Butylbenzene	----------	----------	EPA 8260B	EPA 8260B
Carbon disulfide	----------	----------	EPA 8260B	EPA 8260B
Carbon tetrachloride	----------	----------	EPA 8260B	EPA 8260B
Chlorobenzene	----------	----------	EPA 8260B / 8021B	EPA 8260B / 8021B
2-Chloro-1,3-butadiene	----------	----------	EPA 8260B	EPA 8260B
Chloroethane	----------	----------	EPA 8260B	EPA 8260B
2-Chloroethyl vinyl ether	----------	----------	EPA 8260B	EPA 8260B
Chloroform	----------	----------	EPA 8260B	EPA 8260B
1-Chlorohexane	----------	----------	EPA 8260B	EPA 8260B
Chloromethane	----------	----------	EPA 8260B	EPA 8260B
Chloroprene	----------	----------	EPA 8260B	EPA 8260B
4-Chlorotoluene	----------	----------	EPA 8260B	EPA 8260B
2-Chlorotoluene	----------	----------	EPA 8260B	EPA 8260B
Cyclohexane	----------	----------	EPA 8260B	EPA 8260B
Cyclohexanone	----------	----------	EPA 8260B	EPA 8260B
Dibromochloromethane	----------	----------	EPA 8260B	EPA 8260B
1,2-Dibromo-3-chloropropane (DBCP)	----------	EPA 504.1	EPA 504.1 / 8260B / 8011	EPA 8260B / 8011
Dibromochloromethane	----------	----------	EPA 8260B	EPA 8260B
Dichlorodifluoromethane	----------	----------	EPA 8260B	EPA 8260B
Dibromomethane	----------	----------	EPA 8260B	EPA 8260B
1,2 Dibromoethane (EDB)	EPA 8011	EPA 504.1	EPA 504.1 / 8260B / 8011	EPA 8260B / 8011
1,2-Dichlorobenzene	----------	----------	EPA 8260B / 8021B	EPA 8260B / 8021B

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
1,3-Dichlorobenzene	----------	----------	EPA 8260B / 8021B	EPA 8260B / 8021B
1,4-Dichlorobenzene	----------	----------	EPA 8260B / 8021B	EPA 8260B / 8021B
cis-1,4-Dichloro-2-butene	----------	----------	EPA 8260B	EPA 8260B
trans-1,4-Dichloro-2-butene	----------	----------	EPA 8260B	EPA 8260B
1,1-Dichloroethane	----------	----------	EPA 8260B	EPA 8260B
1,2-Dichloroethane	EPA 8260B	----------	EPA 8260B	EPA 8260B
1,1-Dichloroethene	----------	----------	EPA 8260B	EPA 8260B
1,2-Dichloroethene	----------	----------	EPA 8260B	EPA 8260B
cis-1,2-Dichloroethene	----------	----------	EPA 8260B	EPA 8260B
trans-1,2-Dichloroethene	----------	----------	EPA 8260B	EPA 8260B
Dichlorofluoromethane	----------	----------	EPA 8260B	EPA 8260B
1,2-Dichloropropane	----------	----------	EPA 8260B	EPA 8260B
1,3-Dichloropropane	----------	----------	EPA 8260B	EPA 8260B
2,2-Dichloropropane	----------	----------	EPA 8260B	EPA 8260B
1,1-Dichloropropene	----------	----------	EPA 8260B	EPA 8260B
1,3-Dichloropropene	----------	----------	EPA 8260B	EPA 8260B
cis-1,3-Dichloropropene	----------	----------	EPA 8260B	EPA 8260B
trans-1,3-Dichloropropene	----------	----------	EPA 8260B	EPA 8260B
Diethyl ether	----------	----------	EPA 8260B	EPA 8260B
Di-isopropylether	EPA 8260B	----------	EPA 8260B	EPA 8260B
1,4-Dioxane	----------	----------	EPA 8260B / 8260B SIM	EPA 8260B / 8260B SIM
Ethanol	----------	----------	EPA 8260B / 8015B / 8015C	EPA 8260B / 8015B / 8015C
Ethyl Acetate	----------	----------	EPA 8260B	EPA 8260B
Ethyl Benzene	EPA 8260B/8021B	----------	EPA 8260B / 8021B / AK101/ OK DEQ GRO	EPA 8260B / 8021B/ AK101/ OK DEQ GRO
Ethyl Methacrylate	----------	----------	EPA 8260B	EPA 8260B
Ethyl tert-Butyl Ether	EPA 8260B	----------	----------	----------
Ethylene Glycol	----------	----------	EPA 8015C	EPA 8015C
Gas Range Organics (GRO)	EPA 8015C	----------	EPA 8015B / 8015C / AK101 / 8015D/ OK DEQ GRO	EPA 8015B / 8015C / AK101 / 8015D/ OK DEQ GRO
Hexane	----------	----------	EPA 8260B	EPA 8260B
2-Hexanone	----------	----------	EPA 8260B	EPA 8260B
Hexachlorobutadiene	----------	----------	EPA 8260B	EPA 8260B
Isobutyl Alcohol (2-Methyl-1-propanol)	----------	----------	EPA 8260B / 8015B / 8015C	EPA 8260B / 8015B / 8015C
Isopropyl Alcohol	----------	----------	EPA 8260B	EPA 8260B
Isopropylbenzene	----------	----------	EPA 8260B	EPA 8260B
1,4-Isopropyltoluene	----------	----------	EPA 8260B	EPA 8260B
Iodomethane	----------	----------	EPA 8260B	EPA 8260B
Methacrylonitrile	----------	----------	EPA 8260B	EPA 8260B
Methanol	----------	----------	EPA 8015B / 8015C	EPA 8015B / 8015C
Methyl Acetate	----------	----------	EPA 8260B	EPA 8260B
Methyl Cyclohexane	----------	----------	EPA 8260B	EPA 8260B
Methylene Chloride	----------	----------	EPA 8260B	EPA 8260B

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Methyl Ethyl Ketone (MEK)	----------	----------	EPA 8260B	EPA 8260B
Methyl Isobutyl Ketone	----------	----------	EPA 8260B	EPA 8260B
Methyl Methacrylate	----------	----------	EPA 8260B	EPA 8260B
Methyl tert-Butyl Ether (MtBE)	EPA 8260B / 8021B	----------	EPA 8260B / 8021B / OK DEQ GRO	EPA 8260B / 8021B/ OK DEQ GRO
4-Methyl-2-Pentanone	----------	----------	EPA 8260B	EPA 8260B
Naphthalene	EPA 8260B / 8021B	----------	EPA 8260B/ OK DEQ GRO	EPA 8260B / OK DEQ GRO
2-Nitropropane	----------	----------	EPA 8260B	EPA 8260B
2,2' Oxybisethanol	----------	----------	EPA 8015C	EPA 8015C
2-Pentanone	----------	----------	EPA 8260B	EPA 8260B
Propionitrile	----------	----------	EPA 8260B	EPA 8260B
n-Propylbenzene	----------	----------	EPA 8260B	EPA 8260B
Propylene Glycol	----------	----------	EPA 8015C	EPA 8015C
Styrene	----------	----------	EPA 8260B	EPA 8260B
1,1,1,2-Tetrachloroethane	----------	----------	EPA 8260B	EPA 8260B
1,1,2,2-Tetrachloroethane	----------	----------	EPA 8260B	EPA 8260B
Tetrachloroethene	----------	----------	EPA 8260B	EPA 8260B
Tetrahydrofuran	----------	----------	EPA 8260B	EPA 8260B
Toluene	EPA 8260B / 8021B	----------	EPA 8260B / 8021B / AK101 / OK DEQ GRO	EPA 8260B / 8021B / AK101 / OK DEQ GRO
Total Petroleum Hydrocarbons (TPH)	----------	EPA 1664A EPA 1664B	EPA 1664A EPA 1664B	----------
1,2,3-Trichlorobenzene	----------	----------	EPA 8260B	EPA 8260B
1,1,1-Trichloroethane	----------	----------	EPA 8260B	EPA 8260B
1,1,2-Trichloroethane	----------	----------	EPA 8260B	EPA 8260B
Trichloroethene	----------	----------	EPA 8260B / 8260B SIM	EPA 8260B
Trichlorofluoromethane	----------	----------	EPA 8260B	EPA 8260B
1,2,3-Trichlorobenzene	----------	----------	EPA 8260B	EPA 8260B
1,2,4-Trichlorobenzene	----------	----------	EPA 8260B	EPA 8260B
1,2,3-Trichloropropane	----------	EPA 504.1	EPA 504.1 / 8260B / 8011	EPA 8260B / 8011
1,1,2-Trichloro-1,2,2-trifluoroethane	----------	----------	EPA 8260B	EPA 8260B
Triethylene Glycol	----------	----------	EPA 8015C	EPA 8015C
1,2,3-Trimethylbenzene	----------	----------	EPA 8260B	EPA 8260B
1,2,4-Trimethylbenzene	----------	----------	EPA 8260B	EPA 8260B
1,3,5-Trimethylbenzene	----------	----------	EPA 8260B	EPA 8260B
Vinyl Acetate	----------	----------	EPA 8260B	EPA 8260B
Vinyl Chloride	----------	----------	EPA 8260B / 8260B SIM	EPA 8260B
Xylenes, total	EPA 8260B / 8021B	----------	EPA 8260B / 8021B / AK101 / OK DEQ GRO	EPA 8260B / 8021B / AK101 / OK DEQ GRO
1,2-Xylene	EPA 8260B / 8021B	----------	EPA 8260B / 8021B / AK101 / OK DEQ GRO	EPA 8260B / 8021B / AK101 / OK DEQ GRO

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
M+P-Xylene	EPA 8260B / 8021B	----------	EPA 8260B / 8021B / AK101 / OK DEQ GRO	EPA 8260B / 8021B / AK101 / OK DEQ GRO
Methane	----------	----------	RSK-175	----------
Ethane	----------	----------	RSK-175	----------
Ethylene (Ethene)	----------	----------	RSK-175	----------
Acetylene	----------	----------	RSK-175	----------
Acetylene Ethane	----------	----------	RSK-175	----------
Extractable Organics (semivolatiles)				
Acenaphthene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Acenaphthylene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Acetophenone	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2-Acetylaminofluorene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Alachlor	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
4-Aminobiphenyl	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Aniline	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Anthracene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Aramite	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Atrazine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Azobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Benzaldehyde	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Benzidine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Benzoic acid	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Benzo (a) Anthracene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Benzo (b) Fluoranthene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Benzo (k) Fluoranthene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Benzo (ghi) Perylene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Benzo (a) Pyrene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Benzyl Alcohol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Bis (2-chloroethoxy) methane	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Bis (2-chloroethyl) Ether	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Bis (2-chloroisopropyl) Ether (2,2'Oxybis(1-chloropropane)	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Bis (2-ethylhexyl) Phthalate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
4-Bromophenyl Phenyl Ether	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Butyl Benzyl Phthalate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2-sec-Butyl-4,6-Dinitrophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Carbazole	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
4-Chloroanilene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Chlorobenzilate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
4-Chloro-3-Methylphenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1-Chloronaphthalene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2-Chloronaphthalene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2-Chlorophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
4-Chlorophenyl Phenyl Ether	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Chrysene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Cresols	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Diallate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Dibenzo (a,h) Anthracene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Dibenzofuran	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,2-Dichlorobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,3-Dichlorobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,4-Dichlorobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
3,3'-Dichlorobenzidine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2,4-Dichlorophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
2,6-Dichlorophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Diethyl phthalate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Dimethoate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
3,3-Dimethylbenzidine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
p-Dimethylaminoazobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
7,12-Dimethylbenz(a)anthracene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Alpha-,alpha-Dimethylphenethylamine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2,4-Dimethylphenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Dimethyl Phthalate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Di-n-Butyl Phthalate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Di-n-Octyl Phthalate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,3-Dinitrobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,4-Dinitrobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2,4-Dinitrophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2,4-Dinitrotoluene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2,6-Dinitrotoluene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,4-Dioxane	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Diphenylamine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,2-Diphenylhydrazine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Disulfoton	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Diesel Range Organics (DRO)	EPA 8015C	----------	EPA 8015B / 8015C, AK102/ 8015D / OK DEQ DRO	EPA 8015B / 8015C, AK102 / 8015D / OK DEQ DRO
Ethyl Methanesulfonate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Famphur	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Fluoroanthene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Fluorene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Hexachlorobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Hexachlorobutadiene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Hexachlorocyclopentadiene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Hexachloroethane	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Hexachloropropene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Indeno (1,2,3-cd) Pyrene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Isodrin	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Isophorone	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Isosafrole	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Methapyrilene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
3-Methylcholanthrene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2-Methyl-4,6-Dinitrophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Methyl Methane Sulfonate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1-Methylnaphthalene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
2-Methylnaphthalene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
2-Methylphenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
3+4-Methylphenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Naphthalene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
1,4-Naphthoquinone	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1-Naphthylamine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2-Naphthylamine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2-Nitroaniline	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
3-Nitroaniline	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
4-Nitroaniline	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Nitrobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2-Nitrophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
4-Nitrophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Nitroquinoline-1-Oxide	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
N-Nitrosodiethylamine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
N-Nitrosodimethylamine	----------	----------	EPA 8270C / 8270D/ 8270D SIM	EPA 8270C / 8270D/ 8270D SIM
N-Nitrosodi-n-Butylamine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
N-Nitrosodi-n-Propylamine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
N-Nitrosodiphenylamine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
N-Nitrosomethylethylamine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
N-Nitrosomorpholine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
N-Nitrosopiperidine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
N-Nitrosopyrrolidine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
5-Nitro-o-Toluidine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2,2-oxybis(1-chloropropane)	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Parathion, Methyl	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Parathion, Ethyl	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Pentachlorobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Pentachloroethane	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Pentachloronitobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Pentachlorophenol	----------	----------	EPA 8270C / 8270D / 8321A / 8321B	EPA 8270C / 8270D / 8321A / 8321B
Phenacetin	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Phenanthrene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Phenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Phorate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2-Picoline	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Pronamide	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Pyrene	----------	----------	EPA 8270C / 8270D / 8270SIM	EPA 8270C / 8270D / 8270SIM
Pyridine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Safrole	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Sulfotepp	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,2,4,5-Tetrachlorobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2,3,4,6-Tetrachlorophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Thionazin	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
o-Toluidine	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,2,4-Trichlorobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2,4,5-Trichlorophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
2,4,6-Trichlorophenol	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
o,o,o-Triethyl Phosphorothioate	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
1,3,5-Trinitrobenzene	----------	----------	EPA 8270C / 8270D	EPA 8270C / 8270D
Motor Oil (Residual Range Organics)	----------	----------	EPA 8015B / 8015C, 8015D, AK103 / OK DEQ RRO	EPA 8015B / 8015C, 8015D, AK103 / OK DEQ RRO
Pesticides/Herbicides/PCBs				
Aldrin	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Atrazine	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Azinophos ethyl	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Azinophos methyl	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
alpha-BHC	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
beta-BHC	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
delta-BHC	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
gamma-BHC	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Bolstar	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
alpha-Chlordane	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
gamma-Chlordane	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Chlordane (technical)	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Chloropyrifos	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Coumaphos	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
2,4-D	----------	----------	EPA 8151A / 8321A	EPA 8151A /8321A
Dalapon	----------	----------	EPA 8151A / 8321A	EPA 8151A / 8321A
2,4-DB	----------	----------	EPA 8151A / 8321A	EPA 8151A / 8321A
4,4'-DDD	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
4,4'-DDE	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
4,4'-DDT	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Demeton-O	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Demeton-S	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Demeton, total	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Diazinon	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Dicamba	----------	----------	EPA 8151A / 8321A	EPA 8151A / 8321A
Dichlorovos	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Dichloroprop	----------	----------	EPA 8151A / 8321A	EPA 8151A / 8321A
Dieldrin	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Dimethoate	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Dinoseb	----------	----------	EPA 8151A / 8321A	EPA 8321A
Disulfoton	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Endosulfan I	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Endosulfan II	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Endonsulfan sulfate	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Endrin	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Endrin aldehyde	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Endrin ketone	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
EPN	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Ethoprop	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Ethyl Parathion	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Famphur	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Fensulfothion	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Fenthion	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Heptachlor	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Heptachlor Epoxide	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Hexachlorobenzene	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Malathion	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
MCPA	----------	----------	EPA 8151A / 8321A	EPA 8151A / 8321A
MCPP	----------	----------	EPA 8151A / 8321A	EPA 8151A / 8321A
Merphos	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Methoxychlor	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Methyl parathion	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Mevinphos	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Naled	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
PCB-1016 (Arochlor)	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
PCB-1221	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
PCB-1232	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
PCB-1242	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
PCB-1248	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
PCB-1254	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
PCB-1260	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
PCB-1262	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
PCB-1268	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
Total PCBs	----------	----------	EPA 8082 / 8082A	EPA 8082 / 8082A
Phorate	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Phosmet	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Propazine	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Ronnel	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Simazine	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Stirophos	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Sulfotepp	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
2,4,5-T	----------	----------	EPA 8151A / 8321A	EPA 8151A / 8321A
Thionazin	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Tokuthion	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
2,4,5-TP	----------	----------	EPA 8151A / 8321A	EPA 8151A / 8321A
Toxaphene	----------	----------	EPA 8081A / 8081B	EPA 8081A / 8081B
Trichloronate	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
o,o,o-Triethylphos Phorothioate	----------	----------	EPA 8141A / 8141B	EPA 8141A / 8141B
Explosives				
1,3,5-Trinitrobenzene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
1,3-Dinitrobenzene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
2,4,6-Trinitrotoluene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
3,5-Dinitroaniline	----------	----------	EPA 8330B	EPA 8330B
2,4-Dinitrotoluene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
2,6-Dinitroltoluene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
2-Amino-4,6-Dinitrotoluene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
2-Nitrotoluene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
3-Nitrotoluene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
4-Amino-2,6-Dinitrotoluene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
4-Nitrotoluene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
Nitrobenzene	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
Nitroglycerin	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
Octahydro-1,3,5,7-Tetrabitro-1,3,5,7-Tetrazocine (HMX)	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
Pentaerythritoltetranitrate (PETN)	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
Picric acid	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
RDX (Hexahydro-1,3,5-Trinitro-1,3,5-Triazine)	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
Tetryl (Methyl 2,4,6-Trinitrophenylnitramine	----------	----------	EPA 8330A / 8330B / 8321A / 8321B	EPA 8330A / 8330B / 8321A / 8321B
Perfluorinated Hydrocarbons (PFCs) and Perfluorinated Sulfonates (PFSs)				
Perfluorobutanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluoropentanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorohexanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluoroheptanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorooctanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorononanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorodecanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluoroundecanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorododecanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorotridecanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorotetradecanoic Acid	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorobutane Sulfonate	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorohexane Sulfonate	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorooctane Sulfonate	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorodecane Sulfonate	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Perfluorooctane Sulfonamide	----------	SOP DV-LC-0012	SOP DV-LC-0012	SOP DV-LC-0012
Hazardous Waste Characteristics				
Conductivity	----------	----------	EPA 9050A	EPA 9050A
Corrosivity	----------	----------	EPA 9040B/ 9040C	EPA 9045C / 9045D
Ignitibility	----------	EPA 1010/EPA 1010A	EPA 1010 / 1010A	EPA 1010 / 1010A

Parameter/Analyte	WY Storage Tank Program	Non-Potable Water	Solid Hazardous Waste (Water)	Solid Hazardous Waste (Solid)
Paint Filter Liquids Test	----------	----------	EPA 9095A	EPA 9095A
Synthetic Precipitation Leaching Procedure (SPLP)	----------	----------	EPA 1312	EPA 1312
Toxicity Characteristic Leaching Procedure	----------	----------	EPA 1311	EPA 1311
Organic Prep Methods				
Separatory Funnel Liquid-Liquid Extraction	----------	----------	EPA 3510C	----------
Continuous Liquid-Liquid Extraction	----------	----------	EPA 3520C	----------
Soxhlet Extraction	----------	----------	----------	EPA 3540C
Microwave Extraction	----------	----------	----------	EPA 3546
Ultrasonic Extraction	----------	----------	----------	EPA 3550B
Ultrasonic Extraction	----------	----------	----------	EPA 3550C
Waste Dilution	----------	----------	EPA 3580A	EPA 3580A
Solid Phase Extraction Volatiles Purge and trap Volatiles Purge and Trap for Soils	----------	----------	EPA 3535A EPA 5030B	EPA 5030B EPA 5035
Organic Cleanup Procedures				
Florisil Cleanup	----------	----------	EPA 3620B	EPA 3620B
Florisil Cleanup	----------	----------	EPA 3620C	EPA 3620C
Sulfur Cleanup	----------	----------	EPA 3660B	EPA 3660B
Sulfuric Acid/Permanganate Cleanup	----------	----------	EPA 3665A	EPA 3665A
Metals Digestion				
Acid Digestion Total Recoverable or Dissolved Metals	----------	----------	EPA 3005A	----------
Acid Digestion for Total Metals	----------	----------	EPA 3010A	----------
Acid Digestion for Total Metals	----------	----------	EPA 3020A	----------
Acid Digestion of Sediments, Sludges and Soils	----------	----------	----------	EPA 3050B

American Association for Laboratory Accreditation

Accredited DoD ELAP Laboratory

A2LA has accredited

TESTAMERICA DENVER

Arvada, CO

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 4.2 of the DoD Quality System Manual for Environmental Laboratories (QSM); accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

Presented this 5th day of November 2013.

President & CEO
For the Accreditation Council
Certificate Number 2907.01
Valid to november 30, 2015
Revised October 29, 2015

For the tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.