Naval Facilities Engineering Systems Command

Naval Facilities Engineering Systems Command Northwest
Silverdale, Washington

Final

Sampling and Analysis Plan Per- and Polyfluoroalkyl Substances Site Inspection Seaplane Base

Naval Air Station Whidbey Island
Oak Harbor, Washington

March 2021

SAP Worksheet #1—Title and Signature Page

Naval Facilities Engineering Systems Command Northwest
Silverdale, Washington

Final

Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances Site Inspection
Seaplane Base

Naval Air Station Whidbey Island
Oak Harbor, Washington

March 2021

Prepared for NAVFAC Northwest
by CH2M HILL, Inc.
Bellevue, Washington
Contract N62470-16-D-9000
CTO 4041

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SAP Worksheet #1—Title and Signature Page (continued)

Approval Signatures:

TBD
Naval Facilities Engineering Systems Command Atlantic
Quality Assurance Officer

Other Approval Signatures:

Kendra Leibman
Naval Facilities Engineering Systems Command Northwest
Remedial Project Manager

Chan Pongkhamsing
United States Environmental Protection Agency Region 10
Remedial Project Manager

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Executive Summary

The Department of the Navy (Navy), Naval Facilities Engineering Systems Command (NAVFAC) Northwest has contracted CH2M HILL, Inc. (CH2M) to conduct a Site Inspection (SI) specific to known or suspected releases of per- and polyfluoroalkyl substances (PFAS) to the environment at Naval Air Station Whidbey Island (NASWI), Seaplane Base, in Oak Harbor, Washington in Island County (**Figure 10-1**). This Uniform Federal Policy-Sampling and Analysis Plan/Quality Assurance Project Plan (SAP) describes the inspection activities to be conducted on Seaplane Base in Oak Harbor. CH2M prepared this document under the NAVFAC Comprehensive Long-term Environmental Action – Navy 9000 Contract N62470-16-D-9000, Contract Task Order 4041, for submittal to NAVFAC Northwest, NAVFAC Atlantic, and the United States Environmental Protection Agency (USEPA).

Seaplane Base is located on Whidbey Island near Oak Harbor, Washington, and is one of three NASWI installations (**Figure 10-1**). Seaplane Base was commissioned in 1942 and was constructed using dredged fill from Oak and Crescent Harbors. The Patrol Bomber Catalina, which resembled a large flying boat, began operations from Seaplane Base in December 1942.

Although flight operations ceased by the mid-1960s, Seaplane Base continued operational support of Ault Field, including a constructed fuel farm (removed in the 1990s), housing, and storage areas. Currently, Seaplane Base contains the Family Services Center, Commissary, Navy Exchange, family housing and lodge, sanitary wastewater treatment plant, gas station, vehicle maintenance facility, fire station, and storage facilities.

Based on the preliminary assessment (PA) at Seaplane Base, there are two potential source areas where PFAS may have been stored, used, or released (CH2M 2018). The following areas were identified in the PA for Seaplane Base as requiring further investigation:

- Vehicle Maintenance – Building 18
- Biosolids Land Application Area

Additionally, during the development of this SAP, information regarding the operations of the Building 18 wash rack was identified that was unknown during the PA. The new information was that the sanitary waste water treatment plane (WWTP) receives water from the Building 18 wash rack when the valve is manually turned. Although the WWTP was evaluated in the PA and not recommended for further evaluation, due to the relevant new information, the WWTP was identified as a potential PFAS source area and its investigation is included in this SAP.

The vehicle maintenance building, Building 18, is located on the peninsula of Seaplane Base northwest of the intersection of Coral Sea Avenue and Tulagi Avenue (**Figure 11-1**). The building is surrounded by a large concrete parking lot with small areas of grass to the east, south, and west. There is one storm drain inlet located on the north side of the building, and a wash rack drain located on the east side of the building. While the wash rack drain is part of a recycled system, a valve associated with this drain allows connection to the sanitary WWTP.

Aqueous film-forming foam (AFFF) holding tanks on the fire trucks at Seaplane Base were filled using 5-gallon buckets. Refilling of the AFFF tank on fire trucks typically occurs at Ault Field, but based on information provided by Naval Air Station (NAS) employees during a site visit, isolated filling at the storm drain inlet or at the wash rack may have occurred. After AFFF filling activities, the fire trucks could have been washed at the same storm drain inlet or wash rack drain, potentially washing AFFF residue off the trucks and releasing it to the environment through the storm drain.

The Seaplane Base sanitary WWTP, which includes three lagoons, was constructed in 1960 to treat wastewater from Navy housing on Seaplane Base (**Figure 11-2**) (CH2M, 2018). The sanitary WWTP is a lagoon system with a headworks and effluent polishing, and discharges to Crescent Harbor through an outfall. The solids are sent to the Island County Landfill for disposal. In 1987, the Navy entered an agreement with the City of Oak Harbor to run the

Seaplane Base sanitary WWTP for both the Seaplane Base and City of Oak Harbor. The City of Oak Harbor and the Navy have both invested in many WWTP improvements and expansions over the years. (CH2M, 2018).

No formal records of AFFF storage, use, or disposal were identified during the review of the Seaplane Base in the PA. However, it was discovered during SI planning activities that the wash rack catch basin at Building 18 is connected to the sanitary WWTP. It is possible that truck washing activities at Building 18 could release small amounts of AFFF to the sanitary system.

The Biosolids Land Application Area encompasses 2.3 acres of land (**Figure 11-3**). Biosolids from the Ault Field WWTP were land applied at multiple locations within NASWI, at Seaplane Base. The location identified in **Figure 11-3** received approximately 400 cubic yards of biosolids material from the Ault Field WWTP.

The objectives of the SI are to:

- Determine if PFAS are present in soil at Building 18, Biosolids Land Application Area, and Sanitary WWTP at levels that pose potential risks to human health and the environment and determine if soil at all three sites have the potential to act as a source to groundwater. Determine if PFAS are present in groundwater in the three potential source areas at concentrations posing potential risks to human receptors or the environment

Groundwater and soil samples will be collected from the three potential source areas identified in the PA and analyzed for PFAS by LCMSMS compliant with QSM 5.3 Table B-15, or the most recent version of the QSM for which the lab is accredited at the time of the investigation.

Site Inspection Sampling of Areas Near Potential Source Areas

- Collection of approximately eight subsurface grab soil samples in the capillary fringe via boreholes (four at Building 18, three at the WWTP, and one at the Biosolid Land Application Area) for analysis of 18 PFAS constituents
- Collection of four composite surface soil samples at the Biosolid Land Application area for analysis of 18 PFAS constituents
- Installation and sampling of five monitoring wells (four at Building 18, and one at the Biosolid Land Application Area (due to the limited size) for 18 PFAS constituents. Groundwater sampling at the WWTP will utilize existing wells.
- Lithologic logging of continuous cores collected during well installation
- Sampling of groundwater
- Collect groundwater samples for the analysis of 18 PFAS constituents from newly installed and existing monitoring wells

This SAP was developed in accordance with the following guidance documents:

- Guidance for Quality Assurance Project Plans (USEPA, 2002)
- Uniform Federal Policy for Quality Assurance Project Plans (USEPA, 2005)
- Guidance on Systematic Planning Using the Data Quality Objectives Process (USEPA, 2006)
- Interim Per- and Polyfluoralkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update (Navy, 2017a)

CH2M prepared this SAP in accordance with the Navy's Uniform Federal Policy Sampling and Analysis Plan policy guidance to help ensure that environmental data collected are scientifically sound, of known and documented quality, and suitable for intended uses.

This SAP consists of 37 worksheets specific to the scope of this inspection. All tables are embedded within the worksheets. All figures are included at the end of the document. Field standard operation procedures (SOPs) are included in **Appendix A**. Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP) Accreditation letters are included in **Appendix B**. Laboratory SOPs are included in **Appendix C**.

The laboratory information cited in this SAP is specific to Battelle Analytical Services, the laboratory that has been selected to support the laboratory needs for this project. If additional laboratory services are necessary to meet the project objectives, revised SAP worksheets will be submitted to NAVFAC Northwest and regulatory agencies (as appropriate) for approval and appended to this SAP.

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SAP Worksheets

Appendixes

Tables

Figures

Acronyms and Abbreviations

±	plus or minus
%	percent
>	more than
<	less than
≤	less than or equal to
°C	degree Celsius
µg/L	micrograms per liter
AQM	Activity Quality Manager
AM	Activity Manager
AFFF	aqueous film-forming foam
amu	atomic mass unit
API	American Petroleum Institute
ASTM	ASTM International
bgs	below ground surface
CA	corrective action
CCV	continuing calibration verification
CH2M	CH2M HILL, Inc.
CLEAN	Comprehensive Long-term Environmental Action—Navy
DL	detection limit
DoD	Department of Defense
DQI	data quality indicator
DV	data validator
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
FD	field duplicate
FTL	Field Team Leader
gpm	gallons per minute
H&S	health and safety
HDPE	high density polyethylene
HQ	hazard quotient
HSM	Health and Safety Manager
HSP	Health and Safety Plan
ICAL	initial calibration
ICV	initial calibration verification
ID	identification
IDW	investigation-derived waste
ISC	instrument sensitivity check
KHW	Keystone Hill Well
LC/MS/MS	liquid chromatography – tandem mass spectrometer
LCS	laboratory control sample
LCL	lower confidence limit

LOD	limit of detection
LOQ	limit of quantitation
mL	milliliter(s)
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NAS	Naval Air Station
NAVD88	North American Vertical Datum of 1988
NAVFAC	Naval Facilities Engineering Systems Command
Navy	Department of the Navy
NEtFOSAA	n-ethylperfluoro-1-octancesulfonamidoacetic acid
NMeFOSAA	n-methylperfluoro-1-octanesulfonamidoacetic acid
NTR	Navy Technical Representative
PA	preliminary assessment
PAL	project action limit
PC	Project Chemist
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutane sulfonate
PFDA	perfluorodecanoic acid
PFDoA	perfluorododecanoic acid
PFHxA	perfluorohexanoic acid
PFHpA	perfluoroheptanoic acid
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PFTeDA	perfluorotetradecanoic acid
PFTrDA	perfluorotridecanoic acid
PFUnA	perfluoroundecanoic acid
PID	Photoionization Detector
PM	Project Manager
POC	point of contact
PQL	project quantitation limit
PQO	Project Quality Objective
PSA	potential source area
QA	quality assurance
QAO	Quality Assurance Officer
QC	quality control
QSM	Quality Systems Manual
RI	remedial investigation
RL	reporting limit
RPD	relative percent difference
RPM	Remedial Project Manager
RSL	regional screening level

SAP	Sampling and Analysis Plan
SBO	safe behavior observation
SI	site inspection
SME	Subject Matter Expert
SOP	standard operating procedure
SSC	Site Safety Coordinator
SSL	soil screening level
STC	Senior Technical Consultant
TAT	turn-around time
TBD	to be determined
TM	Task Manager
UCL	upper confidence limit
UCMR	Unregulated Contaminant Monitoring Rule
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
WWTP	Wastewater Treatment Plant

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SAP Worksheet #2—Sampling and Analysis Plan Identifying Information

Site Name/Number:	Seaplane Base, Oak Harbor, Naval Air Station Whidbey Island (NASWI)
Operable Unit:	Not Applicable (N/A)
Contractor Name:	CH2M HILL, Inc. (CH2M)
Contract Number:	N62470-16-D-9000, Contract Task Order 4041
Contract Title:	Comprehensive Long-term Environmental Action – Navy (CLEAN) Program 9000
Work Assignment:	Site Inspection (SI) specific to known or suspected releases of per- and polyfluoroalkyl substances (PFAS) to the environment for Naval Facilities Engineering Systems Command (NAVFAC) northwest at Seaplane Base in Oak Harbor, Washington.

1. **This Sampling and Analysis Plan (SAP) was prepared in accordance with the following guidance documents:**
   - *Guidance for Quality Assurance Project Plans* (USEPA, 2002)
   - *Uniform Federal Policy for Quality Assurance Project Plans* (USEPA, 2005)
   - *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)
   - *Interim Per- and Polyfluoralkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update* (Navy, 2017a)
2. **Identify regulatory Program:** Comprehensive Environmental Response, Compensation and Liability Act of 1980.
3. **This document is a project-specific SAP.** The approval entities are the NAVFAC Northwest Remedial Project Manager (RPM) and NAVFAC Atlantic Quality Assurance Officer (QAO).
4. **List dates of scoping sessions that were held:**

Scoping Session	Date
Project Scoping Session with NAVFAC Northwest RPM	March 14, 2019
Follow Up Project Scoping Session with NAVFAC Northwest RPM	April 26, 2019

5. **List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation:**

Document	Date
None	

SAP Worksheet #2—Sampling and Analysis Plan Identifying Information (continued)

6. List organizational partners (stakeholders) and identify the connection with lead organization:

Organization Partners/Stakeholders	Connection	Date
NAVFAC Atlantic	Project QAO	2017–present
NAVFAC Northwest – Kendra Leibman	RPM	2017-present
United States Environmental Protection Agency (USEPA) Region 10 – Chan Pongkhamsing	Technical Representative	2018-present
Island County, Washington – Doug Kelly	Technical Representative	2017-present

7. Lead organization:

- Navy – NAVFAC Northwest

8. If any required SAP elements and required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion as follows:

- Crosswalk table is excluded because all required information is provided in this SAP.

SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number	E-mail Address or Mailing Address
Kendra Leibman	RPM/Task Order Contracting Officer's Representative	NAVFAC Northwest	(360) 396-0022	kendra.leibman@navy.mil
Steve Skeehan	Navy Technical Representative (NTR)	NAVFAC Northwest	(253) 279-0212	Steve.skeehan@navy.mil
Charlie Escola	NTR	NAVFAC Northwest	(503) 201-5020	charles.escola@navy.mil
Chan Pongkhamsing	USEPA Technical Representative	USEPA Region 10	(206) 553-1806	Pongkhamsing.Chan@epa.gov
Doug Kelly	Environmental Health, Hydrogeologist	Island County	(360) 678-7885	D.Kelly@islandcountywa.gov
Jennifer Madsen	Activity Manager (AM) Project Manager (PM)	CH2M	(425) 233-3293	Jennifer.madsen@jacobs.com
Peter Lawson	Senior Technical Consultant (STC)	CH2M	(530) 229-3383	peter.lawson@jacobs.com
Paul Townley	Activity Quality Manager (AQM)	CH2M	(425) 233-5302	paul.townley@jacobs.com
Laura Cook	Subject Matter Expert (SME)	CH2M	(757) 671-6214	Laura.cook@jacobs.com
Allan Erickson	Project Task Manager (TM)	CH2M	(208) 383-6133	allan.erickson@jacobs.com
Janna Staszak	Program SAP Quality Reviewer	CH2M	(757) 671-6256	Janna.staszak@jacobs.com
Anita Dodson	Program Chemist/SAP Reviewer	CH2M	(757) 671-6218	anita.dodson@jacobs.com
Tiffany Hill	Project Chemist	CH2M	(541) 768-3109	tiffany.hill@jacobs.com
To be determined (TBD)	Data Validator	CH2M	TBD	TBD
TBD	Field Team Leader (FTL)	CH2M	TBD	TBD
TBD	Site Safety Coordinator (SSC)	CH2M	TBD	TBD
Jonathan Thorn	Laboratory PM	Battelle Analytical Services	(781) 681-5565	thorn@battelle.org

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SAP Worksheet #4—Project Personnel Sign-Off Sheet

Name	Organization/Title/Role	Telephone Number	Signature/Email Receipt	SAP Section Reviewed	Date SAP Read
Jennifer Madsen	CH2M/AM	(425) 233-3293			
Peter Lawson	CH2M/STC	(530) 229-3383			
Paul Townley	CH2M/AQM	(425) 233-5302			
Laura Cook	CH2M/SME	(757) 671-6214			
Jennifer Madsen	CH2M/PM	(425) 233-3293			
Allan Erickson	CH2M/TM	(208) 383-6133			
Anita Dodson	CH2M/Program Chemist/SAP Reviewer	(757) 671-6218			
Tiffany Hill	CH2M/PC	(541) 768-3109			
TBD	CH2M/Data Validator	TBD			
Loren Kaehn	CH2M/Health and Safety Manager (HSM)	(208) 383-6212			
TBD	CH2M/FTL	TBD			
TBD	CH2M/SSC	TBD			
Jonathan Thorn	Battelle Analytical Services/Laboratory PM	(781) 681-5565			

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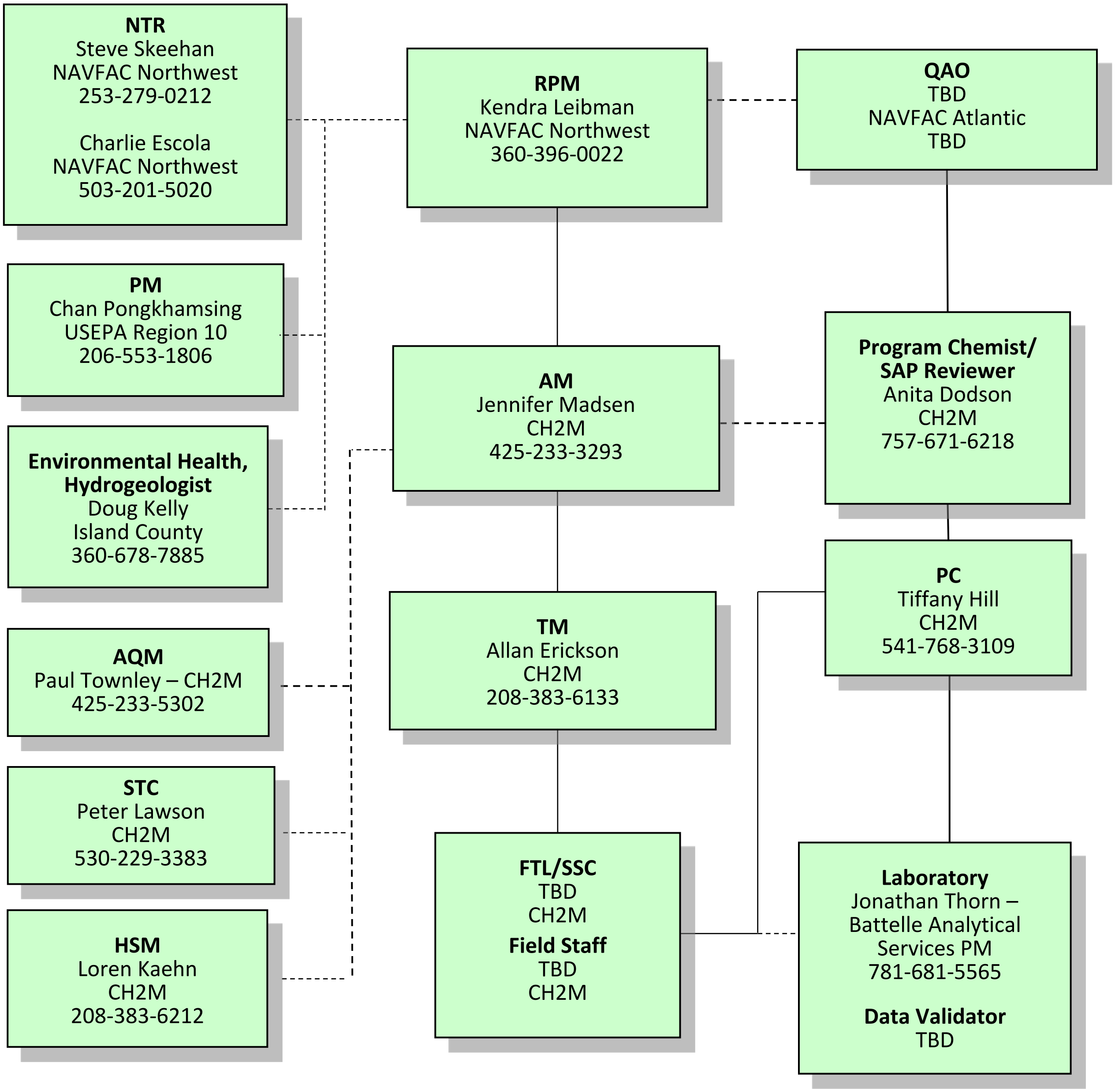
SAP Worksheet #5—Project Organizational Chart



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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure
Communication with Navy (lead agency)	NTR	Steve Skeehan	steve.skeehan@navy.mil (253) 279-0212	Primary point of contact (POC) for the Navy for the contractor during field work; oversees field work, provides base-specific information, provides coordination with Naval Air Station (NAS) Whidbey Island, and can delegate communication to other internal POCs.
Communication with Navy (lead agency)	NTR	Charlie Escola	charles.escola@navy.mil (503) 201-5020	Primary POC for the Navy for the contractor during field work; oversees field work, provides base-specific information, provides coordination with NASWI, and can delegate communication to other internal POCs.
Communication with Navy (lead agency and outside stakeholders)	RPM	Kendra Leibman	kendra.leibman@navy.mil (360) 396-0022	Primary POC for the Navy; can delegate communication to other internal or external POCs. CH2M PM will notify the NTR and RPM by email or telephone call within 24 hours for changes affecting the scope or implementation of the SAP.
Communication regarding overall project status and implementation and primary POC with RPMs and project team	CH2M AM	Jennifer Madsen	jennifer.madsen@jacobs.com (425) 233-3293	Oversees the project and will be informed of project status by the TM. If field changes are necessary, AM will work with the RPM to prepare a field change request (FCR) to be submitted to the NTR, RPM and NAVFAC Atlantic QAO and will communicate in-field changes to the team by email within 24 hours. All data results will be communicated to appropriate team members following data receipt and review.
Technical communications for project implementation, and data interpretation	CH2M STC	Peter Lawson	peter.lawson@jacobs.com (530) 229-3383	Contact STC regarding questions/issues encountered in the field, input on data interpretation, as needed. STC will have 24 hours to respond to technical field questions as necessary. Additionally, STC will review the data as necessary prior to Base and Navy discussions and reporting review.
Quality issues	CH2M AQM	Paul Townley	paul.townley@jacobs.com (425) 233-5302	Contact AQM regarding quality issues during project implementation. The AQM will report to the PM, NTR, and RPM.
Technical communications for project implementation, and data interpretation related to PFAS	CH2M SME	Laura Cook	laura.cook@jacobs.com (757) 671-6214	Contact SME regarding PFAS-related questions/issues encountered in the field, input on data interpretation, as needed. SME will have 24 hours to respond to technical field questions as necessary. Additionally, SME will review the data as necessary prior to Base and Navy discussions and reporting review.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure
Communication regarding items specific to Seaplane Base tasks and primary POC for field team	CH2M TM	Allan Erickson	allan.erickson@jacobs.com (208) 383-6133	Oversees the investigation task and will be informed of task status by the FTL. If field changes are necessary, TM will work with the PM to produce and FCR for the NTR, RPM and NAFVAC Atlantic QAO will communicate in-field changes to the team by email within 24 hours.
Health and safety (H&S)	CH2M HSM	Loren Kaehn	loren.kaehn@jacobs.com (208) 383-6212	Responsible for generation of the Health and Safety Plan (HSP) and approval of the activity hazard analyses prior to the start of fieldwork. The PM will contact the HSM as needed regarding questions/issues encountered in the field.
H&S	CH2M SSC	TBD	TBD	Responsible for the adherence of team members to the site safety requirements described in the HSP. Will report H&S incidents and near losses to the PM as soon as possible.
Stop Work Order	CH2M AM	Jennifer Madsen	Jennifer.madsen@jacobs.com (425) 233-3293	Any field member can immediately stop work if an unsafe condition that is immediately threatening to human health is observed. The field staff, FTL, or SSC should notify the NTR, RPM, and the CH2M PM immediately. Ultimately, the FTL and PM can stop work for a period of time. NAVFAC Northwest can stop work at any time.
	CH2M TM	Allan Erickson	allan.erickson@jacobs.com (208)383-3833	
	CH2M FTL/SSC	TBD	TBD	
	CH2M Field Team Members	TBD	TBD	
Work plan changes in field	CH2M FTL	TBD	TBD	Documentation of deviations from the work plan will be made in the field notes, and the PM will be notified immediately. Deviations will be made only with approval from the PM.
Communication regarding SAP changes	CH2M Program Chemist	Anita Dodson	anita.dodson@jacobs.com (757) 671-6218	Changes to the project that would prompt a SAP change that would require Navy QAO approval include: the addition of an analytical suite not previously included in the SAP, the addition of an environmental matrix not previously included in the SAP, laboratory accreditation to a new DoD QSM version, inclusion of a new laboratory into the SAP for any reason, or updates to the Conceptual Site Model that prompt new data quality objectives. Updated laboratory limit of quantitation (LOQ), limit of detection (LOD), detection limit (DL) values will not prompt a SAP update for Navy QAO approval unless those updates negatively impact the ability to meet project action levels.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure
Field changes/field progress reports	CH2M FTL	TBD	TBD	Documentation of field activities and work plan deviations (made with the approval of STC and/or QAO) in field notes; provide daily progress reports to PM.
Reporting laboratory data quality issues	Battelle Analytical Services PM	Jonathan Thorn	thornj@battelle.org (781) 681-5565	All quality assurance (QA)/quality control (QC) issues with project field samples will be reported within 2 days to the PC by the laboratory. The Navy RPM will be notified of significant issues who may discuss with the Navy chemist.
Analytical corrective actions (CAs)	PC	Tiffany Hill	tiffany.hill@jacobs.com (541) 768-3109	Any CAs for field and analytical issues will be determined by the FTL and/or the PC and reported to the PM within 4 hours. The PM will ensure SAP requirements are met by field staff for the duration of the project.
Data tracking from field collection to database upload Release of analytical data	PC	Tiffany Hill	tiffany.hill@jacobs.com (541) 768-3109	Tracks data from sample collection through database upload daily. No analytical data can be released until validation of the data is completed and has been approved by the PC. The PC will review analytical results within 24 hours of receipt for release to the PM. The PC will inform the Navy CLEAN Program Chemist, who will notify the Navy QAO of any laboratory issues that would prevent the project from meeting project quality objectives or would cause significant delay in the project schedule.
Reporting data quality issues	Data Validator (DV)	TBD	TBD	The DV reviews and qualifies analytical data as necessary. The data along with a validation narrative are returned to the PC within 7 calendar days.
Field CAs	AM, TM, and FTL	Jennifer Madsen	Jennifer.madsen@jacobs.com (425) 233-3293	Field and analytical issues requiring CA will be determined by the FTL and/or TM PM on an as-needed basis. The PM will ensure SAP requirements are met by field staff for the duration of the project. The FTL will notify the PM via phone of any need for CA within 4 hours. The PM may notify the NTR and RPM of any field issues that would negatively affect schedule or the ability to meet project data quality objectives.
		Allan Erickson	allan.erickson@jacobs.com (208) 383-6133	
		TBD	TBD	

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SAP Worksheet #7—Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Kendra Leibman	RPM	NAVFAC Northwest	Oversees project for Navy and provides base-specific information, and coordination with NASWI.
Charlie Escola	NTR	NAVFAC Northwest	Oversees field work; provides base-specific information, and coordination with NASWI.
Steve Skeehan	NTR	NAVFAC Northwest	Oversees field work; provides base-specific information, and coordination with NASWI.
TBD	NAVFAC QAO/Chemist	NAVFAC Atlantic	Provides QA oversight and reviews SAPs.
Jennifer Madsen	AM	CH2M	Oversees and manages project activities.
Peter Lawson	STC	CH2M	Provides senior technical support for project approach and execution.
Paul Townley	AQM	CH2M	Provides QA oversight.
Laura Cook	SME	CH2M	Provides PFAS-related senior technical support for project approach and execution.
Allan Erickson	Project TM	CH2M	Oversees and manages all tasks associated with Seaplane Base
Janna Staszak	SAP Reviewer	CH2M	Reviews and approves changes or revisions to the SAP.
Anita Dodson	Program Chemist/SAP Reviewer	CH2M	Provides SAP project delivery support, reviews and approves SAPs, and performs final data evaluation and QA oversight.
Tiffany Hill	PC	CH2M	Data management: Performs data evaluation and QA oversight, is the POC with laboratory and validator for analytical issues.
Loren Kaehn	HSM	CH2M	Prepares HSP and manages H&S for all field activities.
TBD	DV	TBD	Validate laboratory data from an analytical standpoint prior to data use.
TBD	FTL	CH2M	Coordinates all field activities and sampling.
TBD	Field Staff	CH2M	Conducts field activities.
Jonathan Thorn	Laboratory PM	Battelle Analytical Services	Manages samples tracking and maintains good communication with PC.
Gail DeRuzzo	Laboratory QAO	Battelle Analytical Services	Responsible for audits, CA, and checks of QA performance within the laboratory.

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SAP Worksheet #8—Special Personnel Training Requirements Table

No special personnel training requirements are required to meet project objectives. Standard operating procedures (SOPs) related to sampling of PFAS sites are listed in **Worksheet #21** and will be discussed at the field kick-off meeting.

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SAP Worksheet #9-1—Project Scoping Session Participants Sheet

Project Name: Seaplane Base Site Inspection **Projected Date(s) of Sampling:** March – April 2021 **PM:** Jennifer Madsen/CH2M			**Site Name:** Seaplane Base NASWI **Site Location:** Oak Harbor, Washington	
Date of Session: Thursday, 14 March 2019 **Scoping Session Purpose:** To obtain consensus on the path forward for the SI for PFAS at Seaplane Base				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
Kendra Leibman	RPM	NAVFAC Northwest	(360) 396-0022	Kendra.Leibman@navy.mil
Allan Erickson	TM	CH2M	(208) 383-6133	Allan.Erickson@jacobs.com
Jennifer Madsen	PM	CH2M	(425) 233-3392	Jennfier.Madsen@jacobs.com

Comments

The purpose of the scoping session was to discuss the draft SI strategy with the Navy to obtain consensus on the path forward for the SI at Seaplane Base. Field work is expected to begin in August 2019.

Action Items

- Discuss other ongoing on-Base PFAS sampling being conducted by NASWI Environmental. Ensure continued communication between CH2M and NASWI Environmental to further refine SI scope as needed.
- Update the SI strategy to not include a phased approach. Identified SI areas will undergo soil where the media is available. All SI areas will have at least one groundwater well installed with a soil sample collected from the borehole at the water table interface.

SAP Worksheet #9-2—Project Scoping Session Participants Sheet

Project Name: Seaplane Base Site Investigation **Projected Date(s) of Sampling:** March – April 2021 **PM:** Jennifer Madsen/CH2M			**Site Name:** Seaplane Base NASWI **Site Location:** Oak Harbor, Washington	
Date of Session: Friday, 26 April 2019 **Scoping Session Purpose:** To gain consensus on the new information regarding potential PFAS release at the Seaplane Base at WWTP.				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
Kendra Leibman	RPM	NAVFAC Northwest	(360) 396-0022	Kendra.leibman@navy.mil
Jennifer Madsen	PM	CH2M	(425) 233-3293	Jennifer.madsen@jacobs.com
Allan Erickson	TM	CH2M	(208) 383-6133	Allan.Erickson@jacobs.com

Comments

The purpose of the scoping session was to discuss findings from recent information provided by NASWI Environmental to gain consensus on the new information regarding potential PFAS release at the Seaplane Base. Recently discovered unknown information indicated that the WWTP was a possible source for PFAS. Field work is expected to begin in August 2019.

Action Items

- Include the WWTP in the SI as a possible source for PFAS.
- Navy will provide direction for documenting the WWTP as a possible source.

Consensus Decisions

The team agreed that the Seaplane Base sanitary WWTP should be included in the SI. The approach would be limited to investigation of groundwater downgradient of the sanitary lagoons.

SAP Worksheet #10—Conceptual Site Model

Seaplane Base is located on Whidbey Island near Oak Harbor, Washington (**Figure 10-1**). **Figure 10-2** presents the layout of Seaplane Base and the surrounding area. **Table 10-1** presents a summary of the site description and background.

Table 10-1. Site Description and Background
Seaplane Base, NASWI, Oak Harbor, Washington

Site Name	Seaplane Base, NASWI, Oak Harbor, Washington
Study Area Description	Seaplane Base is located adjacent to the eastern border of the town of Oak Harbor, Washington (**Figure 10-1**), and is one of three NASWI installations. Seaplane Base was commissioned in 1942 and was constructed using dredged fill from Oak and Crescent Harbors. The Patrol Bomber Catalina, which resembled a large flying boat, began operations from Seaplane Base in December 1942. There are three areas identified for the site investigation. The three areas to be investigated are located north of Crescent Harbor. • Vehicle Maintenance Building (Building 18) Wash Rack The vehicle maintenance building, Building 18, is located on the peninsula of Seaplane Base northwest of the intersection of Coral Sea Avenue and Tulagi Avenue. The building is surrounded by a large concrete parking lot with small areas of grass to the east, south, and west. There is one storm drain inlet located on the north side of the building. The location of the outfall for this storm drain is just west of building 22. An additional drain is located on the east side of the building associated with a wash rack. The wash rack drain is known to be tied into the sanitary sewer system via a manual valve. • Sanitary Wastewater Treatment Plant (WWTP) The sanitary WWTP, which includes four lagoons, was constructed in 1960 to treat wastewater from Navy housing on Seaplane Base (**Figure 10-2**). The WWTP is a lagoon system with a headworks and effluent polishing and discharges to Crescent Harbor through an outfall. The solids are sent to the Island County Landfill for disposal. • The Biosolids Land Application Area The Biosolids Land Application area is located northeast of Crescent Harbor and encompasses 2.3 acres of land. (**Figure 10-2**). The land application area is secured due to nearby munitions storage areas and consists of an open field area with trees to the north and east and Crescent Bay to the south and west. The biosolids from Ault Field WWTP were applied in 2015 and in 2017 with approximately 400 cubic yards of material during each year.
Potential Sources	Vehicle Maintenance Building (Building 18) – wash rack: AFFF holding tanks on the fire trucks at Seaplane Base were filled using 5-gallon buckets. Refilling of the AFFF tank on fire trucks typically occurs at Ault Field, but based on interviews completed during the PA, isolated filling at the storm drain inlet or at the wash rack may have occurred. The frequency of filling fire trucks with AFFF was very low since AFFF is rated to last 25 years. In addition, the risk manual states that spills during the loading of AFFF were reduced by the introduction of an automatic loading apparatus which keeps the AFFF within tubing during the transfer from the storage tank into the AFFF tank on the fire truck. Visual Site Inspection of the vehicle maintenance building identified a designated wash rack for vehicles located on the eastern side of Building 18. Additionally, a large storm drain inlet located north of the building was observed and confirmed by NASWI personnel to have been used while washing trucks. Based on the information provided, it is possible that small releases of PFAS occurred during fire truck washing activities if AFFF residue was washed off of trucks. The wash rack drain ties into the sanitary WWTP.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site Description and Background
Seaplane Base, NASWI, Oak Harbor, Washington

Potential Sources (cont.)		Sanitary WWTP: No formal records of AFFF storage, use, or disposal were identified during the review of this area. It is not known if any floor drains from buildings flow to the WWTP. The stormwater drain inlets discharge to the stormwater outfall directly and do not connect to the WWTP. There was no anecdotal evidence that disposal of AFFF occurred at the Seaplane Base WWTP. However, PFAS was detected in a sample collected from the wash rack catch basin drain at Building 18. This catch basin is connected via a manually operated valve to the sanitary WWTP. Biosolids Land Application Area No formal records of AFFF storage, use, or release were identified during the PA. In 2014, an AFFF release of approximately 500 gallons (1/8 gallon AFFF and 500 gallons of water) occurred at Ault Field and was potentially disposed of at the Ault Field WWTP. Biosolids from the Ault Field WWTP were land applied at multiple locations within NASWI, including east of the munitions storage area at Seaplane Base. The location, identified in **Figure 10-2,** received approximately 400 cubic yards of biosolids material from Ault Field WWTP. Based on the operational history of the Ault Field WWTP, there is a potential of PFAS release to the environment at the Biosolids Land Application area.
Study Area Investigation History		Several reports that document past environmental investigations were reviewed for PFAS-related information pertaining to the use, storage, or release of AFFF at Seaplane Base. These reports included the 1993 RI report (URS, 1993) and the 2016 Third 5-Year Review report (Navy, 2016). According the information provided by base personnel, perfluorooctane sulfonate (PFOS)/perfluorooctanoic acid (PFOA) was detected above Lifetime Health Advisory in a sample collected from the Building 18 wash rack catch basin drain. The presence of PFAS in surface soil or groundwater at the three potential source areas is unknown.
Current Use		Although flight operations ceased by the mid-1960s, Seaplane Base continued operational support of Ault Field, including a constructed fuel farm (removed in 1990s), housing, and storage areas. Currently, Seaplane Base contains the Family Services Center, Commissary, Navy Exchange, family housing and lodge, sanitary wastewater treatment plant, gas station, vehicle maintenance facility, fire station, and storage facilities. Because of the proximity to Puget Sound, groundwater at Seaplane Base is tidally influenced and brackish, and therefore is not a suitable source of potable water. The primary source of fresh water is supplied to the City of Oak Harbor and Seaplane Base from the City of Anacortes located on the mainland 16 miles to the north via a pipeline (URS, 1993). Some residents upgradient of Seaplane Base to the north have private water supply wells but these are completed several hundred feet below ground surface within the sea-level aquifer, with the nearest well approximately 1.3 miles away (Section 2.3.1).
Site Conditions	**Physical Characteristics**	Whidbey Island, including the entire proposed sampling area, lies within the Puget Lowland, a topographic and structural depression between the Olympic Mountains and the Cascade Range.
	Geology and Hydrogeology	Seaplane Base is generally level in the developed areas of the base with localized elevation ranges from 0 to 50 feet above mean sea level (msl). The stratigraphy of the base generally consists of glaciomarine drift overlying Vashon till and advance outwash (Shannon and Wilson, 1978; USGS, 1986). The low-lying marsh area north of Crescent Harbor generally contains organic-rich silt and clay. The narrow strip of land that connects Whidbey Island to the Maylor peninsula was originally a tombolo (narrow sandy strip of land. A near-surface, unconfined aquifer exists closer to Seaplane Base (CH2M, 2018). This unconfined aquifer contains surficial dredged materials and the shallow underlying sediments appear to behave as a single aquifer. Monitoring wells drilled in the area defined the bottom of the surficial aquifer to be about 67 feet below ground surface, where the lithology changed to silty sand with clay and acts as an aquitard. The depth to groundwater ranges from 15 to 25 feet below grade.
Site Conditions (cont.)	**Geology and Hydrogeology (cont.)**	Tidal forces also influence groundwater flow, especially in the low-lying area north of Crescent Harbor. Based on previous investigations at the site, groundwater level measurements (CH2M, 2018), the groundwater flow direction is generally to the south.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site Description and Background
Seaplane Base, NASWI, Oak Harbor, Washington

		However, the groundwater elevation changes with the tides and the degree of change and lag times in groundwater levels appears to be inversely related to the distance of the wells from Crescent Harbor. Additionally, because most of the production wells on Whidbey Island pump from the sea-level aquifer, pumping water levels are below msl for most of the major wells. This indicates that lateral seawater intrusion towards pumping wells threatens water quality in the vicinity of Seaplane Base and Oak Harbor (CH2M, 2018). Groundwater at Seaplane Base within the fill material between Whidbey Island and the Maylor peninsula flows due west towards the Oak Harbor shoreline (CH2M, 2018). A groundwater divide is likely present between this area and areas to the east where groundwater flows to the east towards Crescent Harbor. The groundwater in the area along the north shore of Crescent Harbor varies due to tidal influences, but generally flows to the south to Crescent Harbor.
Contaminants of Potential Concern (COPCs)		18 PFAS compounds, see **Worksheet #15** for complete list of compounds.
Nature and Extent		PFOS and PFOA are known to be present in the wash rack catch basin at Building 18. A water sample collected at the wash rack catch basin identified the presence of PFOS and PFOA concentrations of 150 nanograms per liter (ng/L) and 14 ng/L respectively, exceeding the Lifetime Health Advisory. The wash rack catch basin is connected to the WWTP via a manual valve. No data has been collected to determine presence of PFOS and PFOA at the WWTP. No data has been collected in these areas to determine whether or not PFOS and PFOA are presently associated with the storm drain north of Building 18. No data has been collected from Biosolids Land Application Area to determine if PFOS and PFOA are present.
Migration Pathways		• Potential releases to surface and/or subsurface soil • Direct release to stormwater • Leaching of PFAS currently and/or historically present from soil (if present) to groundwater • Transport via advection with groundwater flow (if present)
Potential Receptors/ Exposure Routes		• Groundwater: Groundwater at and near the Base is not used as a drinking water source. Construction worker direct contact (dermal) with groundwater if excavation activities encounter groundwater • Soil: direct contact with soil during excavation and/or subsurface work, future residential, and ecological receptors, nearby residents, construction workers, maintenance/industrial workers, and visitors could be exposed to PFAS in soil through incidental ingestion of and dermal contact with surface and subsurface soil or respiration of surface soil dust in the air.
Data Needs		• Soil and groundwater sampling data are necessary to evaluate whether surface releases of PFAS-containing substances have occurred, and which media have been impacted at 3 on-Base potential source areas.

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SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements

Problem Definition, Environmental Questions, and Project Quality Objectives

Three potential source areas with suspected surface releases on-Base warrant further investigation. The presence or absence of PFAS within the groundwater or soil has not been determined.

The objectives, environmental questions, general investigation approaches, and project quality objectives (PQOs) contained in this SAP are described in **Table 11-1** and are based on the USEPA *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006) and its seven-step process. The detailed sampling approach, including numbers of samples and a full list of analytes, is provided in **Worksheet #17**. Planned sample locations are shown on **Figures 11-1** through **11-3**

What are the Project Action Limits?

The following list summarizes the Project Action Limits (PALs) applicable to soil and groundwater samples at Seaplane Base.

Groundwater data will be screened against residential scenario risk screening levels (SLs) based on an HQ of 0.1 and consistent with Department of Defense technical guidance (DoD, 2019a). That is, the current USEPA tap water regional screening level (RSL) for PFBS (based on an HQ of 0.1), and tap water SLs for PFOS and PFOA generated using the USEPA RSL calculator as described in DoD, 2019a and based on an HQ of 0.1 (see worksheet 15).

Groundwater will also be screened against the USEPA Lifetime Health Advisory for PFOA and PFOS, which is 70 ng/L individually; if both chemicals are detected, then 70 ng/L is the Lifetime Health Advisory for the cumulative concentration of the two chemicals. Although not a PAL, the USEPA Lifetime Health Advisory has been considered to warrant maximum usability of the data. There are no PALs for other PFAS analytes.

Soil data will be screened against residential scenario risk SLs based on an HQ of 0.1 and consistent with Department of Defense technical guidance (DoD, 2019a). That is, the current USEPA residential soil RSL for PFBS (based on an HQ of 0.1), and residential soil SLs for PFOS and PFOA generated using the USEPA RSL calculator as described in DoD, 2019a and based on a HQ of 0.1 (see worksheet 15). There are no PALs for other PFAS analytes.

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

For What Will the Data be Used?

Data will be used by the Navy, its contractors, and the other stakeholder agencies to address the environmental questions and PQOs listed in **Table 11-1**.

What types of data are needed?

The types of data needed include:

- Subsurface lithology from soil borings and monitoring well installations to improve understanding of the distribution of stratigraphic units across the Base along with identification of the main water bearing units at the site. These data will be utilized to improve the overall Seaplane Base conceptual site model.
- Groundwater sample data from newly installed monitoring wells to determine presence or absence of PFAS in potential source areas and help inform vertical distribution of PFAS in groundwater.
- Soil sample data from potential source areas to determine presence or absence of PFAS in soil and help inform the spatial and vertical distribution of PFAS in the vadose zone.

- Field measurements of groundwater quality (pH, dissolved oxygen, temperature, conductivity, oxidation-reduction potential, and turbidity) during sampling of the newly installed monitoring wells. These data will improve understanding of the physical and geochemical properties of the groundwater across the base.
- Samples to be collected and analyzed to meet the project objectives are described in **Table 17-1**. The well installation methodology and sampling are included in **Worksheet #14**. Justification for individual samples are provided in **Worksheets #17 and #18**. The specific target analytes and PALs are included in **Worksheet #15**.

Are there special data quality needs, field or laboratory, to support environmental decisions?

Offsite laboratory analytical data will be of the quantity and quality necessary to provide technically sound and defensible assessments with respect to the aforementioned project objectives. Additionally, laboratory-specific LODs will be less than the RSL calculator-based SLs for PFOA and PFOS of 40 ng/L or 0.04 µg/L for water (for the sum of the two constituents); detection limits for soil will be less than the RSL calculator-based SLs for PFOS, PFOA, and PFBS in soil: 0.13 mg/kg, 0.13 mg/kg, and .13 mg/kg; QC sample requirements are detailed in **Worksheet #20**. For action decisions, the laboratory will follow the Measurement Performance Criteria (MPC) in **Worksheets #24** and **#28** for laboratory QC samples. These MPC are consistent with the Department of Defense (DoD) Quality Systems Manual (QSM) (DoD, 2017) as applicable and laboratory in-house limits where the QSM does not apply.

Where, when, and how should the data be collected and generated?

Field activities for the collection of soil and groundwater data at the Seaplane Base will be conducted in accordance with **Worksheets #14, #17, and #18**, and the project schedule outlined in **Worksheet #16**. The data will be collected following the SOPs presented in **Worksheet #21**.

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements (continued)

Table 11-1. Project Quality Objectives/Systematic Planning Process Statements

Objectives	Environmental Question(s)	General Investigation Approach	PQOs
Determine if PFAS are present in soil at Building 18, Biosolids Land Application Area, and Sanitary WWTP at levels that pose potential risks to human health and the environment.	Were there releases of PFAS-containing compounds to soil that pose potentially unacceptable risks?	The SI will focus on areas at or downgradient of Building 18, the Sanitary WWTP, and the Biosolids Land Application Area. Approximately 8 soil borings will be advanced to approximately 35 feet below ground surface (bgs) (four at Building 18, three at the Sanitary WWTP, and one at the Biosolids Land Application Area [due to the small footprint]) (**Figure 11-1 through 11-3**). For each boring location, lithology will be logged, and one soil sample will be collected at the capillary fringe. Additional soil samples will also be collected at the Biosolids Land Application area. The Biosolids Land Application Area will be divided into four quadrants. Within each quadrant, ten sample locations will be identified. Surface soil samples will be collected from the ten sample locations and then composited into a single sample. A total of four composite samples (one from each quadrant) will be sent to the lab (**Figure 11-3**). Soil samples will be submitted to Battelle Analytical Services for analysis of PFAS by LCMSMS compliant with QSM 5.3 Table B-15.	Data will be evaluated in accordance with the decision logic in **Figure 11-4**.
Determine if PFAS are present in groundwater in the three potential source areas at concentrations posing potential risks to human receptors or the environment.[1,2]	Were there releases of PFAS-containing compounds to shallow groundwater from the 3 on-Base potential source areas at levels posing potential risks to human health and/or the environment?	For each boring location completed, with the exception of WWTP, as part of the first objective, a monitoring well will be installed, and a groundwater sample will be collected. Groundwater samples at the WWTP will be collected at existing wells. Groundwater samples will be submitted to Battelle Analytical Services for analysis of PFAS by LCMSMS compliant with QSM 5.3 Table B-15.	Data will be evaluated in accordance with the decision logic in **Figure 11-4**.

Notes:

[1] Risk screening activities will be conducted only on PFAS constituents for which toxicology data are currently available (PFOA, PFOS, and PFBS). Other constituents to be analyzed will be included in the report in the event that additional toxicity data become available in the future. USEPA has not yet released ecological screening values for any PFAS constituent.

[2] If USEPA develops screening values for PFAS analytes not evaluated as part of this investigation, additional investigation may be needed to address those constituents. If toxicity data changes and the extent of contaminants currently being analyzed is not defined to levels of concern, additional investigation may be needed.

[3]

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SAP Worksheet #12-1—Measurement Performance Criteria Table – Field QC Samples

Matrix: Groundwater

Analytical Group: PFAS

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
Matrix Spike (MS)/ Matrix Spike Duplicate (MSD)	PFAS	One per 20 samples	Accuracy/Precision	See **Worksheet #28**.
Equipment Rinsate Blank		One per day of field sampling for decontaminated equipment	Bias/Contamination	No target analytes detected > ½ LOQ
Field Duplicate (FD)		One per 10 samples	Precision	Relative percent difference (RPD) less than (<) 30%
Field Blank		One per site per day of sampling	Bias/Contamination	No analytes detected greater than (>) ½ LOQ or >1/10 sample concentration, whichever is greater
Cooler Temperature Indicator		One per cooler	Accuracy/Representativeness	Temperature less than or equal to (≤) 10 degrees Celsius (°C), not frozen

SAP Worksheet #12-2—Measurement Performance Criteria Table – Field QC Samples

Matrix: Subsurface Soil
Analytical Group: PFAS

QC Sample	Analytical Group	Frequency	DQIs	Measurement Performance Criteria
MS/MSD	PFAS	One per 20 samples	Accuracy/Precision	See **Worksheet #28**.
Equipment Rinsate Blank		One per day of field sampling for decontaminated equipment	Bias/Contamination	No target analytes detected > ½ LOQ
Field Blank		One per site	Bias/Contamination	No target analytes detected > ½ LOQ, or greater than 1/10 sample concentration, whichever is greater
FD		One per 10 samples	Precision	RPD less than 30%
Cooler Temperature Indicator		One per cooler	Accuracy/Representativeness	Temperature less than or equal to (≤) 10°C, not frozen

SAP Worksheet #13—Secondary Data Criteria and Limitations Table

No secondary data will be used to support the project objectives outlined in this SAP.

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SAP Worksheet #14—Summary of Project Tasks

Applicable SOPs for project tasks outlined in this section are listed in **Worksheet #21** and provided in **Appendix A**.

Premobilization Tasks

- Subcontractor procurement
  - Analytical laboratories
  - Data validation (DV)
  - Utility locator
  - Driller
  - Investigation-derived waste (IDW) transportation and disposal contractor
- Fieldwork scheduling
- Coordination with NASWI for site access and IDW staging at Seaplane Base

Mobilization

Mobilization for the field effort includes procurement of necessary field equipment and initial transport to the site. Equipment and supplies will be brought to the site when the CH2M field team mobilizes for field activities. Before beginning any phase of work, CH2M and its subcontractors will have field meetings to discuss the work items and worker responsibilities, and to familiarize workers with the HSP.

Utility Locating

Utilities will be cleared before beginning intrusive activities. CH2M will coordinate utility clearance. In addition, a third-party utility clearance subcontractor will be procured by CH2M to clearly mark the proposed monitoring well locations. Any proposed well or soil boring locations within 5 feet of utility locations will be relocated to avoid impact to utilities. If a well or soil boring location needs to be relocated, the field team will consult with the CH2M PM and NAVFAC Northwest RPM to establish a new well location.

Soil Borings

Soil borings will be advanced in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix A**.

Soil borings will be installed as follows:

- Up to 8 soil borings will be advanced in the vicinity of the potential source areas to a maximum depth of 35 feet bgs. One soil sample will be collected from each soil boring at the capillary fringe.

Monitoring Well Installation and Development

Monitoring wells will be installed and developed in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix A**.

Monitoring wells will be installed and developed as follows:

- Up to 5 on-Base monitoring wells will be installed in the vicinity of the potential source areas.
- All monitoring wells will be installed in accordance with the State of Washington well construction standards by a Washington-licensed driller. Monitoring wells will be installed using rotosonic drilling techniques in accordance with the SOP listed in **Worksheet #21** and provided in **Appendix A**.
- Five monitoring wells will be constructed with a 2-inch inside-diameter Schedule 40 polyvinyl chloride (PVC) riser connected to a 2-inch inside-diameter factory slotted (0.020-inch or 20-slot), PVC screen with a bottom cap. All drilling and well construction materials will be free of fluorine. No fluorine containing greases, bentonite, or other materials will be used.

SAP Worksheet #14—Summary of Project Tasks (continued)

- An investigation will take place to determine the impact tidal fluctuations have on the groundwater table. Following analysis the monitoring wells will be screened to reflect any observed fluctuations. . The top of the screen will be set just above the high groundwater level. A sand filter pack (10/20 or equivalent washed silica) will be placed around the annular space of the well screen from the bottom of the boring and extend to a minimum height of 2 feet above the top of the well screen. A bentonite seal, at least 2 feet thick, will be placed above the top of the sand pack. The locations of the proposed monitoring wells are provided on **Figures 11-1** through **11-3**.
- Upon completion of the well installation, each monitoring well will be developed by the drilling subcontractor using a combination of surging and pumping throughout the well screen. During monitoring well development, the CH2M field crew will measure WQPs, including pH, temperature, conductivity, and turbidity with a water quality meter. Development will continue for a minimum of 1 hour and until the turbidity of the water removed from the well is as clear as practicable, using professional judgement. Surge blocks and pumps with Teflon parts will not be used during development.
- Development information, including turbidity, pH, specific conductivity, temperature, and gallons of water removed will be recorded as field notes on loose leaf notebook paper. In addition, the water quality meter will be calibrated daily (at a minimum) and the calibration documented in the field notes.

Soil Logging

All soil borings will be logged for lithology and field screened by a photoionization detector (PID) at every interval in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix A**.

Surveying

The newly installed monitoring wells will be surveyed by a Washington-licensed surveyor in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix A**.

Sampling Tasks

Applicable field notes and forms should be filled out completely each day.

- Soil sampling
  - Soil sampling at the bio-solids land application area will be completed in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix A**. A four-quadrant grid will be established in the bio-solids land application area. Ten grab samples from 0-6 inches in depth will be collected within each quadrant. The ten grab samples of each quadrant will be composited into one sample per quadrant. All soil samples will be sent to Battelle Analytical Serves for PFAS analysis with a standard TAT.
- Monitoring Well Sampling
  - Groundwater sampling will be completed at all new monitoring wells in accordance with the SOP listed in **Worksheet #21** and provided in **Appendix A**. Samples will be submitted to Battelle Analytical Services for PFAS analysis with standard TAT.

Decontamination

- All drilling and sampling equipment used during well installation and sampling, and re-usable sampling equipment will be decontaminated immediately after each use in accordance with applicable SOPs referenced in **Worksheet #21** and provided in **Appendix A**. Sensitive instrumentation such as equipment used to collect water quality parameters will be decontaminated in accordance with the equipment manufacturers' guidelines.

SAP Worksheet #14—Summary of Project Tasks (continued)

IDW Handling

- IDW will be managed in accordance with the Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update (Navy, 2017a) and in accordance with SOPs listed in **Worksheet #21** and provided in **Appendix A**.

Analyses and Testing Tasks

- Battelle Analytical Services will process and prepare soil samples for analysis and analyze samples in accordance with **Worksheet #18** and **#19**.
- Soil samples will be analyzed for PFAS by Battelle Analytical Services using LC/MS/MS in accordance with **Worksheets #18** and **#19**.
- Groundwater samples will be submitted to Battelle Analytical Services for analysis of 18 PFAS compounds via analytical method PFAS by LC/MS/MS in accordance with **Worksheets #18** and **#19**.

QC Tasks

- Implement SOPs for field and laboratory activities being performed.
- QC samples are described on **Worksheet #20**.

Secondary Data

- NA.

Data Validation, Review, and Management Tasks

- See **Worksheets #34** through **#36** for discussion of data management procedures.

Documentation and Reporting

- A summary of field activities as well as a data evaluation will be documented in a SI Report and submitted to the NAVFAC Northwest RPM for review and approval. In addition, daily field work summaries will be submitted to the NAVFAC Northwest RPM.

Assessment and Audit Tasks

- **Worksheets #31** and **#32**.

Demobilization

Full demobilization will occur when the project is completed, and appropriate QA/QC checks have been performed. Personnel no longer needed during field operations may be demobilized prior to the final project completion date. The following will occur prior to demobilization:

- Chain-of-custody records will be reviewed to verify that all samples were collected as planned and submitted for appropriate analyses.
- Restoration of the site to an appropriate level will be verified by the CH2M FTL and necessary base personnel.
- All equipment will be inspected, packaged, and shipped to the appropriate location.

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SAP Worksheet #15-1—Reference Limits and Evaluation Tables

Matrix: Groundwater
Analytical Group: PFAS – PFAS by LC/MS/MS Compliant with QSM 5.3 Table B-15[1]

Analyte	Chemical Abstract Service Number	USEPA Lifetime Health Advisory (ng/L)	RSLs Tap water HQ = 0.1 (May 2019) (ng/L)	PQL Goal[2] (ng/L)	Laboratory Limits (ng/L)			LCS and MS/MSD Recovery Limits and RPD[3] (%)		
					LOQs (ng/L)	LODs (ng/L)	DLs (ng/L)	LCL	UCL	RPD
Perfluorooctanoic acid (PFOA)	335-67-1	70	40[4]	5	5	0.5	0.18	71	133	30
Perfluorooctane Sulfonate (PFOS)	1763-23-1	70	40[4]	5	5	0.5	0.19	65	140	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	--	40,000	5	5	0.5	0.13	72	130	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	5	5	0.5	0.19	72	129	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	5	5	0.5	0.16	72	130	30
Perfluorohexane sulfonate (PFHxS)	355-46-4	--	--	5	5	0.4	0.11	68	131	30
Perfluorononanoic acid (PFNA)	375-95-1	--	--	5	5	1	0.26	69	130	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	5	5	0.5	0.16	71	129	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	5	5	1	0.29	69	133	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	5	5	0.5	0.18	72	134	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	5	5	0.5	0.15	65	144	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	--	5	5	1	0.25	71	132	30
N-Ethylperfluoro-1-octanesulfo-namidoacetic acid (NEtFOSAA)	2991-50-6	--	--	5	5	1	0.49	61	135	30
N-Methylperfluoro-1-octanesulfo-namidoacetic acid (NMeFOSAA)	2355-31-9	--	--	5	5	2	0.56	65	136	30
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	5	5	0.4	0.2	74	148	30
4,8-dioxa-3H-perfluoronanoic acid (ADONA)	919005-14-4	--	--	5	5	0.4	0.18	61	143	30
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	763051-92-9	--	--	5	5	0.4	0.18	59	147	30
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	756426-58-1	--	--	5	5	0.4	0.1	52	158	30
PFOA + PFOS (calculated)5	--	70	--	--	--	--	--	--	--	--

Notes:

[1] Analytical method is compliant with QSM v. 5.31 Table B-15 or the most recent version of the QSM for which Battelle has DoD ELAP certification.

[2] The project quantitation limit (PQL) goal is equal to the laboratory LOQ.

[3] Accuracy and precision are per DoD QSM 5.3. For analytes not found in DoD QSM 5.3, laboratory in house limits will be used. Analytes using in house laboratory limits are bolded.

[4] Tapwater RSLs for PFOA and PFOS were generated from the RSL calculator on 7/10/19 and is considered the PAL for groundwater.

[5] If both PFOS and PFOA are detected, the combined concentration will be compared to 70 ng/L. Otherwise, the chemicals will be compared to the USEPA lifetime health advisory of 70 ng/L individually. The LHA is considered the PAL for drinking water exposure.

Limits are verified on a quarterly basis per DoD QSM and may be subject to change. Any changes to these limits which impact the project SAP objectives, must be approved by the NAVFAC RPM and NAVFAC LANT QAO in advance of sample testing.

DL = detection limit
LCL = lower confidence limit
LCS = laboratory control sample
LOD = limit of detection
UCL = upper confidence limit

SAP Worksheet #15-2—Reference Limits and Evaluation Table

Matrix: Soil

Analytical Group: PFAS by LCMSMS Compliant with QSM 5.3 Table B-15[1]

Analyte	Chemical Abstract Service (CAS) Number	USEPA Residential Soil RSL, HQ = 0.1, May 2019 (µg/kg)		PQL Goal (µg/kg)[3]	Laboratory Limits (µg/kg)[2]			LCS and MS/MSD Recovery Limits and RPD (%)[5]		
					LOQs (µg/kg)	LODs (µg/kg)	DLs (µg/kg)	LCL	UCL	RPD
Perfluorooctane Sulfonate (PFOS)	1763-23-1	130[4]		5.0	5.0	1.0	0.27	68	136	30
Perfluorooctanoic acid (PFOA)	335-67-1	130[4]		5.0	5.0	1.0	0.5	69	133	30
Perfluorobutane sulfonate (PFBS)	375-73-5	130,000		5.0	5.0	1.0	0.36	72	128	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--		5.0	5.0	1.0	0.33	70	132	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--		5.0	5.0	1.0	0.44	71	131	30
Perfluorohexane sulfonate (PFHxS)	355-46-4	--		5.0	5.0	0.5	0.22	67	130	30
Perfluorononanoic acid (PFNA)	375-95-1	--		5.0	5.0	1.0	0.43	72	129	30
Perfluorodecanoic acid (PFDA)	335-76-2	--		5.0	5.0	1.0	0.27	69	133	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--		5.0	5.0	1.0	0.44	64	136	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--		5.0	5.0	0.5	0.24	69	135	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--		5.0	5.0	1.0	0.28	66	139	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--		5.0	5.0	2.0	0.63	69	133	30
N-Ethylperfluoro-1-octancesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--		5.0	5.0	2.0	0.57	61	139	30
N-Methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--		5.0	5.0	2.5	1.12	63	144	30
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--		5.0	5.0	2.0	0.57	71	153	30
4,8-dioxa-3H-perfluoronanoic acid (ADONA)	919005-14-4	--		5.0	5.0	1.0	0.32	61	139	30
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	763051-92-9	--		5.0	5.0	1.0	0.4	60	140	30
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	756426-58-1	--		5.0	5.0	1.0	0.45	40	160	30

Notes:

[1] Analytical method is compliant with Quality Systems Manual (QSM) 5.3 Table B-15 or the most recent version of the QSM for which Battelle has DoD ELAP certification.

[2] Results for nonaqueous samples are reported on a dry-weight basis.

[3] The PQLs are listed as the laboratory LOQ. Laboratory limits for PFOS and PFOA are not sensitive enough to meet Soil to Groundwater RSLs. Not detected values will not be considered as exceedances. Data evaluation will be based on reported concentrations above the DL. In cases where the Soil to Groundwater RSLs is less than the DL and the results are nondetect, results will be discussed in the uncertainty analysis.

[4] Soil to Groundwater and Residential Soil RSLs for PFOA and PFOS were generated using the USEPA online calculator on 7/10/19.

[5] Accuracy and precision limits are per DoD QSM 5.3. For analytes not found in DoD QSM 5.3, laboratory in house limits will be used. Analytes using in house laboratory limits are bolded.

Limits are verified on a quarterly basis per DoD QSM and may be subject to change. Any changes to these limits which impact the project SAP objectives, must be approved by the NAVFAC RPM and NAVFAC LANT QAO in advance of sample testing.

SAP Worksheet #16—Project Schedule/Timeline Table

Activities	Organization	Dates (MM/DD/YY)		Deliverable
		Anticipated Date(s) of Initiation	Anticipated Date of Completion	
Internal Draft SAP preparation	CH2M	April 2019	August 2019	Internal Draft SAP
Navy SAP review	Navy	August 2019	June 2020	Comments
Draft Final SAP preparation	CH2M	June 2020	June 2020	Draft SAP
Stakeholder review	USEPA Region 10 Island County, Washington	July 2020	August 2020	Comments
Final SAP	CH2M	November 2020	February 2021	Final SAP
Pre-sampling, subcontracting	CH2M	TBD	TBD	
Monitoring Well Installation	CH2M, Subcontractor	TBD	TBD	
Groundwater Sampling	CH2M	TBD	TBD	
Analytical Data	Subcontractor	28 day turnaround time		Analytical data
Data management	CH2M	TBD	TBD	
Reporting	CH2M	TBD	TBD	Draft and Final Technical Memorandum

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SAP Worksheet #17—Sampling Design and Rationale

The objectives of the investigation described in this worksheet are listed in **Worksheet #11**. Media to be investigated for this SAP is limited to soil collected from on-Base soil borings, surface soils, and groundwater from on-Base monitoring wells. The sampling strategy and rationale are detailed in **Tables 17-1 through 17-4.**

Table 17-1. Sampling Strategy Table –Site Investigation– Sampling of Areas Downgradient from Building 18, Biosolids Land Application Area, and SWWTP

Matrix	Depth of Samples	Analysis and Method	Approximate Number of Samples	Strategy and Rationale
Groundwater	Shallow (5-15 ft bgs)	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	8	Samples will be collected from 5 newly installed groundwater monitoring wells and 3 existing wells near or downgradient of the on-Base potential source areas identified in the PA as requiring further investigation (**Figures 11-1, 11-2 and 11-3**). Data will be used to determine if PFAS is present in groundwater downgradient of where AFFF is known or is suspected to have been released.
Soil	Top of capillary fringe[1]		8	Soil samples will be collected from at the top of the capillary fringe in the unsaturated soil at four locations north and west of Building 18 (**Figure 11-1**) and three borehole locations at the WWTP and the single monitoring well location at the Biosolids Land Application Area(**Figures 11-2 and 11-3**) where AFFF is known or is suspected to have been released. Presence of PFAS in the vadose zone could represent an ongoing release to groundwater.
Surface Soil	Surface (0-6 inches bgs)		4	Four (composite of 10 evenly distributed sample locations) surface soil samples will be collected at the Biosolids Land Application Area (**Figure 11-3**) where AFFF is known or is suspected to have been released. Data will be used to determine if PFAS is present in the soil.

Notes:

[1] The final number and placement of samples may be modified in the field based on the field team's professional opinion in consultation with CH2M PM and the NAVFAC Northwest RPM.

[2] Analytical method is compliant with QSM v. 5.3 Table B-15 or the most recent version of the QSM for which Battelle has DoD ELAP certification.

GW = groundwater

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SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements Table

Station Identification (ID)	Sample ID	Matrix	Depth (ft bgs)	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
Building 18						
WI-SP-MW01	WI-SP-GW01-MMYY	Groundwater	5-15	PFAS (LC/MS/MS Compliant with QSM v. 5.3, Table B-15[1])	1	**Worksheet #21**
	WI-SP-SB01-XXYY	Subsurface Soil	TBD		1	
WI-SP-MW02	WI-SP-GW02-MMYY	Groundwater	5-15		1 – 2 (FD)	
	WI-SP-GW02P-MMYY					
	WI-SP-SB02-XXYY	Subsurface Soil	TBD		1	
WI-SP-MW03	WI-SP-GW03-MMYY	Groundwater	5-15		1	
	WI-SP-SB03-XXYY	Subsurface Soil	TBD		1	
WI-SP-MW04	WI-SP-GW04-MMYY	Groundwater	5-15		1	
	WI-SP-SB04-XXYY	Subsurface Soil	TBD		1	
Sanitary Waste Water Treatment Plant						
WI-SP-MW-2 APN870	WI-SP-GW70-MMYY	Groundwater	5-15	PFAS (LC/MS/MS Compliant with QSM v. 5.3, Table B-15[1])	1	**Worksheet #21**
	WI-SP-SB05-XXYY	Subsurface Soil	TBD		1 – 3 (MS/MSD)	
	WI-SP-SB05-XXYY-MS	Subsurface Soil	TBD			
	WI-SP-SB05-XXYY-MSD	Subsurface Soil	TBD			
WI-SP-MW-3 APN871	WI-SP-GW71-MMYY	Groundwater	5-15		1	
	WI-SP-SB06-XXYY	Subsurface Soil	TBD		1	
WI-SP-MW-4 APN872	WI-SP-GW72-MMYY	Groundwater	5-15		1 – 3 (MS/MSD)	
	WI-SP-GW72-MMYY-MS	Groundwater	5-15			
	WI-SP-GW72-MMYY-MSD	Groundwater	5-15			
	WI-SP-SB07-XXYY	Subsurface Soil	TBD		1	
Biosolids Land Application Area						
WI-SP-MW08	WI-SP-GW08-MMYY	Groundwater	5-15	PFAS (LC/MS/MS Compliant with QSM v. 5.3, Table B-15[1])	1	**Worksheet #21**
	WI-SP-SB08-XXYY	Subsurface Soil	TBD		1 – 2 (FD)	
	WI-SP-SB08P-XXYY					

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements Table (continued)

Station Identification (ID)	Sample ID	Matrix	Depth (ft bgs)	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
WI-SP-SO01	WI-SP-SS01-000H	Composite Surface Soil	0-0.5	PFAS (LC/MS/MS Compliant with QSM v. 5.3, Table B-15[1])	1	**Worksheet #21**
WI-SP-SO02	WI-SP-SS02-000H				1 – 2 (FD)	
	WI-SP-SS02P-000H					
WI-SP-SO03	WI-SP-SS03-000H				1 – 3 (MS/MSD)	
	WI-SP-SS03-000H-MS					
	WI-SP-SS03-000H-MSD					
WI-SP-SO04	WI-SP-SS04-000H				1	
Field QC Samples						
WI-SP-QC	WI-SP-FB01-GW-MMDDYY	QC	N/A	PFAS (LC/MS/MS Compliant with QSM v. 5.3, Table B-15[1])	1	**Worksheet #21**
	WI-SP-FB02-GW-MMDDYY				1	
	WI-SP-FBXX-GW-MMDDYY[2]				TBD	
	WI-SP-FB01-SO-MMDDYY				1	
	WI-SP-FB02-SO-MMDDYY				1	
	WI-SP-FBXX-SO-MMDDYY[2]				TBD	
	WI-SP-FB01-SD-MMDDYY				1	
	WI-SP-FB02-SD-MMDDYY				1	
	WI-SP-FBXX-SD-MMDDYY[2]				TBD	
	WI-SP-FB01-SW-MMDDYY				1	
	WI-SP-FB02-SW-MMDDYY				1	
	WI-SP-FBXX-SW-MMDDYY[2]				TBD	
	WI-SP-EB01-GW-MMDDYY				1	
	WI-SP-EB02-GW-MMDDYY				1	
	WI-SP-EBXX-GW-MMDDYY[2]				TBD	

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements Table (continued)

Station Identification (ID)	Sample ID	Matrix	Depth (ft bgs)	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
	WI-SP-EB01-SO-MMDDYY				1	
	WI-SP-EB02-SO-MMDDYY				1	
	WI-SP-EBXX-SO-MMDDYY[2]				TBD	
	WI-SP-EB01-SD-MMDDYY				1	
	WI-SP-EB02-SD-MMDDYY				1	
	WI-SP-EBXX-SD-MMDDYY[2]				TBD	

Notes:

[1] Analytical method is compliant with QSM v. 5.3 Table B-15 or the most recent version of the QSM for which Battelle has DoD ELAP certification.

[2] For field QC sample frequency: one field reagent blank should be collected weekly with samples and daily equipment blanks should be collected per matrix/equipment used for sampling.

[3] QC samples: field duplicates, matrix spike, and matrix spike duplicates are selected for convenience. Other locations may be selected upon field conditions or limitations as long as the appropriate frequency is met. One per 10 samples for field duplicates and one per 20 for MS/MSDs.

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SAP Worksheet #19—Analytical SOP Requirement Table

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Containers	Sample Volume	Preservation Requirements	Maximum Holding Time[1] (preparation/analysis)
Groundwater	PFAS	PFAS by LC/MS/MS Compliant with QSM v. 5.3 Table B-15[2]/ SOP 5-370-10/SOP 5-369-08	2 x 250 milliliters (mL) HDPE bottle	2 x 250 mL	≤10°C for up to 48 hours after sampling, upon sample receipt, then stored at laboratory ≤6°C.	14 days to extraction/ 28 days to analysis
Soil	PFAS	PFAS by LC/MS/MS Compliant with QSM v. 5.3 Table B-15[2]/ SOP 5-370-10/SOP 5-369-08	One 6-ounce HDPE jar	20 grams	≤10°C for up to 48 hours after sampling, upon sample receipt, then stored at laboratory ≤6°C, but not frozen.	14 days to extraction/ 28 days to analysis

Notes:

[1] Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

[2] Analytical method is compliant with QSM v. 5.3 Table B-15 or the most recent version of the QSM for which Battelle has DoD ELAP certification.

HDPE = high density polyethylene

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SAP Worksheet #20—Field Quality Control Sample Summary Table

Matrix	**Analytical Group**	**No. of Sampling Locations**[1]	**No. of Field Duplicates**[1]	**No. of MS/MSDs**[1]	**No. of Field Blanks**[1]	**No. of Equipment Blanks**[1]	**No. of Trip Blanks**[1]	**Total No. of Samples to Laboratory**[1]
Groundwater	PFAS	8	1	1/1	1	3	N/A	15
Subsurface soil	PFAS	8	1	1/1	1	2	N/A	14
Composite Surface soil	PFAS	4	1	1/1	1	1	N/A	9

Notes:

[1] Samples will be collected as detailed in **Worksheets #14, #17,** and **#18** of this SAP. Field QA/QC samples will be collected as detailed in **Worksheet #12**.

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SAP Worksheet #21—Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
SOP CH2M-1	Guidelines for Logging Soil Borings Rev. Sep 2015	CH2M	None	N	Provides guidance on characterizing soil borings.
SOP CH2M-3	Multi RAE PID Rev. April 2015	CH2M	Multi RAE PID	N	Describes procedure for operation and general maintenance of the Multi RAE PID.
SOP CH2M-4	Groundwater Sampling for Per- and Polyfluoroalkyl Substances (PFAS) Rev Nov 2018	CH2M	All field equipment within the sample collection area	N	Provides guidance for groundwater sample collection for samples that will be analyzed for PFASs via LC/MS/MS Compliant with QSM v. 5.3 (or the most recent version of the QSM for which Battelle has DoD ELAP certification) for Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-6	Soil Sampling for Per- and Polyfluoroalkyl Substances Rev. July 2018	CH2M	All field equipment within the sample collection area	N	Provides guidance for soil sample collection for samples that will be analyzed for PFASs via LC/MS/MS Compliant with QSM v. 5.3 (or the most recent version of the QSM for which Battelle has DoD ELAP certification) for Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-7	Management of Liquid Waste Containing Per- and Polyfluoroalkyl Substances (PFAS) Rev. Nov 2018	CH2M	None	N	Provides guidelines for managing liquid waste containing PFAS or Navy CLEAN projects under Contract N62470-16-D-9000.
SOP I-A-1	Planning Field Sampling Activities, Rev. Feb 2018	NAVFAC Northwest	None	N	Establishes SOPs for planning and scheduling field sampling activities.
SOP I-A-7	IDW Management, Rev. Feb. 2018	NAVFAC Northwest	None	N	Describes activities and responsibilities of NAVFAC Northwest and its subcontractors regarding management of IDW. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.
SOP I-A-9	General Field Operation, Rev. Feb 2015	NAVFAC Northwest	All field equipment	N	Defines organization and structure of sample collection, identification, record keeping, field measurements, and data collection.
SOP I-A-10	Monitoring/Sampling Location Recording, Rev. Feb 2015	NAVFAC Northwest	Field logbook	N	Establishes guidelines for generating information to be recorded for each physical location where sampling is conducted.
SOP I-A-11	Sample Naming, Rev. Feb. 2015	NAVFAC Northwest	None	N	Describes the naming convention to be used for samples collected, analyzed, and reported for NAVFAC Northwest projects.
SOP I-D-7	Field Parameter Measurements, Rev. March 2015	NAVFAC Northwest	Water quality meters	N	Provides instructions for the calibration, use, and checking of instruments and equipment for field measurements. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.
SOP-I-E	Soil and Rock Classification, Rev. March 2015	NAVFAC Northwest	Drilling equipment, camera, and field logbooks	N	Establishes standard protocols for all NAVFAC Northwest field personnel for use in making soil and rock classification decisions.
SOP I-G-1	Land Surveying, Rev. August 2014	NAVFAC Northwest	Surveying equipment	N	Describes the methods by which NAVFAC Northwest field personnel and their contractors will conduct land surveying.
SOP III-F	Sample Containers and Preservation, Rev. Feb 2015	NAVFAC Northwest	Sample Jars	N	Describes conventional containers used for sample collection and discusses sample preservation and holding times
SOP III-G	Sample Handling, Storage, and Shipping, Rev. April 2015	NAVFAC Northwest	Samples	N	Sets forth the methods for use by NAVFAC Northwest field personnel and their contractors engaged in handling, storing, and transporting water, soil samples. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.
SOP III-I	Equipment Decontamination, Rev. April 2015	NAVFAC Northwest	Nondisposable sampling equipment	N	Describes general methods of equipment decontamination for use by NAVFAC Northwest field personnel and their contractors during field sampling activities. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.
SOP III-J	Equipment Calibration, Operation, and Maintenance, Rev. April 2015	NAVFAC Northwest	Field meters	N	Describes the activities and responsibilities of the NAVFAC Northwest personnel pertaining to the operation, calibration, and maintenance of equipment used to collect environmental data. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.

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

Field Equipment	Activity[1]	Frequency	Acceptance Criteria	CA	Resp. Person	SOP Reference[2]	Comments
Horiba U-22 pH probe	Calibration	Daily, before use	pH reads 4.0 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly	FTL	SOP-007	**Appendix A**
Horiba U-22 Specific conductance probe	Calibration	Daily, before use	Conductivity reads 4.49 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	SOP-007	**Appendix A**
Horiba U-22 Turbidity probe	Calibration	Daily, before use	Turbidity reads 0 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	SOP-007	**Appendix A**
Horiba U-22 DO and Temperature Probes	Testing	Daily, before use	Consistent with the current atmospheric pressure and ambient temperature	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	SOP-007	**Appendix A**
Horiba U-22	Maintenance- Check mechanical and electronic parts, verify system continuity, check battery, and clean probes. Calibration check	Daily before use, at the end of the day, and when unstable readings occur.	Stable readings after 3 minutes. pH reads 4.0 ± 3% conductivity reads 4.49 ± 3% turbidity reads 0 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	SOP-007	**Appendix A**
Transducers and data loggers	Calibrate	Daily, As Needed	Parameter specific per model/ instruction manual	Manufacturer technical support for calibration errors	FTL	SOP CH2M-2, SOP-III-J	**Appendix A**
Multi RAE PID	Calibrate using ambient air and isobutylene 100 parts per million calibration gas	Daily and as Needed	Parameter specific per model/ instruction manual	Manufacturer technical support for calibration errors	FTL	SOP CH2M-3, SOP-III-J	**Appendix A**
Groundwater sampling pumps and tubing	Inspect pumps, tubing and air/sample line quick-connects	Regularly	Maintained in good working order according to manufacturer's recommendations	Replace items	FTL	SOP-III-J	**Appendix A**

Notes:

[1] Activities may include: calibration, verification, testing, and maintenance.

[2] Specify the appropriate reference letter or number from the Project Sampling SOP References table (**Worksheet #21**).

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SAP Worksheet #23—Analytical SOP References Table

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work (Y/N)
5-370-10	*Extraction of Poly and Perfluoroalkyl Substances from Environmental Matrices, 3/19/2020, Rev. 10*	Definitive	Soil/ Groundwater/PFAS	N/A	Battelle Analytical Services	N
5-369-08	*Analysis of Poly and Perfluoroalkyl Substances in Environmental Samples by Liquid Chromatography and Tandem Mass Spectrometry (LC-MS/MS), 10/17/2019, Rev. 8*	Definitive	Soil/ Groundwater/ /PFAS	LC/MS/MS	Battelle Analytical Services	N
6-010-19	Sample Receipt, Custody, and Handling, 10/16/18, Rev. 19	N/A	Soil /Groundwater /PFAS	N/A	Battelle Analytical Services	N
5-291-17	*Determination of Method Detection Limits in the Analytical Laboratory, 09/20/18, Rev. 17*	N/A	Soil /Groundwater /PFAS	N/A	Battelle Analytical Services	N

Notes:

Laboratory SOPs meet DoD QSM v. 5.3 (DoD, 2019a) requirements (Attachment 4) for Battelle Analytical Services.

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SAP Worksheet #24—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
LC/MS/MS (PFAS)	Initial calibration (ICAL)	At instrument set-up and after initial calibration verification (ICV) or continuing calibration verification (CCV) failure, prior to sample analysis.	The isotopically labeled analog of an analyte (Extracted Internal Standard Analyte) must be used for quantitation if commercially available (Isotope Dilution Quantitation). Commercial PFAS standards available as salts are acceptable providing the measured mass is corrected to the neutral acid concentration. Results shall be reported as the neutral acid with appropriate CAS number. If a labeled analog is not commercially available, the Extracted Internal Standard Analyte with the closest retention time or chemical similarity to the analyte must be used for quantitation. (Internal Standard Quantitation) Analytes must be within 70-130% of their true value for each calibration standard. ICAL must meet one of the two options below: Option 1: The RSD of the RFs for all analytes must be ≤ 20%. Option 2: Linear or nonlinear calibrations must have r 2 ≥ 0.99 for each analyte.	Correct problem, then repeat ICAL.	Analyst / Laboratory Project Manager	5-369-08 DoD QSM v. 5.3
	Retention Time window position establishment	Once per ICAL and at the beginning of the analytical sequence.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A		
	Retention Time (RT) window width	Every field sample, standard, blank, and QC sample.	RT of each analyte and EIS analyte must fall within 0.4 minutes of the predicted retention times from the daily calibration verification or, on days when ICAL is performed, from the midpoint standard of the ICAL. Analytes must elute within 0.1 minutes of the associated EIS. This criterion applies only to analyte and labeled analog pairs.	Correct problem and reanalyze samples.		
	Initial Calibration Verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis.	Analyte concentrations must be within ± 30% of true value.	Correct problem, rerun ICV. If problem persists, repeat ICAL.		
	Continuing Calibration Verification (CCV)	Prior to sample analysis, after every 10 field samples, and at the end of the analytical sequence.	Concentration of analytes must range from the LOQ to the mid-level calibration concentration. Analyte concentrations must be within ± 30% of their true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, or if two consecutive CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.		
	Mass Calibration	Instrument must have a valid mass calibration prior to any sample analysis. Mass calibration is verified after each mass calibration, prior to initial calibration (ICAL).	Calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. Mass calibration range must bracket the ion masses of interest. The most recent mass calibration must be used for every acquisition in an analytical run. Mass calibration must be verified to be ±0.5 amu of the true value, by acquiring a full scan continuum mass spectrum of a PFAS stock standard.	If the mass calibration fails, then recalibrate. If it fails again, consult manufacturer instructions on corrective maintenance.		
	Mass Spectral Acquisition Rate	Each analyte, Extracted Internal Standard (EIS) Analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	N/A		

SAP Worksheet #24—Analytical Instrument Calibration Table (continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
LC/MS/MS (PFAS, continued)	Peak Asymmetry	With each calibration	First two eluting peaks in a mid-level calibration standard must have an asymmetry factor between 0.8 and 1.5	When the asymmetry factor does not pass, perform corrective action to address the issue. Modification of the standard or extract composition to more aqueous content is not permitted.	Analyst / Laboratory Project Manager	5-369-08 DoD QSM v. 5.3
	Calibration, Calibration Verification, and Spiking Standards	All analytes.	Standards containing both branched and linear isomers must be used when commercially available. PFAS method analytes may consist of both branched and linear isomers, but quantitative standards that contain the linear and branched isomers do not exist for all method analytes. For PFAS that do not have a quantitative branched and linear standard, identify the branched isomers by analyzing a qualitative standard that includes both linear and branched isomers and determine retention times, transitions and transition ion ratios. Quantitate samples by integrating the total response (i.e., accounting for peaks that are identified as linear and branched isomers) and relying on the initial calibration that uses the linear isomer quantitative standard.	N/A		
	Sample PFAS Identification	All analytes detected in a sample.	The chemical derivation of the ion transitions must be documented. A minimum of two ion transitions (Precursor → quant ion and precursor → confirmation ion) and the ion transitions ratio per analyte are required for confirmation. Exception is made for analytes where two transitions do not exist (PFBA and PFPeA). Documentation of the primary and confirmation transitions and the ion ratio is required. In-house acceptance criteria for evaluation of ion ratios must be used and must not exceed 50- 150%. Signal to Noise Ratio (S/N) must be ≥ 10 for all ions used for quantification and must be ≥ 3 for all ions used for confirmation. Quant ion and confirmation ion must be present and must maximize simultaneously (±2 seconds).	N/A		
	Ion Transitions (Parent-> Product)	Every field sample, standard, blank, and QC sample.	In order to avoid biasing results high due to known interferences for some transitions, the following transitions must be used for the quantification of the following analytes: PFOA: 413 —› 369 PFOS: 499 —› 80 PFHxS: 399 —› 80 PFBS: 299 —› 80 4:2 FTS: 327 —› 307 6:2 FTS: 427 —› 407 8:2 FTS: 527 —› 507 NEtFOSAA: 584 —› 419 NMeFOSAA: 570 —› 419 If these transitions are not used, the reason must be technically justified and documented (e.g., alternate transition was used due to observed interferences).	N/A		

SAP Worksheet #24—Analytical Instrument Calibration Table (continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
LC/MS/MS (PFAS, continued)	Instrument Blank	Immediately following the highest standard analyzed and daily prior to sample analysis.	Concentration of each analyte must be ≤ ½ the LOQ. Instrument Blank must contain EIS to enable quantitation of contamination.	If acceptance criteria are not met after the highest calibration standard, calibration must be performed using a lower concentration for the highest standard until acceptance criteria is met. If sample concentrations exceed the highest allowed standard and the sample(s) following exceed this acceptance criteria (>1/2 LOQ), they must be reanalyzed.	Analyst / Laboratory Project Manager	
	Instrument Sensitivity Check (ISC)	Prior to analysis and at least once every 12 hours.	Analyte concentrations must be at LOQ; concentrations must be within ±30% of their true values.	Correct problem rerun ISC. If problem persists, repeat ICAL. No samples shall be analyzed until ISC has met acceptance criteria. ISC can serve as the initial daily CCV.		

Notes:

The specifications in this table meet the requirements of DoD QSM v. 5.3.

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SAP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
LC/MS/MS	PM	PFAS	N/A	6 Months	N/A	N/A	Analyst/supervisor	3-200-02
Balance	Verification	Weight	N/A	Daily	± 0.02 gram or ± 0.1% of calibration weight used (whichever is greater)	Refer to manufacturer’s instruction manual	Analyst/supervisor	3-160-09
Balance	Calibration	Weight	N/A	Annually	Per manufacturer	Remove from service, repair, replace	Analyst/supervisor	3-160-09
Pipette	Verification	Volume	N/A	Daily	± 2% difference from true value, <1% relative standard deviation (n=3)	Remove from service, repair, replace	Analyst/supervisor	3-191-05
Pipette	Calibration	Volume	N/A	Quarterly	Per manufacturer	Remove from service, repair, replace	Analyst/supervisor	3-191-05

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SAP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Project Field Team, FTL/CH2M. Field SOPs are in **Appendix A** of this SAP.
Sample Packaging (Personnel/Organization): Project Field Team, FTL/CH2M. Field SOPs are in **Appendix A** of this SAP.
Coordination of Shipment (Personnel/Organization): FTL/CH2M.
Type of Shipment/Carrier: FedEx Priority Overnight Samples will be shipped directly to Battelle Analytical Services
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Receiving/Battelle Analytical Services
Sample Custody and Storage (Personnel/Organization): Sample Receiving/Battelle Analytical Services
Sample Preparation (Personnel/Organization): Sample Preparation Staff/Battelle Analytical Services
Sample Determinative Analysis (Personnel/Organization): Battelle Analytical Services
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 60 days from receipt
Sample Extract/Digestate Storage (No. of days from extraction/digestion): 28 days after extraction/digestion
Biological Sample Storage (No. of days from sample collection): N/A
SAMPLE DISPOSAL
Personnel/Organization: Sample Disposal/Battelle Analytical Services
Number of Days from Analysis: 60 days after final sample results are reported, unless there is a hold on a particular sample or previous arrangements have been made

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SAP Worksheet #27—Sample Custody Requirements

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory):

Samples will be collected by field team members under the supervision of the FTL. As samples are collected, they will be placed into containers and labeled. Labels will be taped to the jar to ensure they do not separate. Samples will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples 0 to 6°C (but not frozen; requirements are less than 10°C for the first 48 hours) until they are received by the laboratory.

The chain-of-custody record will be placed into the cooler in a resealable zip-top plastic bag. Coolers will be taped up and shipped to the laboratories via FedEx overnight, with the airbill number indicated on the chain of custody (to relinquish custody). Upon delivery, the laboratory will log each cooler and report the status of the samples to CH2M.

See **Worksheet #21** for SOPs containing sample custody guidance.

The CH2M field team will ship all environmental samples directly to the laboratory performing the analysis. This will require shipment to Battelle Analytical Services in Norwell, Massachusetts.

Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal):

Laboratory custody procedures can be found in the laboratory SOPs, which will be provided upon request.

Sample Identification (ID) Procedures:

Sample labels will include, at a minimum, client name, site, sample ID, date/time collected, analysis group or method, preservation, and sampler's initials. The field notes will identify the sample ID with the location and time collected and the parameters requested. The laboratory will assign each field sample a laboratory sample ID based on information in the chain of custody. The laboratory will send sample log-in forms to the CH2M PC to check that sample IDs and parameters are correct.

Chain-of-Custody Procedures:

Chain-of-custody records will include, at minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information. Sample information will include sample ID. Date/time collected, number and type of containers, preservative information, analysis method, and comments. The chain-of-custody record will link location of the sample from the field notes to the laboratory receipt of the sample. The laboratory will use the sample information to populate the Laboratory Information Management Systems database for each sample.

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SAP Worksheet #28-1—Laboratory QC Sample Table

Matrix: Soil /Groundwater
Analytical Group: PFAS
Analytical Method/SOP Reference: PFAS by LC/MS/MS Compliant with QSM 5.3 Table B-15/SOP 5-369-08

QC Sample	Frequency/Number	Method/ SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria (MPC)
Aqueous Sample Preparation	Each sample and associated batch QC samples.	Solid Phase Extraction (SPE) must be used unless samples are known to contain high PFAS concentrations (e.g., AFFF formulations). Inline SPE is acceptable. Entire sample plus bottle rinsate must be extracted using SPE. Known high PFAS concentration samples require serial dilution be performed in duplicate. Documented project approval is needed for samples prepared by serial dilution as opposed to SPE.	NA	Analyst/ Laboratory Project Manager	NA	Same as Method/ SOP QC Acceptance Limits
Soil Sample Preparation	Each sample and associated batch QC samples.	Entire sample received by the laboratory must be homogenized prior to subsampling.	NA		NA	
Sample Cleanup Procedure	Each sample and associated batch QC samples. Not applicable to AFFF and AFFF Mixture Samples	ENVI-CarbTM or equivalent must be used on each sample and batch QC sample.	NA		Bias/Contamination	
Method Blank (MB)	One per preparatory batch.	No analytes detected > 1/2 LOQ or >1/10 the amount measured in any sample or >1/10 regulatory limit, whichever is greater.	Correct problem. If required, re-extract and reanalyze MB and all QC samples and field samples processed with the contaminated blank. Samples may be reextracted and analyzed outside of hold times, as necessary for corrective action associated with QC failure. Examine the project specific requirements. Contact the client as to additional measures to be taken.		Bias/ Contamination	
Laboratory Control Sample (LCS)	One per preparatory batch.	Blank spiked with all analytes at a concentration ≥LOQ and ≤ the mid-level calibration concentration. Refer to Worksheets #15-1 and #15-2 for limits. As per DoD QSM 5.3 table B-15, laboratory in house limits will be used for any analytes not found in DoD QSM 5.3 Appendix C.	Correct problem, then reextract and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available. Samples may be reextracted and analyzed outside of hold times, as necessary for corrective action associated with QC failure. Examine the project specific requirements. Contact the client as to additional measures to be taken.		Precision/ Accuracy/Bias	
Matrix Spike (MS)	One per preparatory batch. Not required for aqueous samples prepared by serial dilution instead of SPE.	Sample spiked with all analytes at a concentration ≥LOQ and ≤ the mid-level calibration concentration. Refer to Worksheets #15-1 and #15-2 for limits. As per DoD QSM 5.3 table B-15, laboratory in house limits will be used for any analytes not found in DoD QSM 5.3 Appendix C	Examine the project specific requirements. Contact the client as to additional measures to be taken. For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.		Precision/ Accuracy/Bias	
Matrix Spike Duplicate (MSD) or Matrix Duplicate (MD)	For MSD: One per preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE.	For MSD: Sample spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. Refer to Worksheets #15-1 and #15-2 for limits. As per DoD QSM 5.3 table B-15, laboratory in house limits will be used for any analytes not found in DoD QSM 5.3 Appendix C RPD ≤ 30% (between MS and MSD or sample and MD).	Examine the project specific requirements. Contact the client as to additional measures to be taken. For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.		Precision/ Accuracy/Bias	

SAP Worksheet #28-1—Laboratory QC Sample Table (continued)

Matrix: Soil /Groundwater
Analytical Group: PFAS
Analytical Method/SOP Reference: PFAS by LC/MS/MS Compliant with QSM 5.3 Table B-15/SOP 5-369-08

QC Sample	Frequency/Number	Method/ SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria (MPC)
Post Spike Sample	Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of <LOQ for analyte(s).	Spike all analytes reported as < LOQ into the dilution that the result for that analyte is reported from. The spike must be at the LOQ concentration to be reported for this sample as < LOQ.When analyte concentrations are calculated as <LOQ, the spike must recover within 70-130% of its true value.	When analyte concentrations are calculated as <LOQ, and the spike recovery does not meet the acceptance criteria, the sample, sample duplicate, and post spike sample must be reanalyzed at consecutively higher dilutions until the criteria is met.		NA	
Extracted Internal Standard (EIS) Analytes	Every field sample, standard, blank, and QC sample.	Added to solid sample prior to extraction. Added to aqueous samples, into the original container, prior to extraction. For aqueous samples prepared by serial dilution instead of Solid Phase Extraction, added to samples prior to analysis. Extracted Internal Standard Analyte recoveries must be within 50% to 150% of ICAL midpoint standard area or area measured in the initial CCV on days when an ICAL is not performed..	If recoveries are acceptable for QC samples, but not field samples, the field samples must be reprepped and reanalyzed (greater dilution may be needed). If recoveries are unacceptable for the QC samples, correct the problem, and reanalyze all associated filed samples.	Analyst/ Laboratory Project Manager	Precision/ Accuracy/Bias	Same as Method/ SOP QC Acceptance Limits
LOD verification	Quarterly for every analyte	Spike a quality system matrix at concentration 2-4x the DL. Must meet 3:1 signal-to-noise ratio, or for data systems that do not measure noise, results must be at least 3 standard deviations greater than the mean method blank concentration.	If verification fails, the DL determination must be repeated and a LOD verification. Alternatively pass two consecutive LOD verification at a higher spike and at the LOD at the higher concentration.		Accuracy	
LOQ verification	Quarterly for every analyte	Spike a quality system matrix at a concentration equal to or greater than the low point of the calibration curve.	Must meet laboratory specified precision and bias limits. If LOQ fails, repeat at a higher level until limits are met.		Precision/Bias	

SAP Worksheet #29—Project Documents and Records Table

Document	Where Maintained
• Field Notes • Chain-of-Custody Records • Air Bills • Telephone Logs • Custody Seals • CA Forms • Electronic data deliverables (EDDs) • ID of QC Samples • Meteorological Data from Field • Sampling Instrument Calibration Logs • Sampling Locations and Sampling Plan • Sampling Notes and Drilling Logs • Water Quality Parameter • Sample Receipt, Chain of Custody, and Tracking Records • Standard Traceability Logs • Equipment Calibration Logs • Sample Preparation Logs • Run Logs • Equipment Maintenance, Testing, and Inspection Logs • CA Forms • Reported Field Sample Results • Reported Result for Standards, QC Checks, and QC Samples • Instrument printouts (raw data) for Field Samples, Standards, QC Checks, and QC Samples • Data Package Completeness Checklists • Sample disposal records • Extraction/Clean-up Records • Raw Data (archived per Navy CLEAN contract) • DV Reports • CA Forms • Laboratory QA Plan • Field Performance Audit Checklists	• Field data deliverables (e.g., field notes entries, chains-of-custody, air bills, and EDDs) will be kept on CH2M's network server. • Field parameter data will be loaded with the analytical data into the Navy database • Analytical laboratory hard copy deliverables and DV reports will be saved on the network server and archived per the Navy CLEAN contract. • Electronic data from the laboratory will be loaded into Navy database • Following project completion, hard copy deliverables (e.g., field notes, chains of custody) will be archived at Iron Mountain: Iron Mountain Headquarters 745 Atlantic Avenue Boston, MA 02111 (800) 899-IRON • Following project completion, hard copy deliverables including chains of custody and raw data will be archived at the Washington National Records Center: Washington National Records Center 4205 Suitland Road Suitland, Maryland 20746-8001 301-778-1550

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SAP Worksheet #30—Analytical Services Table

Matrix	Analytical Group	Sample Locations/ID	Analytical Method	Data Package Turnaround Time	Laboratory/ Organization	Backup Laboratory/ Organization[1]
Groundwater	PFAS	Refer to **Worksheets #18** and **#20**	LC/MS/MS Compliant with QSM v. 5.3, Table B-15[2]	28 Days	Battelle Analytical Services 141 Longwater Drive Suite 202 Norwell, MA 02061 POC: Jonathan Thorn (781) 681-5565	For PFAS: Vista Analytical
Soil				28 Days		

Notes:

[1] SAP addendum required when backup laboratory is used.

[2] Analytical method is compliant with QSM v. 5.3 Table B-15 or the most recent version of the QSM for which Battelle has DoD ELAP certification.

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SAP Worksheet #31—Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (title and organizational affiliation)	Person(s) Responsible for Responding to Assessment Findings (title and organizational affiliation)	Person(s) Responsible for Identifying and Implementing CA (title and organizational affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (title and organizational affiliation)
Field Performance Audit	One during sampling event	Internal	CH2M	PM CH2M	FTL CH2M	PM CH2M	PM CH2M
Safe Work Observation	One during sampling event	Internal	CH2M	SSC CH2M	Field Team Member observed CH2M	HSM CH2M	SSC CH2M
Field Document Review	Daily during sampling event	Internal	CH2M	PM or Task Manager CH2M	FTL CH2M	PM CH2M	PM CH2M

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SAP Worksheet #32—Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (name, title, organization)	Timeframe of Notification	Nature of CA Response Documentation	Individual(s) Receiving CA Response (name, title, organization)	Timeframe for Response
Field Performance Audit	Checklist and Written Audit Report	TBD, FTL, CH2M	Within 1 day of audit	Verbal and Memorandum	FTL CH2M	Within 1 day of receipt of CA Form
Safe Behavior Observation (SBO)	SBO Form	Loren Kaehn, HSM, CH2M	Within 1 week of SBO	Memorandum	Field Team Member CH2M	Immediately
Field Document Review	Markup copy of field documentation	TBD, FTL, CH2M	Within 1 day of review	Verbal and Memorandum	FTL CH2M	Within 1 day of receipt of markup
Offsite Laboratory Technical Systems Audit	TBD by Perry Johnson Laboratory Accreditation, Inc.	TBD, Battelle Analytical Services	Within 2 months of audit	Memorandum	TBD by Perry Johnson Laboratory Accreditation, Inc.u	Within 2 months of receipt of initial notification.

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SAP Worksheet #32-1—Laboratory Corrective Action Form

Person initiating CA: ______________________________ Date: __________

Description of problem and when identified:

____

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____

Cause of problem, if known or suspected:

____

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____

Sequence of CA: (including date implemented, action planned, and personnel/data affected)

____

____

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____

____

CA implemented by: ______________________________ Date: ______________

CA initially approved by: ______________________________ Date: ______________

Follow-up date: ______________________________

Final CA approved by: ______________________________ Date: ______________

Information copies to:

Anita Dodson, CH2M Navy CLEAN Program Chemist

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SAP Worksheet #32-2—Field Performance Audit Checklist

Project Responsibilities

Project No.: ____________________ Date: ____________________

Project Location: ____________________ Signature: ____________________

Team Members

Yes No 1) Is the approved work plan being followed?
Comments ____________________

Yes No 2) Was a briefing held for project participants?
Comments ____________________

Yes No 3) Were additional instructions given to project participants?
Comments ____________________

Sample Collection

Yes No 1) Is there a written list of sampling locations and descriptions?
Comments ____________________

Yes No 2) Are samples collected as stated in the Master SOPs?
Comments ____________________

Yes No 3) Are samples collected in the type of containers specified in the work plan?
Comments ____________________

Yes No 4) Are samples preserved as specified in the work plan?
Comments ____________________

Yes No 5) Are the number, frequency, and type of samples collected as specified in the work plan?
Comments ____________________

Worksheet #32-2—Field Performance Audit Checklist (continued)

Yes No 6) Are QA checks performed as specified in the work plan?

Comments ____

____

Yes No 7) Are photographs taken and documented?

Comments ____

____

Document Control

Yes No 1) Have any accountable documents been lost?

Comments ____

____

Yes No 2) Have any accountable documents been voided?

Comments ____

____

Yes No 3) Have any accountable documents been disposed of?

Comments ____

____

Yes No 4) Are the samples identified with sample tags?

Comments ____

____

Yes No 5) Are blank and duplicate samples properly identified?

Comments ____

____

Yes No 6) Are samples listed on a chain-of-custody record?

Comments ____

____

Yes No 7) Is chain of custody documented and maintained?

Comments ____

____

SAP Worksheet #32-3—Safe Behavior Observation Form

☐ Federal or ☐ Commercial Sector (check one)		☐ Construction or ☐ Consulting (check one)	
Project Number:	Client/Program:		
Project Name:	Observer:		Date:
Position/Title of Worker Observed:		Background Information/ comments:	
Task/Observation Observed:			

- Identify and reinforce safe work practices/behaviors
- Identify and improve on at-risk practices/acts
- Identify and improve on practices, conditions, controls, and compliance that eliminate or reduce hazards
- Proactive PM support facilitates eliminating/reducing hazards (do you have what you need?)
- Positive, corrective, cooperative, collaborative feedback/recommendations

Actions & Behaviors	**Safe**	**At-Risk**	**Observations/Comments**
Current and accurate Pre-Task Planning/Briefing (for example, Project Safety Plan, Safety Training and Consulting, activity hazard analysis, Pre-task Safety Plan, tailgate briefing, as needed)			**Positive Observations/Safe Work Practices:**
Properly trained/qualified/ experienced			
Tools/Equipment Available and Adequate			
Proper Use of Tools			**Questionable Activity/Unsafe Condition Observed:**
Barricades/Work Zone Control			
Housekeeping			
Communication			
Work Approach/Habits			
Attitude			
Focus/Attentiveness			**Observer's CAs/Comments:**
Pace			
Uncomfortable/Unsafe Position			
Inconvenient/Unsafe Location			
Position/Line of Fire			
Apparel (hair, loose clothing, jewelry)			
Repetitive motion			**Observed Worker's CAs/Comments:**
Other			

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SAP Worksheet #33—QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, and so forth)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
Field Audit Report	One during sampling event	TBD	PM CH2M	Included in project files
QA Management Report/Technical Memorandum	Once results have been assessed for data usability	To be submitted with Final SI Report	CH2M Project Team	NAVFAC Northwest RPM and will be posted in project file.

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SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description[c]	Responsible for Verification or Validation	Step I/IIa/IIb[a]	Internal/ External[b]
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	FTL/CH2M	Step I	Internal
Chains-of-Custody and Shipping Forms	Chain of custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain of custody forms will be initialed by the reviewer, a copy of the chains of custody forms retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chain of custody forms will also be reviewed for adherence to the SAP by the PC.	FTL/CH2M PC/CH2M	Step I	Internal and External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the PC in the form of laboratory logins.	PC/CH2M	Step I	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the PC. Documentation will be incorporated into the case narrative, which becomes part of the final hard copy data package.	PC/CH2M	Step I	External
EDDs	EDDs will be compared against hard copy laboratory results (10 percent check). If errors are found during the 10% check, an additional 25% of the EDDs will be checked against hard copy laboratory results.	PC/CH2M	Step I	External
Case Narrative	Case narratives will be reviewed by the DV during the DV process. This is verification that they were generated and applicable to the data packages.	DV	Step I	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Laboratory QAO	Step I	Internal
Laboratory Data	The data will be verified for completeness by the PC. To ensure completeness, EDDs will be compared to the SAP. This is a verification that all samples were included in the laboratory data and that correct analyte lists were reported.	PC/CH2M	Step I	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If CAs are required, a copy of the documented CA taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and CA forms will be reviewed internally to ensure that all appropriate CAs have been taken and that CA reports are attached. If CAs have not been taken, the site manager will be notified to ensure action is taken.	PM/CH2M PC/CH2M	Step I	Internal
CA Reports	CA reports will be reviewed by the PC or PM and placed into the project file for archival at project closeout.	PM/CH2M PC/CH2M	Step I	External
Laboratory Methods	During the pre-validation check, ensure that the laboratory analyzed samples using the correct methods specified in the SAP. If methods other than those specified in the SAP were used, the reason will be determined and documented.	PC/CH2M	Step IIa	External
Target Compound List and Target Analyte list	During the pre-validation check, ensure that the laboratory reported all analytes from each analysis group as per **Worksheet #15**. If the target compound list is not correct, then it must be corrected prior to sending the data for validation. Once the checks are complete, the project manager is notified via email	PC/CH2M	Step IIa	External
Laboratory Limits (DL/LOD/LOQ)	During the pre-validation check, the laboratory limits (DL/LOD/LOQ) will be compared to those listed in the project SAP. If limits were not met, the laboratory will be contacted and asked to provide an explanation, which will then be discussed in the associated project report. Often times the cause for minor laboratory limit deviation from those presented in the SAP is due to the quarterly update of laboratory LOD.	PC/CH2M	Step IIb	External
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed. Any such discrepancies will be discussed first in the data validation narrative and will be included in the associated project report.	Laboratory QAO	Step I	Internal
Sample Chronology	Holding times from collection to extraction or analysis and from extraction to analysis will be considered during the data validation process.	DV	Step IIa and IIb	External
Raw Data	Ten percent review of raw data to confirm laboratory calculations. For a recalculated result, the DV attempts to re-create the reported numerical value. The laboratory is asked for clarification if a discrepancy is identified, which cannot reasonably be attributed to rounding. In general, this is outside five percent difference. Conduct a ten percent review of laboratory calculations. For a recalculated result, the DV attempts to recreate the reported numerical value. The laboratory is asked for clarification if a discrepancy is found, which cannot be reasonably attributed to rounding. If errors are found during the 10% check, an additional 20 percent of the raw data will be checked to confirm calculations. Any discrepancies will be addressed in the data validation narrative.	DV	Step IIa	External

SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table (continued)

Data Review Input	Description[c]	Responsible for Verification or Validation	Step I/IIa/IIb[a]	Internal/ External[b]
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records. Screening data will be included in the project report.	FTL/CH2M	Step IIb	Internal
Documentation of Method QC Results	Establish that all required QC samples were run and met limits. Any deviations will be reported in the data validation narrative.	DV	Step IIa	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run and met limits and discuss QC sampling in the associated project report.	PC/CH2M	Step IIa	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	PC/CH2M	Step I	External
Analytical data for Geotechnical Parameters	Data is for screening purposes only and will be reviewed by project chemist and project team.	PC/CH2M	Step I	Internal
Analytical data for PFAS analyzed for soil and groundwater[d]	Analytical methods and laboratory SOPs as presented in this SAP will be used to evaluate compliance against QA/QC criteria. Should adherence to QA/QC criteria yield deficiencies, data may be qualified. Data may be qualified if QA/QC exceedances have occurred. Guidance and qualifiers from “United States Department of Defense General Data Validation Guidelines” (DoD, 2019b), “Data Validation Guidelines Module 3: Data Validation Procedure for Per- and Polyfluoroalkyl substances Analysis by QSM Table B-15” (DoD, 2020), and “Per- and Polyfluoroalkyl Substances (PFAS): Reviewing Analytical Methods for Environmental Samples” Technical brief (USEPA, 2019)will be applied as appropriate. As specific modules for the analytical methods in this project are published, the data validators will refer to those modules for guidance. In the meantime, if specific guidance is not given for these methods in the General Data Validation Guidelines, the data validator may adapt the guidance from "USEPA National Functional Guidelines for Superfund Organic Methods Data Review" (USEPA, 2017a), may also be applicable.	DV	Step IIa and IIb	External

Notes:

[a] Verification (Step I) is a completeness check that is performed before the data review process continues to determine whether the required information (complete data package) is available for further review. Validation (Step IIa) is a review that the data generated is in compliance with analytical methods, procedures, and contracts. Validation (Step IIb) is a comparison of generated data against measurement performance criteria in the SAP (both sampling and analytical).

[b] Internal or external is in relation to the data generator.

[c] Should CH2M find discrepancies during the verification or validation procedures above, an email documenting the issue will be circulated to the internal project team, and a Corrections to File Memo will be prepared identifying the issues and the corrective action needed. This memo will be sent to the laboratory, or applicable party, and maintained in the project file.

[d] Stage 4 data validation will be performed on 10% of all definitive analyses which will include recalculated results from the raw data to verify calculations. The remaining (90%) of the definitive data will have Stage 2B data validation performed.

SAP Worksheet #37—Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:

- Non-detected site contaminants will be evaluated to ensure that project required PQLs in **Worksheet #15** were achieved. If PQLs were achieved and the verification and validation steps yielded acceptable data, then the data are considered usable.
- During verification and validation steps, data may be qualified as estimated with the following qualifiers: J or UJ. The qualifiers represent minor QC deficiencies, which will not affect the usability of the data. When major QC deficiencies are encountered, data will be qualified with an R and in most cases is not considered usable for project decisions.
  - J = Analyte present. Reported value may or may not be accurate or precise.
  - J+ = Analyte present. Reported value is estimated and may be biased high.
  - J- = Analyte present. Reported value is estimated and may be biased low.
  - UJ = Analyte not detected. Associated non-detect value may be inaccurate or imprecise.
  - R = Rejected result, team discussion. Result not reliable.
  - X = Result recommended for rejection by the validator. Result not reliable.
- The following additional qualifiers may be given by the validator:
  - N = Tentative ID. Consider Present. Special methods may be needed to confirm its presence or absence in future sampling efforts.
  - NJ = Qualitative ID questionable due to poor resolution. Presumptively present at approximate quantity.
  - U = Not Detected.
- Analytical data will be checked to ensure the values and any qualifiers are appropriately transferred to the electronic database. The checks include comparison of hardcopy data and qualifiers to the EDD. Once the data have been uploaded into the electronic database, another check will be performed to ensure all results were loaded accurately.
- Field and laboratory precision will be compared as RPD between the two results.
- Deviations from the SAP will be reviewed to assess whether CA is warranted and to assess impacts to achievement of project objectives.

Describe the evaluative procedures used to assess overall measurement error associated with the project.

- To assess whether a sufficient quantity of acceptable data is available for decision making, the data will be compared to the 95 percent completeness goal and reconciled with MPC following validation and review of DQI.
- If significant biases are detected with laboratory QA/QC samples, they will be evaluated to assess impact on decision making. Low biases will be described in greater detail as they represent a possible inability to detect compounds that may be present at the site.
- If significant deviations are noted between laboratory and field precision, the cause will be further evaluated to assess impact on decision making.

SAP Worksheet #37—Usability Assessment (continued)

Describe the documentation that will be generated during the usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

The following will be prepared by CH2M and presented to and submitted to NAVFAC Northwest for review and decisions on the path forward for the site:

- Data tables will be produced to reflect detected and non-detected site analytes. Data qualifiers will be reflected in the tables and discussed in the data quality evaluation and will be provided in the SI report

Identify the personnel responsible for performing the usability assessment.

The CH2M team, including the PM and PC, will review the data and present to NAVFAC Northwest for review and approval of usability.

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Figures

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DATA SOURCE: ESRI & NIRIS
IMAGERY SOURCE: ESRI 2017

Legend

- ● City
- State Route
- Local Road
- Base Boundary

N

0 0.75 1.5 3 Miles

1 inch = 1.5 miles

Figure 10-1
Seaplane Base Reference Map
Naval Air Station Whidbey Island
Oak Harbor, Washington

R:\ENBG\00_Proj\N\Navy\CLEAN\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4041\SeaplaneBase\SAP\Figure10-2_Potential_PFAS_Source_Areas_Seaplane_Base.mxd5/9/2019SSAVAGE1

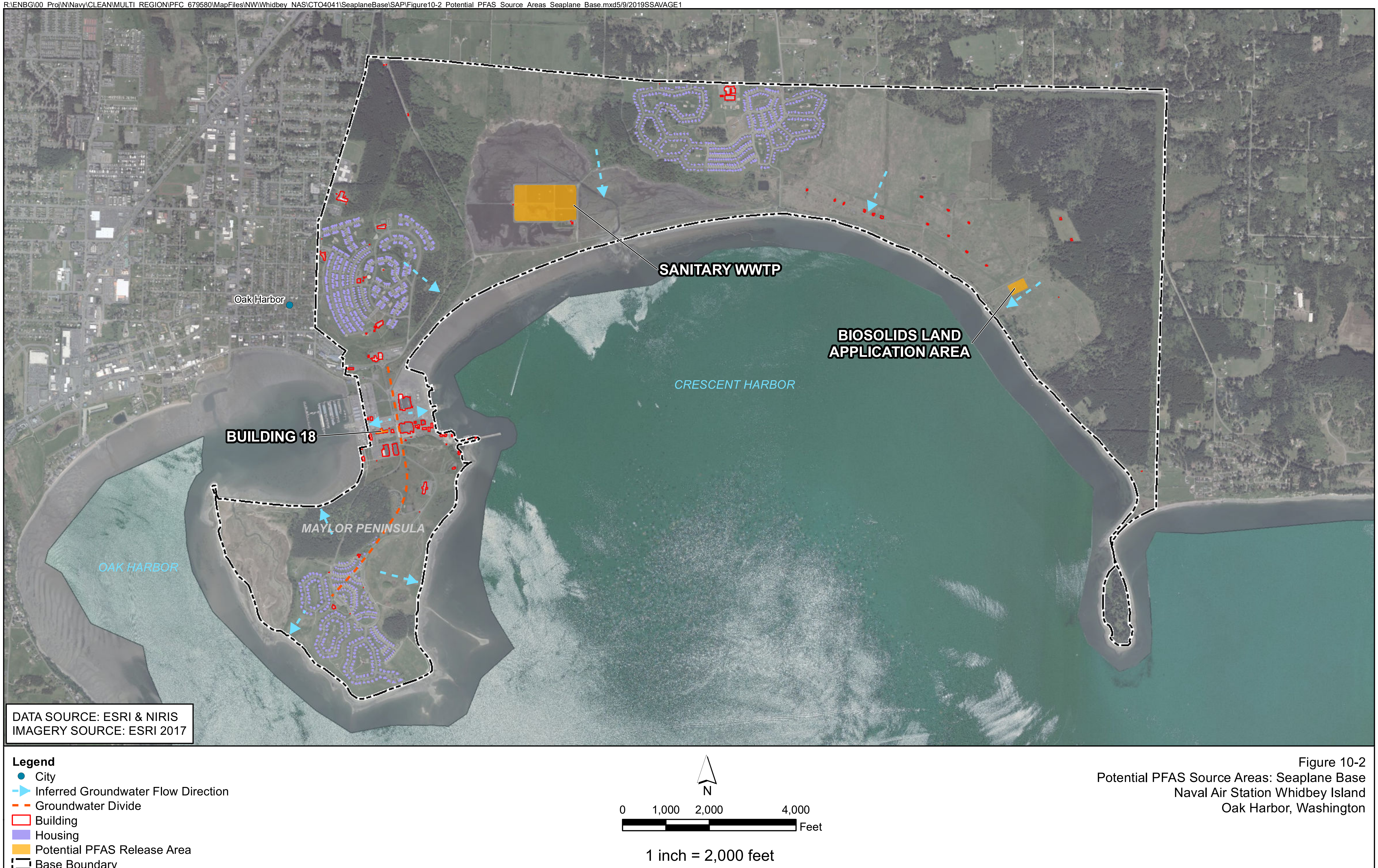

Figure 10-2
Potential PFAS Source Areas: Seaplane Base
Naval Air Station Whidbey Island
Oak Harbor, Washington

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\\dc1vs01\GISNavyClean\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4041\SeaplaneBase\SAP\Figure11-1_ProposedSamplingLocations_Building_18.mxd10/20/2020DRUCKC

DATA SOURCE: ESRI & NIRIS
IMAGERY SOURCE: ESRI, Maxar 2018

Legend

- ● Proposed Groundwater Monitoring Well and Soil Boring
- ● Stormwater Catch Basin
- ▲ Stormwater Outfall
- ━ Culvert
- ╌ Unpaved Ditch
- ➜ Inferred Groundwater Flow Direction
- ☐ Building
- 🟪 Housing
- 🟧 Potential PFAS Release Area
- ⬚ Base Boundary

N

0 60 120 240 Feet

1 inch = 120 feet

Figure 11-1
Proposed Sampling Locations: Building 18
Naval Air Station Whidbey Island
Oak Harbor, Washington

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\\dc1vs01\GISNavyClean\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4041\SeaplaneBase\SAP\Figure11-2_ProposedSamplingLocations_SanitaryWWTP.mxd11/11/2020DRUCKC

DATA SOURCE: ESRI & NIRIS
IMAGERY SOURCE: ESRI, Maxar 2018

Legend

- ● Proposed groundwater monitoring locations from existing wells
- ● Proposed soil boring
- ⇢ Inferred Groundwater Flow Direction
- ✕— Fence
- ☐ Building
- 🟪 Housing
- 🟧 Potential PFAS Release Area
- ⬚ Base Boundary

N

0 200 400 800 Feet

1 inch = 400 feet

Figure 11-2
Proposed Sampling Locations: Sanitary WWTP
Naval Air Station Whidbey Island
Oak Harbor, Washington

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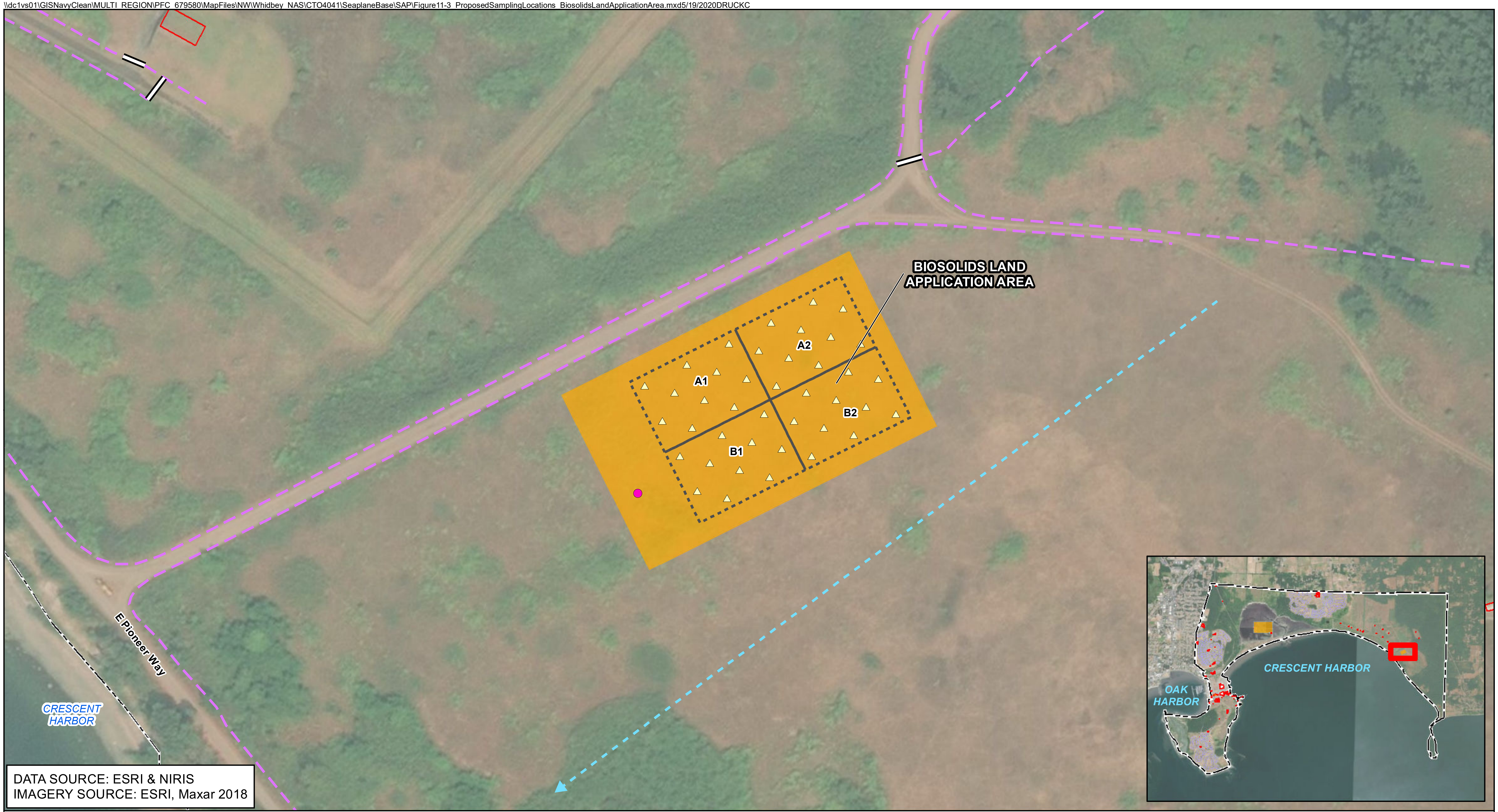
\\dc1vs01\GISNavyClean\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4041\SeaplaneBase\SAP\Figure11-3_ProposedSamplingLocations_BiosolidsLandApplicationArea.mxd5/19/2020DRUCKC



DATA SOURCE: ESRI & NIRIS
IMAGERY SOURCE: ESRI, Maxar 2018

Legend

- ● Proposed Groundwater Monitoring Well and Soil Boring
- ━ Culvert
- ╍ Unpaved Ditch
- ➤ Inferred Groundwater Flow Direction
- ▭ Building
- ■ Housing
- ■ Potential PFAS Release Area
- ⬚ Base Boundary
- △ Gridded Sample Locations
- ⬚ Sampling Grid

N

0 60 120 240 Feet

1 inch = 120 feet

Figure 11-3
Proposed Sampling Locations: Biosolids Land Application Area
Naval Air Station Whidbey Island
Oak Harbor, Washington

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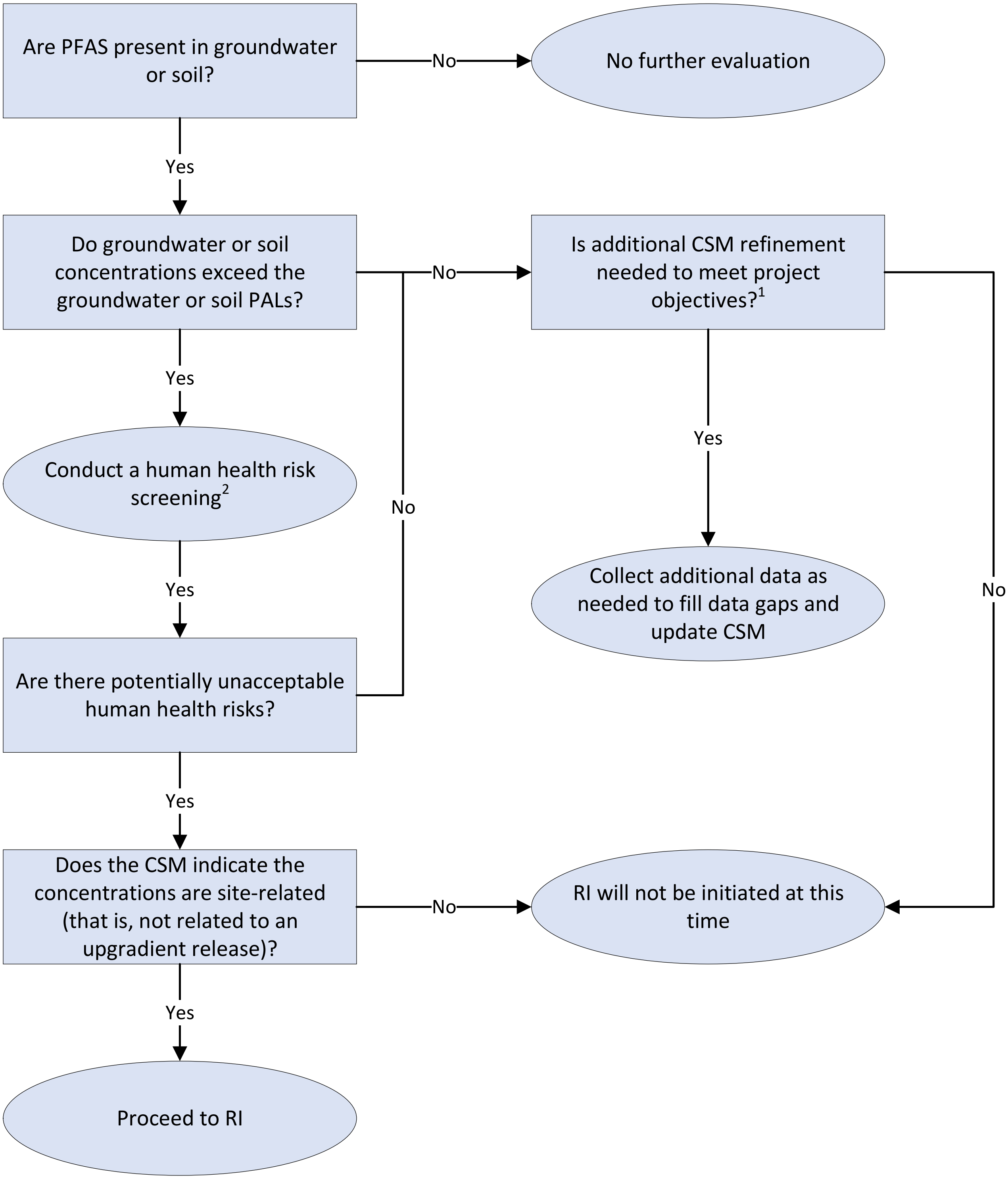


Figure 11-4
Evaluation Decision Logic
Basewide PFAS SI UFP-SAP
Seaplane Base

[1] Additional CSM refinement may be warranted if a release cannot be ruled out based on the existing dataset due to measured groundwater flow direction not in the direction anticipated during initial investigation planning, a potential source area likely outside of the original SI boundary (i.e. highest concentration on the upgradient edge of the assumed site boundary), or any other additional information indicating the existing dataset is insufficient to rule out a release.

[2] The human health risk screening will be limited to the compounds for which toxicity values exist. The data for the remaining compounds will be archived for future use.

Appendix A
Standard Operating Procedures

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the soil boring log form (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for ASTM D1586 (attached), a standard soil boring log form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both sample jar labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, sonic). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil consistency of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch OD, and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch OD). A stiffer rod, such as an "N" rod (2-5/8-inch OD), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

Soil Boring Log Form with a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* (ASTM D2488.pdf)

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

STANDARD OPERATING PROCEDURE

Multi RAE Photoionization Detector (PID)

I. Purpose

The purpose of this SOP is to provide general reference information for using the Multi RAE PID in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

II. Scope

This procedure provides information on the field operation and general maintenance of the Multi RAE PID. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

III. Definitions

Carbon Monoxide Sensor (CO) - Carbon Monoxide concentration in ppm.

Volatile Organic Compound (VOC) – VOC concentration in ppm

Lower Explosive Limit (LEL) - Combustible gas is expressed as a percent of the lower explosive limit.

Hydrogen Sulfide Sensor (H_2S) - Hydrogen Sulfide concentration in ppm.

Oxygen Sensor (OXY) - Oxygen concentration as a percentage.

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

IV. Procedures

The PID operates on the principle that most organic compounds and some inorganic compounds are ionized when they are bombarded by high-energy ultraviolet light. The air sample is drawn across a UV lamp using a pump or a fan. The energy of the lamp determines whether a particular chemical will be ionized. Each chemical compound has a unique photoionization potential (PIP). When the UV light energy is greater than the ionization potential of the chemical, ionization will occur. All PID readings are relative to the calibration gas, usually isobutylene.

It is important to calibrate the PID in the same temperature and elevation that the equipment will be used, and to determine the background concentrations in the field before taking measurements. For environments where background readings are high, factory zero calibration gas should be used.

Note: For volatile and semi-volatile compounds, knowing the PIP is critical in determining the appropriate instrument to use when organic vapor screening. Consult the QAPP and manufacturer's manual to determine that the proper instrument has been selected for the contaminate vapors of interest. If an expected compound at a site has a PIP less than 11.7 eV, it is possible to use a PID. If the ionization potential is greater than 11.7eV, a flame-ionization detector is required.

The following subsections will discuss Mini RAE calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

A. Calibration

For Multi RAE configured with O_2, LEL, H_2S, CO, sensors and a 10.6 eV PID Lamp.

Start up Instrument

- Press **Mode** button
- Observe displays:

On!……..

Multi RAE
Version X.XX

Model Number
SN XXXX

Date Time
Temp

Checking Sensor
Ids….

VOC Installed

CO Installed

H_2S Installed

OXY Installed

LEL Installed

H_2S VOC CO
LEL OXY

```
Alarm Limits=
```

```
XX XX.X XX
XX High XX.X
```

```
XX XX.X XX
XX Low XX.X
```

```
XX XX.X XX
 STEL
```

```
XX XX.X XX
 TWA
```

```
Battery = X.XV
Shut off at 4.2V
```

```
User Mode=
```

```
Alarm Mode=
```

```
Datalog Time Left
```

```
Datalog Mode
```

```
Datalog Period
```

```
Unit ready in…..
10 Seconds
```

- The pump will start, the seconds will count down to zero, and the instrument will be ready for use

Calibration Check and Adjustment

Allow instrument to warm up for 15 minutes.

- Depress the **[N/-]** key first, then while depressing the **[N/-]**, depress the **[Mode]** key also and depress both keys for 5 seconds.
- Display will read:

```
Calibrate
Monitor?
```

- Press the **[Y/+]** key
- Display will read:

Fresh Air
Calibration?

- If “Zero Air” is necessary, attach the calibration adapter over the inlet port of the Multi RAE Monitor and connect the other end of the tube to the gas regulator (HAZCO loaner regulator LREG.5, RAE Systems P/N 008-3011 or suitable .5 LPM regulator) on the Zero Air bottle (HAZCO P/N SGZA, RAE P/N 600-0024). If no Zero Air is available, perform the Fresh Air Calibration in an area free of any detectable vapor.
- Press the **[Y/+]** key
- Display will read:

Zero….
In progress…

CO Zeroed!
Reading = X

VOC Zeroed!
Reading = X

LEL Zeroed!
Reading = X

OXY Zeroed!
Reading = X

Zero Cal done!

H_2S Zeroed!
Reading = X

In each of the above screens, “X” is equal to the reading of the sensor before it was zeroed.

- Display will then read:

Multiple Sensor
Calibration?

- Press the **[Y/+]** key
- The display shows all of the pre-selected sensors and the “OK?” question:

CO H_2S
LEL OK? OXY

- Apply calibration gas – use either HAZCO Services Part Number R-SGRAE4 or Rae Systems Part Number 008-3002 – using a .5 LPM regulator and direct tubing.
- Press the **[Y/+]** key. Display will read:

Apply Mixed gas

Calibration
In progress …

- The display will count down showing the number of remaining seconds:

CO cal'ed
Reading=50

H_2S cal'ed
Reading=25

LEL cal'ed
Reading=50

OXY cal'ed
Reading=20.9

Calibration done
Turn off gas!

- Display will read:

Single Sensor
Calibration?

- Press the **[Y/+]**.
- Display will read:

CO VOC H_2S
LEL pick? OXY

- Attach 100 ppm Isobutylene (HAZCO P/N r-SGISO or Rae P/N 600-0002) using a 1.0 LPM regulator (HAZCO P/N LR10HS or Rae P/N 008-3021). Open regulator.
- Press the **[Mode]** key once, the V of VOC will be highlighted.
- Press the **[Y/+]**. The display will read:

Apply VOC Gas

Calibration
In progress…

- The display will count down showing the number of remaining seconds:, then display:

VOC cal'd
Reading=100

Calibration done
Turn off gas!

Single Sensor
Calibration?

- Press **[Mode]** key twice to return to main screen.

- **CALIBRATION IS COMPLETE!**

B. Operation

Due to the Multi RAE having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 9 to 14.

C. Site Maintenance

After each use, the meter should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

D. Scheduled Maintenance

Function	Frequency
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly
Replace sensors	Biannually or when calibration is unsuccessful

V. Quality Assurance Records

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the field logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g, Multi RAE had wide range fluctuations during air monitoring activities.)

VI. References

Multi RAE Plus Multiple Gas Monitor User Manual, RAE Systems, Revision B1, November 2003.

PLANNING FIELD SAMPLING ACTIVITIES

1.0 PURPOSE

This section sets forth standard operating procedures (SOPs) for planning and scheduling field sampling activities. This SOP shall also be used to determine the number and type of laboratory and field Quality Control (QC) samples required while working on U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) sites/projects, and to prepare and implement Task Order Field Sampling Plans (FSP). For information on the number and type of QC samples required for the various QC Levels, see SOPs III-A, *Laboratory QC Samples (Water and Soil),* III-B, *Field QC Samples (Water and Soil),* III-C *Field and Laboratory QC Samples (Air).*

2.0 PROCEDURES

To prepare a field sampling plan, designated personnel must identify the objectives of the sampling program, determine the number of samples to be collected for each matrix (see SOP I-A-2, *Development of Data Quality Objectives*), and select the analyses to be performed on each sample (see SOPs I-A-3, *Selection of Analytes* and I-A-4, *Analytical Methods Selection*). The duration of sampling for each matrix, the preferred sampling method, the method of shipment, and the type and quantity of supplies (such as coolers, coolant and packing material that will be needed for sample storage and transport) must also be determined. Finally, the number and type of decontamination water sources to be used for each phase of sampling must be identified. The methods of determining each of these elements are addressed below.

2.1 NUMBER OF SAMPLES

Designated project personnel shall determine the number of samples to be collected from each sample matrix (e.g., soil, water), and specify the type of sample analysis. SOPs I-A-2, *Development of Data Quality Objectives*, I-A-3, *Selection of Analytes*, and I-A-4, *Analytical Methods Selection*, shall be used to determine numbers and locations of samples, as well as appropriate analytical methods. These figures will be used to estimate the costs of sample analysis. They will also help determine the number and types of sample containers required; number of field duplicates, field replicates, equipment rinsates, performance evaluation (PE) samples, matrix spike/matrix spike duplicates (MS/MSD), and trip blanks to be collected, and the analyses to be performed on them for each matrix and analytical method; and the number of days required to perform sampling activities.

Sampling intervals for soil borings shall be selected on the basis of potential sources of contamination, the geologic and hydrologic complexity of the site, and the objectives of the sampling program. Areas of high contamination (for example, contamination in the capillary fringe) or complex geology or hydrogeology may require continuous sampling.

2.2 DURATION OF SAMPLING ACTIVITIES

The anticipated number of working days needed to complete field sampling activities shall be determined before fieldwork commences. A schedule should be developed that outlines the approximate number of samples to be collected each day, categorized by sample matrix, method of sample collection, and sample analysis (e.g., 28 soil samples collected using a hand auger and analyzed for organochlorine pesticides and chlorinated herbicides; 15 water samples collected using a bailer—7 analyzed for volatile organics and 8 analyzed for organic lead). This information will be used to determine the number of field equipment rinsate samples that will be collected (if any), the types of analyses to be performed on them, the number of MS/MSDs and field duplicates, equipment needs, and personnel.

2.3 NUMBER OF SAMPLES TO BE ANALYZED FOR VOLATILE ORGANICS

Prior to initiation of site sampling activities, designated personnel shall determine the number of samples to be analyzed for volatile organic compounds (VOCs). This information will be used to determine the approximate number of coolers that will contain samples to be analyzed for VOCs, which will in turn, dictate the number of VOC trip blanks needed, as specified in SOP III-B, *Field QC Samples (Water, Soil).*

2.4 DECONTAMINATION WATER SOURCES

Prior to initiation of sampling activities, designated personnel shall determine the number and type of decontamination water sources. Decontamination water includes both potable water used for equipment washing, and deionized or distilled water used during the final equipment rinse. The locations of potable water supplies for field decontamination activities shall be identified and designated as the only sources to be used during site sampling activities. Similarly, the source(s) of deionized or distilled water shall be identified and designated as the only source(s) to be used during site sampling activities. The intent of this procedure is to reduce variability in equipment decontamination procedures and to make it possible to easily identify the source of contamination in the event that analysis of field blanks reveals the presence of contaminants of concern.

3.0 DOCUMENTATION

The number of samples to be collected, the proposed duration of sampling activities, the number of samples that will be analyzed for VOCs, and the number and type of decontamination water sources that will be used for field activities will be specified in the FSP and QAPP portions of the Work Plan prepared for each NAVFAC NW Task Order. Records of how this information is actually implemented during field activities will be maintained in field logbooks, as specified in SOP III-D, *Logbooks*.

4.0 REFERENCES

SOP I-A-2, *Development of Data Quality Objectives*

SOP I-A-3, *Selection of Analytes*

SOP I-A-4, *Analytical Methods Selection*

SOP II-B, *Field QC Samples (Water and Soil)*

SOP III-A, *Laboratory QC Samples (Water and Soil)*

SOP III-B, *Field QC Samples (Water, Soil)*

SOP III-C *Field and Laboratory QC Samples (Air)*

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

None.

IDW MANAGEMENT

1.0 PURPOSE

This standard operating procedure (SOP) describes the activities and responsibilities of the U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) and their subcontractors with regard to management of investigation-derived waste (IDW). The purpose of this procedure provides guidance for the minimization, handling, labeling, temporary storage, and inventory of IDW generated during site investigations and remediation projects conducted under the direction of NAVFAC NW. **Each base may have specific required procedures**. These procedures are made available to the contractor through the NAVFAC Naval Technical Representative (NTR) or other government point of contact. This SOP is also applicable to personal protective equipment (PPE), sampling equipment, decontamination fluids, non-IDW trash, non-indigenous IDW, and hazardous waste and other regulated wastes generated during implementation of site investigations and removal or remedial actions. The information presented will be used to prepare and implement Work Plans (WP), Field Sampling Plans (FSP), and Waste Management Plans (WMPs) for IDW-related field activities.

2.0 PROCEDURES

The procedures for IDW management in the field are described below in Sections 2.1 to 2.5. The implementation of these procedures requires Remedial Project Managers (RPMs), Field Managers, their designates and subcontractors to perform the following tasks:

- Minimize generation of IDW,
- Segregate IDW,
- Properly handle IDW containers,
- Properly label IDW containers,
- Apply good management practices in storing IDW drums and containers,
- Prepare IDW drum inventories,
- Update and Report changes to IDW drum inventories,
- Perform inspections of IDW containers and storage areas, as required,
- Prepare IDW containers for proper off-site transportation and disposition, as required.

2.1 IDW MINIMIZATION

Field Managers and their designates shall minimize the generation of onsite IDW to reduce the need for special storage or disposal requirements that may result in substantial additional costs and provide little or no reduction in site risks (EPA 1992). The volume of IDW shall be reduced, by applying minimization practices throughout the course of site investigation activities. These minimization strategies include: 1) material substitution; 2) using proper low-volume drilling techniques; 3) using disposable sampling and PPE; 4) using bucket and drum liners; and 5) segregating non-contaminated IDW and trash from contaminated IDW. Waste minimization strategies and types of IDW expected to be generated shall be documented in the appropriate project plans.

2.1.1 Material Substitution

Material substitution consists of selecting materials that degrade readily or have reduced potential for chemical impacts to the site and the environment. An example of this practice is the use of biodegradable detergents (e.g., Alconox® or non-phosphate detergents) for decontamination of non-consumable PPE and sampling equipment. In addition, field equipment decontamination can be conducted using isopropyl alcohol rather than hexane or other solvents (for most analytes of concern), to reduce the potential onsite chemical impacts of the decontamination solvent. Decontamination solvents shall be selected carefully so that solvents, and their known decomposition products, do not result in generation of RCRA hazardous waste.

2.1.2 Drilling Methods

Drilling methods that minimize potential IDW generation should be given priority. Sonic, Hollow stem auger and air rotary methods should be selected, where feasible, over mud rotary methods. Mud rotary drilling produces waste drilling mud, while hollow stem and air rotary drilling methods produce relatively low volumes of soil waste. Sonic drilling produces the least amount of waste. Small diameter borings and cores shall be used when soil is the only matrix to be sampled at the boring location; the installation of monitoring wells requires the use of larger diameter borings.

Soil, sludge, or sediment removed from borings, containment areas, and shallow test trenches shall not be returned to the source, unless allowed by regulation and included in the approved WP, FSP, or WMP.

2.1.3 Decontamination Fluids

The use of disposable sampling equipment, such as plastic bailers, trowels, and drum thieves (which do not require decontamination) minimizes the quantity of decontamination fluids generated. In general, decontamination fluids, and well development and purge water, should not be minimized because the integrity of the associated analytical data may be affected.

2.1.4 PPE and Disposable Sampling Equipment

Visibly soiled PPE and disposable sampling equipment shall be segregated from non-visibly soiled PPE and sampling equipment. Where investigation involves potentially hazardous waste or other regulated wastes, visibly soiled PPE and disposable sampling equipment may require decontamination. The Field Manager shall use best professional judgment to determine if decontamination is appropriate. This determination should be included in the approved WP, FSP, or WMP. If decontamination is performed, PPE and disposable sampling equipment generated in the decontamination process may be double-bagged and disposed of as non-hazardous waste.

2.1.5 Liners

Bucket liners can be used in the decontamination process to reduce the volume of solid IDW-generated and reduce costs on larger projects. The plastic bucket liners can be crushed into a smaller volume than the buckets, and only a small number of plastic decontamination buckets are required for the entire project. Larger, heavy-duty, 55-gallon drum liners can be used for heavily contaminated IDW to provide secondary containment, and reduce the costs of disposal and drum recycling. Drum liners may extend the containment life of the drums in severe climates and will reduce the costs of cleaning out the drums prior to recycling.

2.1.6 Segregation of non-IDW

All waste materials generated in the support zone are considered non-IDW trash. To minimize the total volume of IDW, all trash shall be separated from IDW, sealed in garbage bags, and properly disposed of offsite as municipal waste.

2.1.7 Monitoring Well Construction

Excess cement, sand, and bentonite grout prepared for monitoring well construction shall be kept to a minimum. Well construction shall be observed by Field Managers to ensure that a sufficient, but not excessive, volume of grout is prepared. Some excess grout may be produced. Unused grout that has not come in contact with potentially contaminated soil or ground water shall be considered non-hazardous trash and shall be disposed of offsite by the drilling subcontractor. Surplus materials from monitoring well installation, such as scrap PVC sections, used bentonite buckets, and cement/sand bags that do not come in contact with potentially contaminated soil, shall be considered non-IDW trash and shall be disposed of offsite by the drilling subcontractor.

2.1.8 Field Analytical Test Kits

IDW generated from the use of field analytical test kits consists of those parts of the kit that have been used and/or come into contact with potentially contaminated site media, or excess extracting solvents and other reagents. Potentially contaminated solid test kit IDW shall be contained in plastic bags and stored with PPE or disposable sampling equipment IDW from the same source area as soil material used for the analyses. The small volumes of waste solvents, reagents, and water samples used in field test kits should be segregated, and disposed of accordingly (based upon the characteristics of the materials, MSDS sheets, and as described in the WMP). Most other test kit materials should be considered non-IDW trash, and be disposed of as municipal waste.

2.2 SEGREGATION OF IDW BY MATRIX AND LOCATION

To facilitate subsequent IDW screening, sampling, classification and/or disposal, IDW shall generally be segregated by matrix and source location at the time it is generated. Each drum of solid IDW shall be completely filled, when possible. For liquid IDW, drums should be left with headspace of approximately 5% by volume to allow for expansion of the liquid and potential volatile contaminants. IDW from each distinct matrix shall be stored in a single drum (e.g., soil, water or PPE shall not be mixed in one drum). In general, IDW from separate sources should not be combined in a single drum.

It is possible that monitoring well development and purge water will contain suspended solids, which will settle to the bottom of the storage drum as sediment. Significant observations on the turbidity or sediment load of the development or purge water shall be included in the logbook and reported in attachments to the quarterly drum inventory report (see SOP III-D, *Logbooks* and Section 2.5). To avoid having mixed matrices in a single drum (i.e., sediment and water), it may be necessary to decant the liquids into a separate drum, after the sediments have settled out. This segregation may be accomplished during subsequent IDW sampling activities or during consolidation in a holding tank prior to disposal. Disposal of liquid IDW into the sanitary sewer shall only occur if approved by the appropriate regulatory agencies, municipal entities, and Naval installation. Appropriate precautions per the approved Health and Safety Plan (HASP) shall be implemented to ensure worker protection during these activities.

Potentially contaminated well construction material shall be placed in separate containers. Soil, sediment, sludge, or liquid IDW shall be segregated from potentially contaminated waste well construction materials. Potentially contaminated well construction materials from different monitoring wells shall not be commingled.

Potentially hazardous PPE and disposable sampling equipment shall be segregated from other IDW. PPE from generally clean field activities, such as water sampling, shall be segregated from visibly soiled PPE, double-bagged and disposed of offsite as municipal waste. Disposable sampling equipment from activities such as soil, sediment, and sludge sampling includes plastic sheeting used as liner material in containment areas around drilling rigs and waste storage areas; disposable sampling equipment; and soiled decontamination equipment. Where investigation involves potentially hazardous waste, visibly soiled PPE and disposable sampling equipment may require decontamination. The Field Manager shall use best professional judgment to determine if decontamination is appropriate. If decontamination is performed, PPE and disposable sampling equipment generated in the decontamination process may be double-bagged and disposed of as non-hazardous waste. PPE and disposable sampling equipment generated on separate days may be commingled.

Decontamination fluids shall be stored in drums separate from other IDW. If practical, decontamination fluids generated from different sources should not be stored in the same drum. If decontamination fluids generated over several days or from different sources are stored in a single container, information regarding dates of generation and sources shall be recorded in the field notebook, on the drum label (Section 2.3.2), and in the drum inventory (Section 2.5).

Liquid and sediment portions of the equipment decontamination fluid in the containment unit used by the drilling or excavation field crew should be separated. The contents of this unit normally consist of turbid decontamination fluid above a layer of predominantly coarse-grained sediment. When the contents of the containment unit are to be stored in IDW containers, the Field Manager shall direct the placement of as much liquid into drums as possible and transfer the remaining solids into separate drums. Observations of the turbidity and sediment load of the liquid IDW should be noted in the field notebook, on the drum label (Section 2.3.2), and in attachments to the drum inventory (see Section 2.5). It is likely that decontamination fluids will contain minor amounts of suspended solids that will settle out of suspension to become sediment at the bottom of IDW storage drums. As noted above, it may be necessary to segregate the drummed water from sediment during subsequent IDW sampling or disposal activities.

2.3 DRUM HANDLING AND LABELING

Drum handling consists of those actions necessary to prepare an IDW drum for labeling. Drum labeling consists of those actions required to legibly and permanently identify the contents of an IDW drum. Specific handling, storage, and labeling requirements may differ with the Naval installation or oversight entity. Specific requirements should be determined at the planning stage and documented in the WMP. General requirements are provided in the following sections.

2.3.1 Drum Handling

The drums used for containing IDW shall be approved by the United States Department of Transportation (DOT, 49 CFR 172). 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., 1A1 or 1A2). New steel drums are preferred over recycled drums. For short-term storage of liquid IDW prior to discharge, double-walled bulk steel or plastic storage tanks may be used. Consideration must be given to scheduling and cost-effectiveness of bulk storage, treatment, and discharge system versus longer-term drum storage.

For long-term IDW storage, the DOT-approved drums with removable lids are recommended. The integrity of the foam or rubber sealing ring located on the underside of some drum lids shall be verified prior to sealing drums containing IDW liquids. If the ring is only partially attached to the drum lid, or if a portion of the ring is missing, a drum lid with sealing ring that is in good condition must be used. At some facilities, drums containing liquid IDW will be required to be stored in protective overpacks.

To prepare IDW drums for labeling, the outer wall surfaces and drum lids shall be wiped clean of all material that may prevent legible and permanent labeling. If potentially contaminated material adheres to the outer surface of a drum, that material shall be wiped from the drum, and the paper towel or rag used to remove the material shall be segregated with visibly soiled PPE and disposable sampling equipment.

2.3.2 Drum Labeling

Proper labeling of IDW drums is essential to the success and cost-effectiveness of subsequent waste screening and disposal activities. Labels shall be permanent and descriptive to facilitate correlation of field analytical data with the contents of individual IDW drums.

2.3.2.1 Preprinted Labels

A preprinted drum label as required by the appropriate Naval installation and/or regulatory agency shall be completed. The label will be affixed to the outside of the drum (or overpack if required) with the label easily readable for inspections and inventory. Label requirements may vary based on the site.

The requested information shall be printed legibly on the drum labels in black, indelible ink. Instructions for entering the required drum-specific information for each label field are provided by the Naval installation.

Painted Labels

An alternative method for labeling drums, if acceptable for the project, is to paint label information directly on the outer surface of the drum. At a minimum, the information placed on the drum shall include the contract/delivery order number, a drum number, the source identification type and number, the type of IDW, the generation date(s), and the government point of contact and telephone number. The drum surface shall be dry and free of material that could prevent legible labeling. Label information shall be confined to the upper two-thirds of the total drum height. The printing on the drum shall be large enough to be easily legible. Yellow, white, or red paint markers (oil-based enamel paint) that are non-photodegradable are recommended to provide maximum durability and contrast with the drum surface.

2.3.2.2 Regulatory Marking and Labeling

Federal and State regulations may require specific labeling for IDW generated (i.e., RCRA, TSCA, NESHAPs). Pre-printed labels shall be used as appropriate and completed in accordance with the specific regulatory requirement. These requirements will be identified in the approved project plans. Once determined to be hazardous, weekly inspections must also be conducted to ensure that labels and markings are in good conditions and to ensure the integrity of containers.

In addition, prior to off-site transportation USDOT requirements for marking and labeling of regulated DOT materials must be complied with. These requirements will be identified in the approved project plans or otherwise coordinated with the Field Manager after the IDW has been characterized and off-site disposition is being planned. Note that personnel (i.e., contractors or subcontractors) who perform USDOT functions must be properly trained in accordance with 49 CFR 172, Subpart G.

2.4 DRUM STORAGE

Drum storage procedures shall be implemented to minimize potential human contact with the stored IDW and prevent extreme weathering of the stored drums. Waste accumulation areas will be pre-designated by NAVFAC NW prior to the start of site work. IDW drums should be placed on pallets. Good management practices should be used in storing drums which include: containers shall be in good condition and closed during storage; wastes must be compatible with containers; where liquids are stored, storage areas should have secondary containment; and spill or leaks should be removed as soon as possible. These good management practices are mandatory requirements where RCRA hazardous wastes are stored.

Waste accumulation areas shall be maintained as prescribed by local regulatory entities and the appropriate Naval installation. In general, drums of IDW shall be stored within the Area of Concern (AOC) so that the site can utilize RCRA regulatory flexibility (i.e., administrative requirements, such as 90-day storage, may not be triggered; and LDRs will not be triggered if IDW is placed back in AOC). If IDW is determined to be RCRA hazardous waste, then RCRA storage, transportation and disposal requirements must be met.

Drums shall be stored at identified waste accumulation areas. All IDW drums generated during field activities at a single AOC shall be placed together, in a secure, fenced onsite area to prevent access to the drums by unauthorized personnel. When a secure area is not available, drums shall be placed in an area of the site with the least volume of human traffic. Plastic sheeting (or individual drum covers) and yellow caution tape shall be placed around the stored drums. Drums from projects involving multiple AOCs should remain at the respective source areas where the IDW was generated. IDW should not be transferred offsite for storage elsewhere, except under rare circumstances, such as the lack of a secure storage area onsite.

Proper drum storage practices shall be implemented to minimize damage to the drums from weathering and possible exposure to humans or the environment. When possible, drums shall be stored in dry, shaded areas and covered with impervious plastic sheeting or tarpaulin material. Every effort shall be made to protect the preprinted drum labels from direct exposure to sunlight, which causes ink on the labels to fade. In addition, drums shall be stored in areas that are not prone to flooding. The impervious drum covers shall be appropriately secured to prevent dislodging by the wind. It may be possible to obtain impervious plastic covers designed to fit over individual drums; however, the labeling information shall be repeated on the outside of these opaque covers.

Drums in storage shall be placed with sufficient space between rows of drum pallets and shall not be stacked, such that authorized personnel may access all drums for inspection. Proper placement will also render subsequent IDW screening, sampling, and disposal more efficient. It is recommended that IDW drums be segregated in separate rows/areas by matrix (i.e., soil, liquid or PPE/other).

If repeated visits are made to the project site, the IDW drums shall be inspected to clear encroaching vegetation, check the condition and integrity of each drum, check and replace labels as necessary, and replace or restore protective covers.

2.5 DRUM INVENTORY

Accurate preparation of an IDW drum inventory is essential to all subsequent activities associated with IDW drum tracking and disposal. An inventory shall be prepared for each project in which IDW is generated, stored, and disposed of. Naval installations and local regulatory authorities may have specific requirements associated with waste inventory and these requirements should be included in the planning process and documented in the WP, FSP, and WMP.

The drum inventory information shall include 11 elements that identify drum contents and indicate their fate.

2.5.1 Navy Activity (Generator)/Site Name

Inventory data shall include the Navy activity and the site name where the IDW was generated (e.g., NASWI, NBK Bangor, etc.).

2.5.2 DO Number

Inventory data shall include the contract and delivery order number associated with each drum (e.g., 0089).

2.5.3 Drum Number

The drum number assigned to each drum shall be included in the inventory database.

2.5.4 Storage Location Prior to Disposal

The storage location of each drum prior to disposal shall be included in the inventory (e.g., Building 394 Battery Disassembly Area, or Adjacent to West end of Building 54).

2.5.5 Origin of Contents

The source identification of the contents of each IDW drum shall be specified in the inventory (e.g., soil boring number, monitoring well number, sediment sampling location, or the multiple sources for PPE- or rinse water-generating activities).

2.5.6 IDW Type

Inventory data shall include the type of IDW in each drum (e.g., soil, PPE, disposable sampling equipment, sludge, sediment, development water, steam cleaning water, decontamination rinse water).

2.5.7 Waste Volume

The amount of waste in each drum shall be specified in the inventory as a percentage of the total drum volume or an estimated percentage-filled level (e.g., 95% maximum for liquid IDW).

2.5.8 Recommended Analytical Methods and Test Results Compared with Applicable Regulatory Standards

The recommended EPA analytical methods that adequately characterize IDW contained in each drum will be summarized in a tabular format and attached to the quarterly IDW drum inventory report (see Attachment I-A-7-1). The methodology for sampling and characterizing IDW shall be specified in the appropriate project plans.

2.5.9 Recommended or Actual Disposition of IDW Drum Contents

The recommended means of IDW disposal for each drum shall be summarized in a tabular format (e.g., Offsite, Encapsulated Onsite, Treatment/Sewer, Offsite Incinerator) and attached to the quarterly IDW drum inventory report (see Attachment I-A-7-1). Additional narrative discussion of the rationale for the recommended disposal option shall be attached to the quarterly IDW drum inventory report as data become available.

2.5.10 Generation Date

Inventory data shall include the date IDW was placed in each drum. If a drum contains IDW-generated over more than one day, the start date for the period shall be specified in dd-month-yy format. This date is not to be confused with an RCRA hazardous waste accumulation date (40 CFR 262). The accumulation start date, if required for RCRA wastes, shall be included on the hazardous waste drum label (Section 2.3.2.2).

2.5.11 Expected Disposal Date

The expected date each drum is to be disposed of shall be specified as part of the inventory in month-yy format. This date is for informational purposes only for the Navy, and shall not be considered contractually binding.

2.5.12 Actual Disposal Date

The actual drum disposal date occurs at the time of onsite disposal, or acceptance by the offsite treatment or disposal facility. It shall only be entered in the drum inventory database when such a date is available in dd-month-yy format.

In order to provide information for all 11 of the inventory elements of the quarterly inventory report described above, the main source of information will be provided by RPMs, or their designees, and summarized in Attachment I-A-7-1.

The recommended analytical test methods and actual test results (compared to applicable regulatory standards) will be provided to the appropriate Navy groups, by the RPM, or their designees, when such data are available. Testing methods shall be documented in the associated project plans. Recommended disposal options or actual disposition of the IDW drum contents will also be provided by RPMs as data become available. The NAVFAC Northwest RPM will forward all IDW data to the appropriate Navy authority as attachments to the quarterly IDW drum inventory report. This information constitutes the results of preparing and implementing an IDW screening, sampling, classification, and disposal program for each site.

3.0 DOCUMENTATION

The RPM or designee is responsible for completing and updating the site-specific IDW drum inventory spreadsheet and submitting it as needed. The RPM is also responsible for submitting backup documentation to the U.S. Navy Program Management Office (PMO) about the analytical methods recommended to adequately characterize the IDW in each drum (Section 2.5.8). In addition, actual site or drum sampling results shall be forwarded to the PMO, along with a comparison to the applicable regulatory standards, for inclusion as attachments to the quarterly IDW drum inventory. As necessary, the backup documentation to the quarterly IDW drum inventory report shall also include the recommended means for IDW disposal for each drum (Section 2.5.9). After disposal, the actual means and/or location of disposal shall be indicated in tabular format with supporting narrative.

Field Managers and designates are responsible for documenting all IDW-related field activities in the field notebook, including most elements of the IDW drum inventory spreadsheet. The correct methods for developing and maintaining a field notebook are presented in SOP III-D, *Logbooks*.

Upon receipt of analytical data from the investigation, the information will be forwarded to the appropriate Naval authority for comparison to regulatory waste criteria. The Navy will designate the IDW and disposal options will be assessed based on the waste designation, approved transport/disposal facilities, and schedule for disposal. Naval installations may have additional requirements for reviewing analytical data, characterizing waste materials, transporting and off-site disposal. The RPM shall coordinate with the Naval installation early in the planning process to ensure that these requirements are properly identified, incorporated into the approved project plans, as available, and implemented in the field.

The disposal of IDW must be approved by the Navy and, in some cases, pertinent regulatory agencies. The disposal must be documented.

4.0 REFERENCES

Department of Transportation (DOT), Hazardous Materials Transportation Regulations, 49 CFR Parts 171 – 179.

EPA. 1998. EPA530-F-98-026, Management of Remediation Waste Under RCRA

EPA. 1991. Management of Investigative-Derived Wastes During Site Inspections. U.S. Environmental Protection Agency/540/G-91/009. May.

EPA. 1992. Guide to Management of Investigative-Derived Wastes. Quick Reference Guide. U.S. Environmental Protection Agency: 9345.3-03FS. January.

5.0 ATTACHMENTS

Attachment IA71	Example Format – Quarterly IDW Drum Inventory Updates

Attachment I-A-7-1
Quarterly IDW Drum Inventory Updates

Navy Activity / Site Name (Generator Site)	DO Number (0bbb)	Drum Number (xxxx-AA-Dzzz)	Drum Storage Location	Origin of Contents (Source ID #)	IDW Type	Waste Volume (Fill level %)	Waste Generation Date (dd-mm-yy)	Expected Disposal Date (mm-yy)	Actual Disposal Date (dd-mm-yy)
NSC Pearl Harbor/ Landfill	0068	0068-LF-D001	NSC, Bldg 7	SB-1	Soil Cuttings	100	16-Dec-92	Dec-93	Na
		0068-LF-D002	NA	MW-1	Purge Water	75	20-Dec-92	Jul 93	26-Jul-93
				MW-2					
				MW-3					
		0068-LF-D003	NA	MW-1	Decon Water	95	20-Dec-92	Jul-93	26-Jul-93
				MW-2					
				MW-3					
		0068-LF-D004	NSC, Bldg.16	SB-1	PPE	50	16-Dec-92	Oct-93	NA
				SB-2					
				SB-3					
				SB-4					
				MW-1					
				MW-2					
				MW-3					
NAVSTA Guam/ Drum Storage	0047	0047-DS-001	Hazmat Storage Area	SB-1	Soil Cuttings	100	18-Feb-93	Sep-93	NA
				SB-2					

NA = Not Applicable

GENERAL FIELD OPERATION

1.0 PURPOSE

This standard operating procedure (SOP) defines the general field organization and the field structure of sample collection, sample identification, record keeping, field measurements, and data collection. These SOPs are used to ensure the activities used to document sampling and field operations provide standardized background information and identities.

2.0 PROCEDURES

2.1 MOBILIZATION/DEMOBILIZATION

The SM or designee ensures that all purchase requests have been reviewed and approved by the PM. Then, the SM and PM assemble the project team in order to review the scope of work, disseminate the project plans, and complete the field equipment checklist (provided as Attachment I-A-9-1). After review by the project team, if additional items are required, additional purchase requests are prepared and approved by the PM.

The SM and project team upon arrival at the site inspects all equipment. Packing slips, bills of lading, or other documentation received with the shipment are initialed and returned to the purchasing department and a copy placed into the field file. Quantities, types, and makes of items received are checked against the original purchase requests to validate the shipment. Prior to validation of the shipping receipt, equipment is inspected to ensure all components are present and that the equipment calibrates and is fully functional. Any equipment received that is not fully functional is returned immediately and the vendor contacted to arrange a replacement.

The SM provides copies of the appropriate SOPs to the project team prior to the start of field activities. The most current versions of the SOPs are brought to the field. Any revisions to the SOPs must be approved by the PM and recorded in the field logbook.

It is imperative that rental equipment be cleaned (decontaminated), packaged, and returned immediately following the completion of a task. If any problems occurred on site with any equipment, the problems should be noted in detail in the field logbook and the SM notified. The SM will forward this information to the purchasing department and the vendor.

2.2 SHIPPING

If it is possible and /or practical, equipment and supplies should be shipped directly to the field site. If sensitive field equipment is to be shipped to the site, care shall be taken to ensure the equipment is not damaged en route. All original packaging material should be retained for return shipment of the equipment. Additional packing material (e.g., bubble wrap, bubble bags) may be required to provide additional protection for the shipped items. Equipment should always be shipped in its original carrying case. Each piece being shipped must have an address label on the shipping container separate from the shipping air bill.

2.3 CHAIN OF COMMAND

Chain of command protocols are implemented by the PM. These protocols should be strictly followed while performing field tasks. All decisions concerning priorities, project team assignments, sampling procedures, equipment management, and task approach are made by the PM, the SM, or an approved appointee. The SM or an approved designee will conduct a daily meeting prior to the start of field activities to discuss individual responsibilities. The meeting will also address potential contaminants that may be encountered, safety items (such as use of heavy equipment or protection against noise), special sampling requirements, and site control(s) to be employed to prevent injuries or exposure.

2.4 SAMPLING ORGANIZATION

The SM ensures the sampling design, outlined in project plans, is followed during all phases of the sampling activities at the site. For each sampling activity, field personnel record the information required by the applicable SOPs in their logbooks and on the exhibits provided in the SOPs.

2.5 REVIEW

The PM, SM, and, on occasion, the QAO or an approved designee checks field logbooks, daily logs, and all other documents that result from field operations for completeness and accuracy. Any discrepancies on these documents are noted and returned to the originator for correction. The reviewer acknowledges that review comments have been incorporated into the document by signing and dating the applicable reviewed documents.

3.0 DOCUMENTATION

Project activities shall be recorded in the field logbooks. The logbooks shall be kept current for the daily activities including documentation of all samples collected and the information relevant to the sample collection. All project required field forms shall be completed within a timely manner upon completion of the field task. All required field forms and specific logbook notations should be detailed in the field sampling plan.

4.0 REFERENCES

None.

5.0 ATTACHMENTS

Attachment IA91	Field Equipment Checklist.

Attachment I-A-9-1
Field Equipment Checklist

General

___ 1. Health and Safety Plan

___ 2. Site base map

___ 3. Hand calculator

___ 4. Brunton compass

___ 5. Personal clothing and equipment

___ 6. Personal Protective Equipment (First Aid kit)

___ 7. Cell or radio telephone

Environmental Monitoring Equipment

___ 1. Shovels

___ 2. Keys to well caps

___ 3. pH meter (with calibrating solutions)

___ 4. pH paper

___ 5. Thermometer

___ 6. Conductivity meter (with calibrating solution)

___ 7. Organic vapor analyzer or photoionization detector with calibration gas

___ 8. H2S, O2, combustible gas indicator

___ 9. Draeger tubes

Shipping Supplies

___ 1. Sample preservatives (nitric, hydrochloric, sulfuric acid/sodium hydroxide)

___ 2. Heavy-duty aluminum foil

___ 3. Coolers

___ 4. Ice packs

___ 5. Large zipper locking plastic bags

___ 6. Heavy-duty garbage bags

___ 7. Duct tape

___ 8. Strapping tape

___ 9. Paper towels

___ 10. Bubble pack, foam pellets, or shredded paper

___ 11. Vermiculite

___ 12. Cooler labels (“This Side Up,” “Hazardous Material,” “Fragile”)

___ 13. Federal Express/DHL labels

Sampling Equipment

___ 1. Tool box with assorted tools (pipe wrenches, screwdrivers, socket set and driver, open and box end wrenches, hacksaw, hammer, vice grips)
___ 2. Geologic hammer
___ 3. Trowel
___ 4. Stainless steel and/or Teflon spatula
___ 5. Hand auger
___ 6. Engineer’s tape
___ 7. Steel tape
___ 8. Electric water level sounder
___ 9. Petroleum Interface Probe
___ 10. Batteries
___ 11. Bailers (Teflon, stainless steel, acrylic, PVC)
___ 12. Slug test water displacement tube
___ 13. Vacuum hand pump
___ 14. Electric vacuum pump
___ 15. Displacement hand pump
___ 16. Mechanical pump (centrifugal, submersible, bladder)
___ 17. Portable generator
___ 18. Gasoline for generator
___ 19. Hose
___ 20. Calibrated buckets
___ 21. Stop watch
___ 22. Orifice plate or equivalent flow meter
___ 23. Data logger and pressure transducers
___ 24. Strip chart recorders
___ 25. Sample bottles
___ 26. 0.45-micron filters (prepackaged in holders)
___ 27. Stainless steel bowls
___ 28. SW scoop
___ 29. Peristaltic pump/tubing
___ 30. Sample tags
___ 31. SOPs, HAZWOPER training certificates, MSDs, FSP, QAPP

Decontamination Equipment

___ 1. Non-phosphate laboratory-grade detergent
___ 2. Selected high purity, contaminant free solvents
___ 3. Long-handled brushes
___ 4. Drop cloths (plastic sheeting)
___ 5. Trash container
___ 6. Galvanized tubs or equivalent (e.g., baby pools)
___ 7. Tap Water
___ 8. Contaminant free distilled/deionized water
___ 9. Metal/plastic container for storage and disposal of contaminated wash solutions
___ 10. Pressurized sprayers, H_2O
___ 11. Pressurized sprayers, solvents
___ 12. Aluminum foil
___ 13. Sample containers
___ 14. Emergency eyewash bottle
___ 15. Documentation Supplies

Documentation Supplies

___ 1. Weatherproof, bound field logbooks with numbered pages
___ 2. Daily Drilling Report forms

___ 3. Field Borehole Log forms

___ 4. Monitoring Well Installation Log forms

___ 5. Well Development Data forms

___ 6. Groundwater Sampling Log forms

___ 7. Aquifer Test Data forms

___ 8. Sample Chain-of-Custody forms

___ 9. Custody seals

___ 10. Communication Record forms

___ 11. Documentation of Change forms

___ 12. Camera and film

___ 13. Paper

___ 14. Permanent/indelible ink pens

___ 15. Felt tip markers (indelible ink)

___ 16. Munsell Soil Color Charts

MONITORING/SAMPLING LOCATION RECORDING

1.0 PURPOSE

This standard operating procedure (SOP) describes the guidelines for generating the descriptions and information to be recorded for each physical location where monitoring, or sampling is conducted.

2.0 PROCEDURES

2.1 SAMPLING LOCATION MARKING

Sampling locations are based on criteria presented in the SAP. Whenever possible, each sampling location will be marked by a wooden lathe stake, directly marking the surface with marking paint, or with surveyors flagging. Each should be labeled with the location identifier outlined in the SAP. This should be done during the site visit or as soon as is feasible during field activities. This is to give the utility locators a better idea of the specific area to be cleared. Having the locations marked will also assist the field crew gain a better perspective of the locations to be worked

2.2 PHOTOGRAPHIC DOCUMENTATION

Site photographs showing monitoring/sampling locations with respect to structures or the site in general are encouraged. At certain installations, photography must be approved by the Navy. Prior to commencing work, the Navy must be notified to determine if cameras are allowed at the installation. The Note that the Navy will likely inspect your camera and may purge/delete some pictures if they feel there is a security issue. When possible, a menu board included in the photograph can be used to give relative information regarding the project and location.

For each photograph, record the following information in the field logbook:

- Photo number
- Date and time of the photo
- Orientation of the photo (direction facing)
- Subject-a description of what is contained within the photo. Others may be using the photos that are unfamiliar with the site and locations.

A detailed description of field logbook entries can be found in SOP III-D, *Logbooks*.

2.3 MONITORING/SAMPLING LOCATION INFORMATION FORM

A Monitoring/Sampling Location Information form must be filled out to establish each new sampling location. This form must be provided to the Navy for inclusion into the NAVFAC NW NIRIS Database. Established locations should not be re-established unless new information (such as survey information) is recorded about a location. A location description may be provided about a sampling location. It should contain detailed information regarding the physical features surrounding the location, including relevant site information (i.e., obvious contamination, measurements to physical features, topographical relief, etc.). This description may be a copy of the field logbook or notes on project plan maps. These descriptions shall be attached to the field form. The PM is responsible for insuring that the project personnel have and use consistent terminology and descriptions as established in the SAP. The reverse of the field form contains a brief discussion of the form and descriptions of the information requested on the front.

3.0 DOCUMENTATION

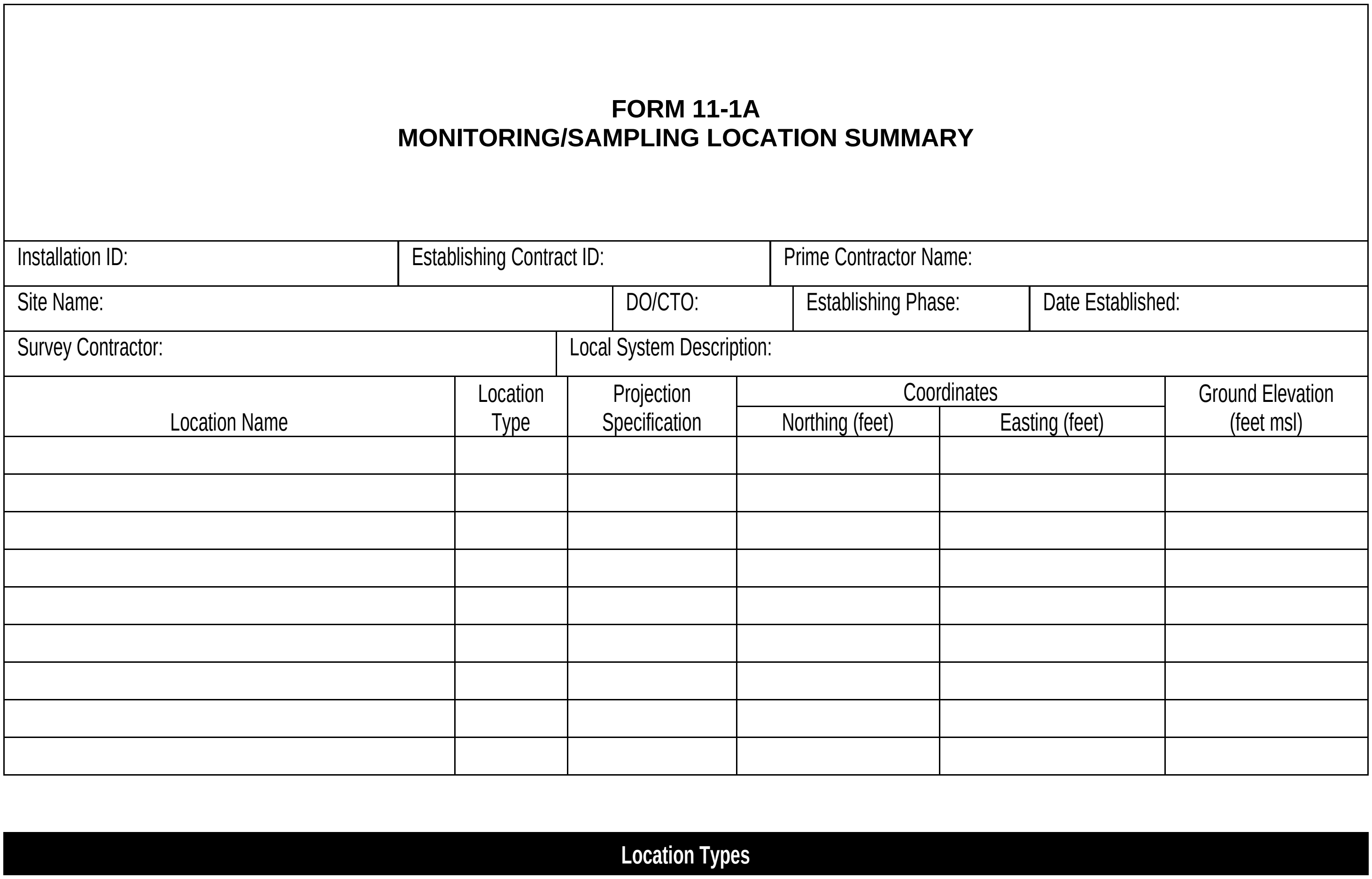
None.

4.0 REFERENCES

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

Attachment IA101 Example Monitoring/Sampling Location Information Form



FORM 11-1A
MONITORING/SAMPLING LOCATION SUMMARY

Installation ID:
Establishing Contract ID:
Prime Contractor Name:
Site Name:
DO/CTO:
Establishing Phase:
Date Established:
Survey Contractor:
Local System Description:

Location Name	Location Type	Projection Specification	Coordinates		Ground Elevation (feet msl)
			Northing (feet)	Easting (feet)	

Location Types

ACID	Acid Pit
ADIT	Adit
AGT	Above ground tank
AIR	Air (not inside a building - ambient conditions)
AMB	Ambient drinking water aquifer monitoring well
AOVM	Ambient organic vapor monitor
ASBTS	Asbestos-Containing Area
BAY	Bay
BF	Backfill
BH	Borehole/Soil boring
BIN	Roll-off bin
BIOL	Biological (plant or animal)
BLDG	Building (includes building air and building materials)
BULK	Bulk sample
BURN	Burn pit
CB	Concrete boring
CENT	Location surveyed at the center of a UST field
CLGP	Canal Level Gauging Point
CPT	Cone penetrometer
CY	Cryopile
DCON	Decontamination pad
DITCH	Channel/Ditch
DP	Direct Push/Geoprobe
DRN	Drain
DRUM	Drum/Container contents
DRW	Drywell
DU	Decision Unit
DW	Domestic well
D_RIG_W	Drill Rig Fluid Container
EC	Electrode
ECT	Electrode
EF	System effluent
EVAP	EVAPORATION POND
EXCV	Excavation
FAGT	Former above ground tank location
FL	Fuel line
FLOOD	Flood Plain
FLOOD_GATE	Flood Control Gate
FLOOR	Floor
FLOOR_SCRP	Floor scrapings
FW	Faucet/Tap/Spigot
GAGE	Gaging station (not USGS)
GW	Geoprobe well
GWTH	Groundwater Test Hold
HA	Hand auger
HDPCH	Hydropunch
HOLE	Hole
HP	Holding pond/Lagoon
ID	Indoors
IMP	Import material
IN	System influent
IT	Intertidal
LAGOON	Lagoon
LENTIC	Freshwater, lentic
LF	Landfarm
LGV	Landfill Gas Vent
LH	Leachate (Landfill)
LK	Lake/pond/open reservoir
LOTIC	Freshwater, lotic
LYS	Lysimeter
MH	Manhole/Catch basin
MS	Sediment e.g., Marine Sediment
NQ	Quality Control sample
ON	Ocean, open water (not bay)
OTHER	Other
OUTFALL	Outfall
OW	Oil-Water Separator
PARK	Plantation/park/forest
PC	Paint chip
PIPE	Pipeline
PUBW	Public drinking water well
PUMP_STATN	Pumping station
RAIN_STATN	Rainfall station
REF	Reference
RES	Residential garden/yard
RV	River/stream
RW	Recovery well
SBAG	Soil bag
SE	Seep
SG	Soil Gas Probe
SIDEW	Side Wall
SLAG	Slag heap
SND_BLST	Sandblast material pile
SP	Spring/Seep
SPT	Septic tank
SR	Sewer System
SS	Ground surface
STEAM_LN	Steam Line
STKP	Stockpile
STRM_DRN	Storm drain
STRM_MH	Storm drain manhole
SUBS	Ground, sub-surface
SUBSLAB	Subslab
SUBT	Subtidal
SUMON	Survey monument
SUMP	Sump
SV	Soil vapor extraction system
SWS	Surface water body - nonspecific
SWSD	Surface Water/Sediment
SWWP	Wipe
SYSTEM	Treatment system air or water
T	Trench
TAA	Temporary accumulation area
TAIL	Mine tailings pile
TK	Tank
TMPM	Temperature Monitoring Point
TP	Test Pit
TRANS	Transformer
TUNNEL	Steam tunnel sampling location
TWP	Temporary well point
UGA	Geophysical anomaly
UNK	Unknown
USGS	USGS gauging station
UST	Underground storage tank
UXO	UXO
UXO_G	UXO grid
UXO_P	UXO point
VAULT	Vault
VPB	Vertical profile boring
WALL	Wall
WEEP	Weep hole
WF	Waste water treatment facility
WL	Well
WLAM	Alluvial Monitoring Well
WLBM	Bedrock Monitoring Well
WLE	Extraction well
WLEA	Alluvial Extraction Well
WLEB	Bedrock Extraction Well
WLHM	Hybrid Monitoring Well
WLI	Injection well
WLIA	Alluvial Injection Well
WLIM	Interface Monitoring Well
WLL	Leaching Well
WLM	Monitoring well
WLS	Sparge well
WLSG	Soil gas probe/Well
WRP	Waste rock pile
WSFI	Water system facility intake
WT	Wetlands
WW	Waste water

Recorder: ___ Date: ______________

Checker: ___ Date: ______________

SAMPLE NAMING

1.0 PURPOSE

This standard operating procedure (SOP) describes the naming convention to be used for samples collected, analyzed, and reported for the U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) projects. Unique sample identifiers are used to facilitate tracking by laboratory and project personnel and for purposes of storing, sorting, and querying data in the NAVFAC NW NIRIS database.

2.0 PROCEDURES

The contractor is responsible for assigning a unique sample ID to every individual sample collected. The contractor may use his or her own designations as long as the sample ID does not already exist in the NIRIS database. The contractor must also clearly identify which samples are field duplicates. This applies to both historical and planned sampling events. The used sampling identification scheme shall be identified and outlined in the field sampling plan.

3.0 DOCUMENTATION

All sample collection information must be recorded within the field logbook. Each sample collected will be clearly associated with the sample location (installation, site, and well or sample point location), matrix type, sample type (i.e. environmental, field duplicate, equipment rinsate), collection date and time, sampling method, and sampling depth (if appropriate). Only data codes and location IDs associated with NIRIS and NAVFAC NW's electronic deliverables SOP (NAVFAC NW 2015) shall be used.

Any sample submitted for analysis shall be documented using a completed chain-of-custody (COC) form that must accompany the shipment and a copy retained for the project records.

Samples submitted to an EPA laboratory shall also include a completed EPA analysis request form. The COC/analytical request form must be used to track all sample IDs.

4.0 REFERENCES

NAVFAC NW. 2015. Navy Environmental Data Transfer, Version 5.0.

5.0 ATTACHMENTS

None.

MONITORING WELL AND PIEZOMETER INSTALLATION

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to outline the methods by which all U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) personnel and their contractors will conduct monitoring well and piezometer installation. This procedure establishes the protocols and necessary equipment for installation of groundwater monitoring wells and piezometers.

2.0 PROCEDURES

2.1 EQUIPMENT

The following is an equipment list:

- Drill rig capable of installing wells to the desired depth in the expected formation material and conditions
- Well casing and well screen
- Bentonite pellets
- Filter pack sand
- Bentonite Grout or Portland Type I or II cement and powdered bentonite for grouting
- Protective well casing with locking cap
- High-pressure steamer/cleaner
- Long-handled bristle brushes
- Wash/rinse tubs
- Appropriate decontamination supplies as specified in the SOP for decontamination procedures
- Location map
- Plastic bags (re-sealable)
- Self-adhesive labels
- Weighted tape measure
- Water level probe
- Deionized water
- Logbook

- Boring log sheets
- Well construction form
- Plastic sheeting
- Drums for containment of cuttings and decontamination and/or development water (if necessary)

2.2 DECONTAMINATION

Before drilling or well installation begins, all drilling and well installation material should be decontaminated according to the protocols in SOP III-I, *Equipment decontamination*. Drilling equipment should be decontaminated between well locations.

2.3 INSTRUMENT CALIBRATION

Before going into the field, the sampler should verify that field instruments are operating properly. Calibration times and readings should be recorded in a notebook to be kept by the field sampler. Specific instructions for calibrating the instruments are provided in the respective SOPs.

2.4 DRILLING AND WELL INSTALLATION PROCEDURES

2.4.1 Drilling Technique

If soil sampling is required by project plans, all soil samples should be collected according to the subsurface soil sampling procedures. The hole should be logged according to the methods specified in the project plans.

Boreholes should be advanced via conventional continuous-flight hollow-stem auger, sonic, air rotary, or mud rotary drilling methods and a drill rig capable of completing the monitor well(s) to the depth(s) specified in the project plans. Before drilling begins, well locations should be numbered and staked. The necessary permits and utility clearances shall be obtained in accordance with permits and utility clearance procedures. The permits and clearances will conform to specific Naval installation procedures or SOP 1-A-6 for utility location procedures.

During the drilling operation, the cuttings from the boring shall be placed into 55-gallon drums or roll-off container as specified in the project plans. Disposal of cuttings should be in accordance with the project plans and follow the specific Naval installation procedures or SOP l-A-7 for investigation-derived waste (IDW) management procedures.

2.4.2 Well Bore Drilling Operations

The procedure for well bore drilling is as follows:

- Set up drilling rig at previously staked and borehole location cleared for utilities.
- Record location, date, time, and other pertinent information in the field logbook.
- Drill hole of appropriate size using the project specified drilling method.
- Collect split-spoon samples at the predetermined intervals, if appropriate, for sample description and/or chemical analysis as specified in the project plans.
- Complete the borehole to the depth specified in the project plans.

- Document any difficult drilling conditions and ensures taken in response to such conditions (such as the addition of clean water to control heave).

2.4.3 Well Design Specifications

The general specifications for wells are as follows:

Boring Diameter. The boring should be of sufficient diameter to permit at least 2 inches of annular space between the boring wall and all sides of the centered riser and screen. The boring diameter should be of sufficient size to allow for the accurate placement of the screen, riser, filter pack, seal, and grout.

Well Casing. The well riser should consist of new, flush-threaded, PVC or stainless steel. The well diameter and thickness should be specified in the project plans. The risers should extend approximately 2 feet above the ground surface, except in the case of flush-mount surface casings. The tops of all well casings should be fitted with plugs or caps in locking monuments and locking caps in non-locking monuments.

Well Screens. The screen length for each well should be specified in the project plans. Well screens should consist of new threaded pipe with factory-machine slots or wrapped screen with an inside diameter equal to or greater than that of the well casing. The slot size should be indicated in the project plans and designed to be compatible with aquifer and sand pack material. The schedule thickness of PVC screen should be the same as that of the well casing. All screen bottoms should be fitted with a cap or plug of the same composition as the screen and should be within 0.5 foot of the open part of the screen. Traps may be used.

2.4.4 Well Installation Procedure

The following procedure should be initiated within 12 hours of well bore completion for uncased holes or partially cased holes and within 48 hours for fully cased holes. Once installation has begun, if no unusual conditions are encountered, there should be no breaks in the installation procedure until the well has been completed and the drill casing has been removed.

The procedure for monitoring well installation is as described below.

1. Decontaminate all well materials according to the SOP for decontamination procedures. After decontamination, all personnel who handle the casing should put on a clean pair of rubber or surgical gloves.

2. Measure each section of casing and screen to nearest 0.10 foot.

3. Assemble screen and casing as it is lowered into the open boring or drill casing (augers, when auger drilling is used) the hollow-stem augers.

4. Lower screen and casing to about 6 inches above the bottom of the boring.

5. Record the level of top of casing and calculate the screened interval. Adjust screen interval by raising assembly to desired interval, if necessary, and add selected filter sand to raise the bottom of the boring.

6. Begin adding filter pack sand around the annulus of the screen and casing a few feet at a time while withdrawing the drill casing or augers. Repeated depth soundings should be taken to monitor the level of the sand.

7. Allow sufficient time for the filter sand to settle through the water column outside the casing before measuring the sand level.
8. Extend the filter pack sand to at least 2 to 5 feet above the top of the well screen.
9. After placing the sand filter pack, install a seal at least 3 to 5 feet thick of bentonite pellets or chips. Add the bentonite pellets or chips slowly through the drill casing to avoid bridging. The thickness of the completed bentonite seal should be measured before the pellets have been allowed to swell. The completed bentonite seal should be allowed to hydrate before proceeding with the grouting operations.
10. Grout the remaining annulus from the top of the bentonite seal to near the ground surface as measured after the drill casing has been removed. The grout should be tremied into the borehole until the annulus is completely filled. The base of the tremie pipe should be placed approximately 5 feet above the bentonite seal. Bentonite chips or pellets may be used to backfill the well borehole.
11. After the grout sets for 24 hours it should be checked for settlement. If necessary, additional grout should be added to top off the annulus. This procedure may not be an option in high traffic or unsecured areas.
12. The steel monument, concrete pad and bollards, if required, should be installed according to the specifications in this SOP. The protective casing and posts should be painted a highly visible color.
13. Optional: Personnel should affix to the outer steel protective casing of each well a permanent, noncorrosive tag that clearly identifies the well number, the client’s name, or the adjusted top of casing elevation. In some states, a state well identification number must be affixed to the monument.

2.4.5 Well Installation Specifications

Filter Pack. The annular space around the well screen should be backfilled with clean, washed silica sand sized to perform as a filter between the formation material and the well screen. The filter pack should extend a minimum 3 feet above the screen and may be tremied into place. The final depth to the top of the filter pack should be measured directly with the use of a weighted tape measure or rod and not by volumetric calculation methods. The grain size of the filter pack should be shown on the well construction log. The filter pack must be selected based on the grain size distribution of the native formation, and should be specified in the project plans.

Bentonite Seal and Grout. A minimum 2-foot-thick bentonite pellet/chip seal should be placed in the annulus above the filter pack. The thickness of the seal may vary slightly based on site conditions. The thickness of the seal should be measured immediately after placement, without allowance for swelling. Bentonite Grout or cement grout should then be placed from the top of the bentonite seal to the ground surface. Bentonite grout is preferred because of potential investigation derived waste issues if too much cement grout is prepared and due to heat generated from cement grout. Bentonite grout shall be “high solids” and prepared in accordance with the manufacturer’s instructions. Cement grout should consist of a mixture of Portland cement (ASTM C150) and clean water, with a ratio of no more than 7 gallons of clean water per bag of cement (1 cubic foot or 94 pounds). Additionally, 3 percent by weight of bentonite powder should be added if permitted by state regulations. The grout should be prepared in a rigid aboveground container by first thoroughly mixing the cement with water, and then mixing in the bentonite powder. Grout mixtures should be placed, by pumping through a tremie pipe. The lower end of the tremie pipe should be kept within 5 feet of the top of the bentonite seal. Grout should be pumped through the tremie pipe until undiluted grout flows from the annular space at the ground surface. The tremie pipe should then be removed and more grout added to compensate for settling. After 24 hours, the drilling contractor should check the site for grout settlement and add more grout to fill any depression. This should be repeated until firm grout remains at the surface.

Protection of Well. Personnel should at all times during the progress of the work take precautions to prevent tampering with the wells or the entry of foreign material into them. Upon completion of a well, a suitable cap should be installed to prevent foreign material from entering the well. The wells should be enclosed in a protective steel casing. Steel casings should be, at a minimum, 6 inches in diameter and should be provided with locking caps and locks. All locks used at a site should be keyed alike. If the well is to be a stickup (i.e., an aboveground monument), as specified in the project plans, a 1/4-inch drainage hole should be drilled in the protective steel casing, centered approximately 1/8-inch above the internal mortar collar for drainage. The well designation should be painted on the protective casing with a brush or paint pen. Painting should be done prior to well development. If specified in the project plans, a concrete pad should be constructed around the protective casing at the final ground level elevation and sloping away from the well. The concrete pad should measure at least 2 by 2 feet, with a thickness of 6 to 8 inches. Three 3-inch-diameter or larger steel posts should be equally spaced around the well and embedded in separate concrete-filled holes just outside the concrete pad. The protective steel posts should extend approximately 1 foot above the well riser. Any well that is to be temporarily removed from service or left incomplete due to a delay in construction should be capped with a watertight cap and equipped with a “vandal-proof” cover, satisfying applicable state or local regulations or recommendations.

3.0 DOCUMENTATION

Observations and data acquired in the field during the drilling and installation of wells should be recorded to establish a permanent record. A boring log should be completed for each well bore.

Additional documentation of well construction in the field logbook will include the following:

- Top of Casing surveyed elevation to 0.01 feet relative to known benchmarks, control points, and coordinate systems as defined in the Survey Specifications of NAVFAC NW SOPs V5.0 (or more current)
- Date
- Time
- Personnel
- Weather
- Subcontractors
- Health and safety monitoring equipment and readings
- Description of well location and triangulation measurements from landmarks, or GPS readings.
- Quantity and composition of grout, seals, and filter pack actually used during construction

- Screen slot size (in inches), slot configuration, outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer
- Coupling/joint design and composition
- Protective casing composition and nominal inside diameter
- Start and completion dates
- Discussion of all procedures and any problems encountered during drilling and well construction

In addition, the well installation details should be shown in a diagram drawn in the field logbook. Each well diagram should consist of the following (denoted in order of decreasing depth from the ground surface):

- Reference elevation for all depth measurements
- Project and site names
- Well number
- Date(s) of installation
- Depth at which the hole diameter changes (if appropriate)
- Depth of the static water level and date of measurement(s)
- Total depth of completed well
- Depth of any grouting or sealing
- Nominal hole diameter(s)
- Depth and type of well casing
- Description (to include length, internal diameter, slot size, and well screen material
- Any sealing off of water-bearing strata
- Static water level upon completion of the well and after development
- Drilling date(s)
- Other construction details of monitoring well including grain size of well filter pack material and location of all seals and casing joints

All entries in the field logbook should be printed in black ink and legible.

4.0 REFERENCES

SOP I-A-7, *IDW Management*

SOP III-I, *Equipment Decontamination*

5.0 ATTACHMENTS

None.

MONITORING WELL DEVELOPMENT

1.0 PURPOSE

This section describes the standard operating procedures (SOP) for monitoring well development to be used by all U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) personnel and their contractors.

2.0 PROCEDURE

2.1 INTRODUCTION

Well development procedures are crucial in preparing a well for sampling. Development enhances the flow of groundwater from the formation into the well and grades the well filter pack to reduce the movement of fine (clay and silt) particles into the well. The reduction in groundwater sample turbidity achieved by development improves the representation of chemical analyses performed on groundwater samples.

The goal of well development is to restore the area adjacent to a well to its natural condition by correcting damage to the formation during the drilling process. Well development should accomplish the following tasks:

- Remove any filter cake or any drilling fluid within the borehole that affects formation permeability.
- Grade the well filter pack to reduce the intrusion of fine formation particles.

Well development should not be performed sooner than 24 hours after the completion of well installation to allow the annular seal to fully set up.

2.2 FACTORS AFFECTING MONITORING WELL DEVELOPMENT

2.2.1 Type of Geologic Materials

Different types of geologic materials are developed more effectively by using certain development methods. Where permeability is greater, water moves more easily into and out of the formation and development is accomplished more quickly. Highly stratified deposits are effectively developed by methods that concentrate on distinct portions of the formation. If development is performed unevenly, a ground-water sample will likely be more representative of the permeable zones. In uniform deposits, development methods that apply powerful surging forces over the entire screened interval will produce satisfactory results.

2.2.2 Design and Completion of the Well

Because the filter pack reduces the amount of energy reaching the borehole wall, it must be as thin as possible if the development procedures are to be effective in removing fine particulate material from the interface between the filter pack and natural formation. Conversely, the filter pack must be thick enough to ensure a good distribution of the filter-pack material during emplacement and allow effective grading during development. Generally, filter pack material must be at least 2 inches thick. Variances from state agencies may be required for filter pack materials of less than 2 inches thick.

The screen slot size must be appropriate for the geologic material and filter pack material in order for development to be effective. If the slot size is too large, the filter pack and native material will enter the well, causing settlement of overlying materials and sediment accumulation in the casing. If the slot size is too small, full development may not be possible and the well yield will be below the potential of the formation. Additionally, incomplete development coupled with a narrow slot size can lead to blockage of the screen openings.

2.2.3 Drilling Method

The drilling method influences development procedure. Typical problems associated with specific drilling methods include the following:

- If a mud rotary method is used, a mudcake builds up on the borehole wall and must be removed during the development process.
- If drilling fluid additives have been used, the development process must attempt to remove all fluids that have infiltrated into the native formation.
- If driven casing or hollow-stem auger methods have been used, the interface between the casing or auger flights and the natural formation may have been smeared with fine particulate matter that must be removed during the development process.
- If an air rotary method has been used in rock formations, fine particulate matter is likely to build up on the borehole walls and may plug pore spaces, bedding planes, and other permeable zones. These openings must be restored during the development process.

2.3 PREPARATION

In preparing for monitoring well development, development logs for any other monitoring wells in the vicinity should be reviewed to determine the general permeability of the water-bearing formation, the associated likely groundwater yield from the well and the appropriate development method.

Depth to groundwater and information from the well construction log should be used in calculating of the required quantity of water to be removed. The distance between the equilibrated water level and the bottom of screen is the saturated section. The saturated section (feet) multiplied by the unit well volume per foot (gallons/linear foot) equals the gallons required to remove one total well volume of water. The unit well volume is the sum of the casing volume and the filter-pack pore volume, both of which depend upon casing and borehole diameter and the porosity of the filter pack material. Well volume for wells can be calculated using Table I-C-2-1 and Table I-C-2-2.

Table I-C-2-1*
Casing Volume

Casing Diameter (inches)	Volume (gallon/linear foot)
2	0.16
4	0.65
6	1.47

Table I-C-2-2*
Filter Pack Pore Volume

Casing Diameter (inches)	Borehole Diameter (inches)	Volume[a] (gallon/linear foot)
2	6	0.52
2	8	0.98
4	10	1.37
4	12	2.09
6	12	1.76

* The above two volumes must be added together to obtain one unit well volume.

[a] Assumes a porosity of 40% for filter pack.

2.4 DECONTAMINATION

The purpose of decontamination of development equipment is to prevent cross-contamination between monitoring wells. A steam-cleaner, if available, should be used to decontaminate development equipment. The equipment should be cleaned away from the monitoring well in such a fashion that decontamination effluent can be containerized.

A triple rinse decontamination procedure is acceptable for equipment such as bailers if access to a steam cleaner is not possible. See SOP III-I, *Equipment Decontamination*.

2.5 WELL DEVELOPMENT MONITORING

Throughout the well development process, a development record should be maintained in the field logbook. A well development field form presented in Attachment 1 (or similar) may be filled out in addition to the field logbook. The record should include the following information:

<u>General</u>

- Well name/number and location
- Date, time, and weather conditions

- Names of personnel involved

Development volume

- Initial and final water level
- Casing total depth and diameter
- Borehole diameter
- Casing volume, filter pack pore volume, total well volume
- Volume of water to be evacuated
- Method and rate of removal
- Appearance of water before and after development

Monitoring data for each sample point

- Date, time, elapsed time
- Cumulative gallons removed, removal method, removal rate
- Temperature, pH, specific conductance, turbidity, dissolved oxygen, and redox potential

Part of the well development procedure should consist of acquisition and analysis of general water quality parameters at periodic intervals, considering the total quantity of water to be removed and the removal rate. Depending on site conditions, the parameters specific conductance, pH, temperature, dissolved oxygen, turbidity, and redox potential may be measured. At a minimum the temperature, pH and turbidity should be monitored. Parameter measurements should be collected on a periodic basis during development. At a minimum, these parameters should be measured after removal of each well volume. The cumulative water volume of removed, the clock time, and the time elapsed during development should be recorded and a flow rate should be calculated. Development should continue until turbidity stabilizes at or below 10 nephelometric units or at least three well volumes have been removed. If three successive parameter measurements show stable values (values within 10% of each other) and turbidity is low, well development may cease. If stabilization has not been attained, if turbidity remains high, or if the well does not readily yield water, development should continue for a reasonable time as determined in the project plans or by the Project Manager.

The discussion of well development in special situations such as low yield formations is described in Section 2.7.

2.6 METHODS OF MONITORING WELL DEVELOPMENT

The methods available for the development of monitoring wells have been inherited from production well practices. Methods include (1) mechanical surging with a heavy, non-disposable bailer (stainless steel or PVC) surge block or swab, and (2) surge pumping. Development methods using air or jetting of water into the well are discouraged because of the potential for affecting water quality. In some circumstances, air or water jet development may be necessary and should be conducted under the supervision of a qualified hydrogeologist.

All development water must be containerized and appropriately labeled, unless it is permissible to discharge onsite. Development should generally utilize mechanical surging or surge pumping, followed by bailing or groundwater removal with a pump. More detailed descriptions of appropriate development methods are presented below.

2.6.1 Mechanical Surging and Bailing

For mechanical surging and bailing, a heavy bailer, surge block or swab is operated either manually or by a drill rig. The bailer, surge block, or swab should be of sufficient weight to free-fall through the water in the well and create a vigorous outward surge. The equipment lifting the tool must be strong enough to extract it rapidly. A bailer is then used to remove fine-grained sediment and groundwater from the well.

Methodologies:

1. Properly decontaminate all equipment entering well.
2. Record the static water level and the total well depth.
3. Lower the bailer, surge block or swab to top of the screened interval.
4. Operate in a pumping action with a typical stroke of approximately 3 feet.
5. Gradually work the surging downward through the screened interval during each cycle.
6. Surge for several minutes per cycle.
7. Remove surge block and attach bailer in its place.
8. Bail to remove fines loosened by surging until water appears clear.
9. Repeat the cycle of surging and bailing until turbidity is reduced and stabilization of water quality parameters occurs.
10. The surging should initially be gentle and the energy of the action should gradually increase during the development process.

The advantages (+) and disadvantages (–) of this method are listed below:

+ It reverses the direction of flow, reduces bridging between large particles; the inflow then moves the fine material into the well for withdrawal.
+ It affects the entire screened interval.
+ It effectively removes fines from the formation and the filter pack.
– It may cause upward movement of water in the filter pack that could disrupt the seal.
– Potential exists for damaging a screen with a tight-fitting surge block or with long surge strokes.

2.6.2 Surge Pumping

Methodologies:

1. Properly decontaminate all equipment entering well.
2. Record the static water level and the total well depth.

3. Lower a submersible pump or airlift pump without a check valve to a depth within 1 to 2 feet of the bottom of the screened section.
4. Start pumping and increase discharge rate causing rapid drawdown of water in the well.
5. Periodically stop and start pump, allowing the water in the drop pipe to fall back into the well and surge the formation (backwashing), thus loosening particulates.
6. The pump intake should be moved up the screened interval in increments appropriate to the total screen length.
7. At each pump position, the well should be pumped, over-pumped, and backwashed alternately until satisfactory development has been attained as demonstrated by reduction in turbidity and stabilization of water quality parameters.

The advantages (+) and disadvantages (–) of this method are listed below:

+ Reversing the direction of flow reduces bridging between large particles, and the inflow then moves the fine material into the well for withdrawal.

+ It effectively removes fines from the formation and filter pack.

– The pump position or suction line must be changed to cover the entire screen length.

– Submersible pumps suitable to perform these operations may not be available for small diameter (2 inches or less) monitoring wells.

– It is not possible to remove sediment from the well unless particle size is small enough to move through pump.

For additional information on well development, consult the references included in Section 4.0 of this SOP.

2.7 SPECIAL SITUATIONS

2.7.1 Development of Low Yield Wells

Development procedures for monitoring wells in low-yield (<0.25 gpm) water-bearing zones are somewhat limited. Due to the low hydraulic conductivity of the materials, surging of water in and out of the well casing is difficult. Also, when the well is pumped, the entry rate of water is inadequate to remove fines from the well bore and the gravel pack. Additionally, the process may be lengthy because the well can be easily pumped dry and the water level will be very slow to recover.

The procedures for mechanical surging and bailing should be followed for low yield wells. During surging and bailing, wells in low yield formations should be drawn down to total depth twice if possible. Development can be terminated, however, if the well does not exhibit 80% recovery after 2 hours have passed.

3.0 DOCUMENTATION

Well development information should be documented in field logbooks in accordance with SOP III-D, *Logbooks* using indelible ink. In addition, well development monitoring forms (Attachment I-C-2-1 or similar) may be filled out in addition to the field logbook documentation. Copies of this information should be sent to the Project Manager and to the project files.

4.0 REFERENCES

Driscoll, F.G. 1987. Ground Water and Wells. Published by Johnson Division, St. Paul, Minnesota.

USEPA. 1992. RCRA, Ground Water Monitoring Technical Enforcement Guidance Document. U.S. Environmental Protection Agency/530/R-93/001. November.

U.S. EPA Environmental Response Team. 1988. Response Engineering and Analytical Contract Standard Operating Procedures. U.S. EPA, Research Triangle Park, NC.

SOP III-I, *Equipment Decontamination*

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

Attachment I-C-2-1	Well Development Record

Attachment 1-C-2-1
Well Development Record

WELL DEVELOPMENT LOG

PROJECT	WELL NO.

JOB NO.	SITE	PREPARED BY

METHOD
OVERPUMPAGE __________
BAILER __________

SURGE
BLOCK __________
AIR LIFT __________
OTHER __________

INITIAL WATER LEVEL __________
FINAL WATER LEVEL __________

REMARKS:

CAPACITY OF CASING
(GALLONS/LINEAR FOOT)

2” = 0.16
4” = 0.65
6” = 1.47

VOLUME BETWEEN CASING AND HOLE
(GALLONS/LINEAR FOOT)
(ASSUMING 40% POROSITY)
2” CASING AND 6” HOLE - 0.52
2” CASING AND 8” HOLE - 0.98
4” CASING AND 10” HOLE = 1.37
4” CASING AND 12” HOLE - 2.09

Hole Diameter d_h =_____

Well Casing:

Inside Diameter d_wID =_____

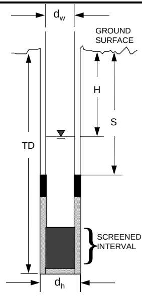
Outside Diameter d_wOD =_____

Depth to Water: H =_____

Depth to Base of Seal: S =_____

Depth to Base of Well: TD =_____

Estimated Filter Pack Porosity: P =_____



WELL VOLUME CALCULATION :

$$\text{CASING VOLUME} = V_c = \Pi\left(\frac{d_w\text{ID}}{2}\right)^2(\text{TD} - \text{H}) = 3.14\left(\frac{\_\_\_\_}{2}\right)^2(\_\_\_\_ - \_\_\_\_) = \_\_\_\_\_\_$$

$$\text{FILTER PACK PORE VOLUME} = V_f = \Pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_w\text{OD}}{2}\right)^2\right](\text{TD} - (\text{S or H}^*)(\text{P}) = \_\_\_\_\_\_$$

$$(^*\text{if S} > \text{H, use S; if S} < \text{H, use H})$$

$$= 3.14\left[\left(\frac{\_\_\_\_}{2}\right)^2 - \left(\frac{\_\_\_\_}{2}\right)^2\right](\_\_\_\_ - \_\_\_\_)(\_\_\_\_) = \_\_\_\_\_\_$$

$$\text{TOTAL WELL VOLUME} = \text{VT} = \text{Vc} + \text{Vf} = \_\_\_\_ + \_\_\_\_ = \_\_\_\_\_\_ \text{ ft.}^3 \times 7.48 = \_\_\_\_\_\_ \text{ gal.}$$

DEVELOPMENT LOG:					CUMULATIVE WATER REMOVED	WATER QUALITY						COMMENTS
DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	GALLONS	pH	TEMP	CONDUC-TIVITY	D.O.*	REDOX	TURBID-ITY	

* = Dissolved Oxygen

LOW-FLOW GROUNDWATER PURGING AND SAMPLING

1.0 PURPOSE

This standard operating procedure (SOP) describes the conventional monitoring well sampling procedures to be used by all U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) personnel and contractors. Conventional monitoring well sampling procedures are provided in SOP I-C-4, *Groundwater Sampling from Temporary Wells (Piezometers)*.

2.0 PROCEDURE

2.1 PURPOSE

This procedure establishes the method for sampling groundwater monitoring wells for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples with as little alteration of water chemistry as possible.

2.2 PREPARATION

2.2.1 Site Background Information

A thorough understanding of the purposes of the sampling event should be established prior to commencing field activities. A review of available data obtained from the site and pertinent to the water sampling should also be conducted. Copies of well logs or summary tables regarding well construction information should be available on-site if possible.

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that may 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.

It is highly recommended that the field sampling team is familiar with the U.S. EPA recommended protocols for low-flow sampling outlined in the April 1996 Ground Water Issue *Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures* (U.S. EPA 1996).

2.2.2 Groundwater Analysis Selection

The requisite field and laboratory analyses should be established prior to performing water sampling. The types and numbers of quality assurance/quality control (QA/QC) samples to be collected (refer to SOP III-B, *Field QC Samples (Water, Soil)*) should be specified in the QA plan developed for the site.

2.3 GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling procedures at a site should include: (1) measurement of depth to groundwater and total depth, (2) assessment of the presence or absence of an immiscible phase (if required by the project plan), (3) assessment of purge parameter stabilization, (4) purging of static water within the well and well bore, and (5) 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.

2.3.1 Measurement of Static Water Level Elevation

The depth to water and the total depth of the well should be measured 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). Dependent upon individual project requirements, synoptic water level collection may be required prior to groundwater sampling activities. In the event that synoptic water levels **are not** collected prior to sampling activities, total depth measurements should be collected **after** purging and sampling activities to prevent the suspension of fine-grained sediment that may be present at the bottom of the well. Each well should be marked with a permanent, easily identified reference point for water level measurements whose location and elevation have been surveyed.

An electronic water level meter accurate to 0.01 foot should be used to measure the water level surface and depth of the well. 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.

2.3.2 Decontamination of Equipment

Each piece of non-dedicated equipment should be decontaminated prior to entering the well. Decontamination should also be conducted prior to the start of sampling at a site, even if the equipment is known to be decontaminated subsequent to its last usage. This precaution is taken to minimize the potential for cross-contamination. In addition, each piece of equipment used at the site should be decontaminated prior to leaving the site. Dedicated sampling equipment need only be decontaminated prior to installation within the well. Clean sampling equipment should not be placed 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 onsite decontamination.

Further details are presented in SOP III-I, *Equipment Decontamination*.

2.3.3 Detection of Immiscible Phase Layers

Unless specified in the project plans, groundwater samples should not be collected from wells with detectable amounts of LNAPL and DNAPL.

2.3.4 Purging Equipment and Use

To help minimize the potential for cross-contamination, well sampling should proceed from the least contaminated to the most contaminated. This order may be changed in the field if conditions warrant, particularly if dedicated sampling equipment is used. If decontamination of tubing is required by the project, Teflon® tubing is recommended. All groundwater removed from potentially contaminated wells should be handled in accordance with the investigation-derived waste (IDW) handling procedures described in SOP I-A-7, *IDW Management*.

Purging should be accomplished by removing groundwater from the well at low flow rates using a pump. According to the U.S. EPA (1996), the rate at which groundwater is removed from the well during purging ideally should be between than 0.1 to 0.5 L/min. The pump intake should be placed in the middle of the calculated saturated screened interval. The purge rate should be low enough that substantial drawdown (>0.3 foot) in the well does not occur during purging. If a stabilized drawdown in the well can't be achieved and the water level is approaching the top of the screened interval, reduce the flow rate or turn the pump off (for 15 minutes) and allow for recovery. It should be noted whether or not the pump has a check valve. A check valve is required if the pump is shut off. ***Under no circumstances should the well be pumped dry or otherwise over-purged***. Begin pumping at a lower flow rate, if the water draws down to the top of the screened interval again turn pump off and allow for recovery. If two tubing volumes (including the volume of water in the pump and flow cell) have been removed during purging then sampling can proceed next time the pump is turned on. This information should be noted in the field notebook or groundwater sampling log with a recommendation for a different purging and sampling procedure (USEPA, 2012).

Water level measurements should be collected to assess the water level effects of purging. A low purge rate also will reduce the possibility of stripping VOCs from the water, and will reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

Water quality parameters should be collected and recorded on a regular basis (every 3-5 minutes) during well evacuation. Field parameters to be collected may include temperature, pH, specific conductance, salinity, dissolved oxygen, Redox potential, and turbidity. At least seven readings should be taken during the purging process unless the field parameters stabilize more quickly. These parameters are measured to demonstrate that the formation water, not stale well casing water, is being evacuated. Purging should be considered complete when the high and low values between three consecutive field parameter measurements stabilize within 10%. Turbidity may be considered stable if values are less than 10 nephelometric turbidity units (NTUs). The criterion for temperature may not be applicable if a submersible pump is used during purging due to the heating of the water by the pump motor. Field personnel should refer to the project-specific Sampling and Analysis Plan (SAP) for specific measurement requirements and well stabilization criteria.

All information obtained during the purging and sampling process should be entered into the field logbook. In addition to the field logbook, the data may be logged on a groundwater sampling log (Figure I-C-5-1 or equivalent). In special situations where LNAPL has been detected in the monitoring well and a groundwater sample is determined to be necessary by the Project Manager, a stilling tube should be inserted into the well prior to well purging. The stilling tube should be composed of a material that meets the performance guidelines for sampling devices. The stilling tube should be inserted into the well to a depth that allows groundwater from the screened interval to be purged and sampled. The bottom of the tube should be set below the upper portion of the screened interval where the LNAPL is entering the well screen. The goal is to sample the aqueous phase (groundwater) while preventing the LNAPL from entering the sampling device. To achieve this goal, the stilling tube must be inserted into the well in a manner that prevents the LNAPL from entering the stilling tube.

One method of doing this is to cover the end of the stilling tube with a membrane or material that will be ruptured by the weight of the pump. A piece of aluminum foil can be placed over the end of the stilling tube. The stilling tube is lowered slowly into the well to the appropriate depth and then attached firmly to the top of the well casing. When the pump is inserted, the weight of the pump breaks the foil covering the end of the tube, and the well can be purged and sampled from below the LNAPL layer. The membrane or material that is used to cover the end of the stilling tube must be fastened firmly so that it remains attached to the stilling tube when ruptured. Moreover, the membrane or material must retain its integrity after it is ruptured. Pieces of the membrane or material must not fall off of the stilling tube into the well. Although aluminum foil is mentioned in this discussion as an example of a material that can be used to cover the end of the tube, a more chemically inert material may be required, based on the site-specific situation. Stilling tubes should be thoroughly decontaminated prior to each use. Groundwater removed during purging should be collected and stored onsite until its disposition is determined based upon laboratory analytical results. Storage should be in secured containers such as DOT-approved drums. Containers of purge water should be labeled with NAVFAC NW approved labels or paint pens.

2.3.5 Groundwater Sampling Methodology

The well should be sampled when groundwater within it is representative of aquifer conditions and after it has recovered sufficiently to provide enough volume for the groundwater sampling parameters. A period of no more than 2 hours should elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. The water level should be measured and recorded prior to sampling to demonstrate the degree of recovery of the well. Sampling equipment should never be dropped into the well, because this could cause aeration of the water upon impact. In addition, the sampling methodology utilized should 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.

2.3.6 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable; therefore, samples must be preserved. The U.S. Environmental Protection Agency document entitled *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods (SW-846)* (U.S. EPA 1995), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 specifies the sample containers that should be used for each constituent or common set of parameters. In general, check with specific laboratory 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 team may add preservatives in the field.

Improper sample handling may alter the analytical results of the sample. Samples should be transferred 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 Quality Assurance Project Plan.

When sampling for VOCs, water samples should be collected in vials or containers specifically designed to prevent loss of VOCs from the sample. An analytical laboratory should provide these vials, preferably by the laboratory that will perform the analysis. Groundwater from the sampling device should be collected in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment should not touch the interior of the vial. The vial should be filled above the top of the vial to form a positive meniscus with no overflow. No headspace should be present in the sample container once the container has been capped. The sample can be checked for headspace by inverting the sample bottle 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 is aerated or naturally carbonated. In these cases, the investigator should note the problem to account for possible error. Field logs and laboratory analysis reports should note any headspace in the sample container(s) at the time of receipt by the laboratory, as well as at the time the sample was first transferred to the sample container at the wellhead.

2.3.6.1 Special Handling Considerations

Samples requiring analysis for organics should not be filtered. Samples should 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.

Groundwater samples to be analyzed for total and dissolved metals should be obtained sequentially. The sample to be analyzed for total metals, should be obtained directly from the pump and be unfiltered. The second sample should be filtered through a 0.45-micron membrane in-line filter and transferred to a container to be analyzed for dissolved metals. Allow at least 500 ml of effluent to flow through the filter prior to sampling. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and adsorption of ions onto the particles.

2.3.6.2 Field Sampling Preservation

Samples should be preserved immediately upon collection. Ideally, sample jars contain preservatives of known concentration and volume during the initial filling of the jar to a predetermined final sample volume. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 ml of 1:1 nitric acid added to 500 ml of groundwater will produce a pH less than 2.0. 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. It should be noted that introduction of preservatives will dilute samples, and may require normalization of results. Guidance for the preservation of environmental samples can be found in the EPA "Handbook for Sampling and Sample Preservation of Water and Wastewater:" (U.S. EPA 1982).

3.0 DOCUMENTATION

Information collected during groundwater sampling should be documented in the field logbook in accordance with SOP III-D, *Logbooks*. In addition, groundwater sampling purge logs may be (Figure I-C-5-1 or equivalent) may be filled out in addition to the field logbook. Copies of this information should be sent to the Project Manager and to the project files.

A groundwater sampling log should be documented in the field logbook and contain the following information:

- Identification of well
- Well depth
- Static water level depth
- Presence of immiscible layers
- Purge volume and pumping rate
- Time that the well was purged
- Collection method for immiscible layers
- Sample IDs
- Well evacuation procedure/equipment
- Date and time of collection
- Parameters requested for analysis
- Field analysis data

- Field observations on sampling event
- Name of collector

Figure 1-C-5-1
Groundwater Sampling Log

Project Number: ________________________ Date: ________________________

Location: ________________________ Time: ________________________

Well Number: ________________________ Climatic Conditions: ________________________

Initial Measurements:	Static Water Level:	____________	
	Total Depth:	____________	
Well Purging:	Length of Saturated Zone:	____________	linear feet
	Volume of Water to be Evacuated:	____________	gals./linear ft. x
	Linear feet of Saturation x Casing Volumes* =	____________	gallons
	Method of Removal:	____________	
	Pumping Rate:	____________	gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	SP. COND.	D.O.	REDOX	TURBIDITY

Sample Withdrawal Method: ________________________

Appearance of Sample:
- Color ________________________
- Turbidity ________________________
- Sediment ________________________
- Other ________________________

Laboratory Analysis Parameters and Preservatives: ________________________

Number and Types of Sample Containers Used: ________________________

Sample ID(s): ________________________

Decontamination Procedures: ________________________

Notes: ________________________

Sampled by: ________________________
Samples delivered to: ________________________
Date/Time: ________________________
Transporters: ________________________

* Capacity of casing (gallons/linear foot): 2”-0.16, 4”-0.65, 6”-1.47, 8”-2.61, 10”-4.08, 12”-5.87

4.0 REFERENCES

SOP I-A-7, IDW Management

SOP *-C-4, *Groundwater Sampling from Temporary Wells (Piezometers)*

SOP III-I, Equipment Decontamination

SOP III-B, Field QC Samples

SOP III-D, Logbooks

U.S. EPA. 1982. Handbook for Sampling and Sample Preservation of Water and Wastewater. EPA-600/4-82-029. September 1982.

U.S. EPA. 1986. RCRA Ground-Water Monitoring Technical Enforcement Guidance Document.

U.S. EPA. 1996. Ground Water Issue, Low-flow (Minimal Drawdown) Groundwater Sampling Procedures. EPA/540/S-95/504. April 1996

U.S. EPA. 1995 and as revised. Test Methods for Evaluating Solid Waste–Physical/Chemical Methods (SW-846). January 1995.

U.S. EPA. 2012. Standard Operating Procedure Low-Stress (Low Flow) / Minimal Drawdown Ground-Water Sample Collection, USEPA, Region 9, Management and Technical Services Division, April 2012.

5.0 ATTACHMENTS

None.

AQUIFER TESTS

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish standard methods by which U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) personnel and contractors should conduct aquifer tests.

2.0 PROCEDURES

2.1 CONSTANT DISCHARGE AQUIFER PUMPING TESTS

Constant discharge pumping tests are commonly performed at hazardous waste sites to estimate the hydraulic conductivity, transmissivity, specific yield, and/or storativity of an aquifer. These data assist in analyzing contaminant fate and transport and site remediation options. A wide variety of aquifer test methods and aquifer conditions (e.g., confined, unconfined, leaky, etc.) exist and each test must consider both the goals of the test and site conditions.

Pumping tests that are properly designed and implemented can evaluate well efficiency and detect hydraulic boundaries, vertical leakage, or delayed yield effects, and allow assessment of hydraulic conductivity and storativity.

The proper design and implementation of a pumping test requires knowledge of the hydrogeologic setting. Information required prior to the design of the test includes:

- Objectives of the pumping test.
- Location of observation and pumping wells.
- Climatic conditions.
- Screened intervals of all wells to be used in the test.
- Installation and completion methods for wells ("As-built").
- Generalized hydrogeologic conditions.
- Regional ground-water flow direction.
- Boundary conditions.
- Existence of improperly completed or developed wells.
- Presence of pumping or irrigation.
- Potential for the capture of insoluble or dissolved contaminants.

- Hydraulic conductivity estimate for aquifer.
- Discharge flow rate estimated for test.
- Presence and location of confining layers.
- Potential well water disposal problems.
- Potential for tidal effects.
- Previous sampling results and development records.

The pumping test interpretation method is based upon an analytical solution that considers well and site conditions. The hydraulic response of the aquifer is compared to a theoretical analytical response. Different analytical solutions exist for unconfined and confined aquifers, each taking into account assumptions about test and aquifer conditions. It is important to document the assumptions applied to the interpretation of a particular test. It is beyond the scope of this procedure to provide a detailed explanation of aquifer testing analytical solutions. Several texts that address pumping test theory are included in Section 4.0, References.

Constant discharge pumping tests provide results that are more representative of aquifer characteristics than those provided by slug tests; however, pumping tests require greater effort and expense. In general, slug testing should be used only in situations where hydraulic conductivity is sufficiently low to preclude a pumping testing.

2.1.1 Interferences and Potential Problems

The conditions that exist at a site during the performance of a pumping test are often far from ideal. Hydrogeologic factors that may be encountered at a site include:

- Localized or regional pumping
- Barometric effects
- Tidal effects
- Aquifer compression (e.g., trains, traffic, ground shaking from seismic events)
- Boundary effects
- Recharge effects
- Leakage from underlying or overlying aquifers.
- Heterogeneous and anisotropic aquifers.

Many of these potential complications may be detected during the pre-test period, or anticipated from an examination of existing hydrogeological data.

Information about the location, completion, and development of the pumping and observation wells may be useful in evaluating potential complications. Complicating factors may include:

- Partially penetrating wells.
- Improperly completed or developed wells.

- Low-permeability conditions that may lead to well-bore storage effects, well dewatering, or slow responding observations wells.
- Wells completed within aquitards, possibly designed to evaluate the pressure response and leakage into adjacent aquifers.
- Potential skin effects caused by well bore conditions.

2.1.2 Pumping Test Planning

Prior to implementation of the pumping test, the following should be considered:

1. Monitoring pre-test and post-test water levels (preferably for at least 3 days). Groundwater systems are rarely static and localized conditions such as nearby pumping wells, tidal effects, barometric effects, variable recharge conditions, and other "non-ideal" conditions are likely to be present at a site.
2. The performance of a long-term, constant discharge, pumping test should consider the volume of water that will be generated during the test, storage, treatment, characterization, and disposal methods for the water generated during the test (SOP I-A-7, IDW Management). If free product is present within the vicinity of the pumping well, an oil/water separator shall be included as part of the groundwater treatment process. Permits may be required for any onsite discharge of water.
3. Observation well design, location and installation.
4. Use of subcontractors for installing and operating pumping equipment during constant discharge pumping tests.
5. Selection of pumping equipment.
6. Pump placement in well.
7. Staff scheduling, security and safety during overnight aquifer testing.
8. Traffic control and protection of pipes and cables that cross traffic flow paths.
9. Equipment decontamination (SOP III-I, *Equipment Decontamination*). Select a well containing uncontaminated groundwater for pump testing.

2.1.3 Field Procedures

2.1.3.1 Preparation

1. Review the site work plan, and become familiar with information about the wells to be tested, e.g., depth to water, well depth, aquifer hydraulic conductivity, distances between pumping and observation wells, and anticipated drawdown.
2. Check out the operation of all field equipment. Unless other methods are approved by the Technical Director/QA Program Manager, an electronic data logger shall be used for all aquifer testing. Ensure that the electronic data logger is fully charged. Calibrate the electronic data logger and transducers at measured depths in a container of water. Always bring additional transducers in case of malfunctions. Calibrate the flow meter at several known discharge rates.

Ensure that the calibration is linear in the anticipated test range. Have pH and conductivity meters onsite to assess water quality periodically during the pumping test.

3. Assemble a sufficient number of field pumping test forms.
4. Ensure that the pumping well has been properly developed prior to testing.
5. If a flow meter is not operating properly, calibrate an orifice weir, bucket, or other type of water measuring device to accurately measure and monitor discharge from the pumping well.
6. Have sufficient lengths of pipe on hand to transport the discharge from the pumping well to a holding tank or to a discharge point well beyond the influence of the expected cone of depression.
7. Install a flow-control valve on the discharge pipe to control the pumping rate. Ball, gate, and butterfly valves should not be used for flow control. Preferred valves for flow control are globe, diaphragm, or knife-blade with V-notch. The type of valve selected for flow control should be appropriate for the expected flow rate.
8. Install an outlet at the wellhead to obtain water quality samples during the pumping test.
9. Install a check valve on the pump so water cannot flow back into the well after the pump is shut off.
10. Install transducers in wells, making sure to secure them firmly at the wellhead and allow sufficient depth for drawdown (generally 5 to 10 feet below the water surface in the well). Measure the depth to the transducer and ensure that the transducer is not placed at a depth below the water surface beyond its range (this will ruin the transducer).
11. Arrange for treatment, special storage and handling, or a discharge permit before mobilization.

Pre-test water levels at the test site shall be monitored for at least 3 days prior to performance of the test. A continuous-recording device is recommended. The pre-test data allows researchers to make a determination of the barometric efficiency of the aquifer. When compared to barometric readings at the site, the pre-test data also helps assess experiencing variations in head with time due to tidal influences or recharge or pumping in the nearby area.

If barometric pressure is found to significantly affect water levels in the aquifer, then changes in barometric pressure should be recorded during the test (preferably using an onsite barometer) in order to correct water levels for fluctuations that may occur because of changing atmospheric conditions. Trends in pre-test water levels can then be projected for the duration of the test. Correcting water levels during the test produce results that are representative of the hydraulic response of the aquifer caused by pumping of the test well in the absence of atmospheric pressure changes.

The influence of ocean tides or localized pumping can mask the water level response to the pumping test. Water levels can be corrected for the effect of ocean tides by adding or subtracting values of tidal fluctuation from the response of the pumping. Pumping test data can be corrected for the effect of localized pumping if the pumping response prior to the test is known and predictable over the duration of the drawdown and recovery phases of the test. Non-rhythmic and "unique" water-level fluctuations may be difficult to resolve and substantial hydrologic judgment is required to properly interpret the data.

2.1.3.2 Step Drawdown Test

Prior to initiating a constant-discharge pumping test, a step drawdown test shall be conducted. The purpose of the step drawdown test is to estimate the greatest flow rate that may be sustained during a constant-discharge test. The step drawdown test is typically conducted over a 4- to 8-hour period prior to commencing the constant discharge test.

To correctly assess the maximum yield of the well, the well must be pumped at discharge rates varying from relatively low to the maximum rate that the well can produce. The discharge increments for each step shall be distributed as evenly as possible through the range of well yields. Four steps should be utilized for the test. Each step shall last approximately 2 hours depending on the response of water levels to pumping. Water level recovery following the test shall be measured for approximately 8 hours.

Water levels shall be measured periodically during the step test within the pumping well and within observation wells that may be used during the constant discharge test. For each step increment, levels within the pumping well shall be measured on the same time basis as that used for the beginning of the constant discharge test (i.e., approximately on a logarithmic basis, see Section 2.1.3.3). Observation wells may be measured using a longer time scale because the primary reason for measurement is to assess whether the aquifer responds to pumpage rather than to gather data for quantitative analysis. Water levels shall also be measured during the recovery phase of the step test.

Prior to initiating the constant discharge test, the data from the step drawdown test shall be analyzed to identify the appropriate discharge rate for the long-term test. The generated drawdown versus time data shall be plotted on a semi-logarithmic graph and the sustainable discharge rate shall be determined from this graph by projecting the straight line formed by each data set for each step increment to the longer pumping times associated with the constant discharge test. Based on the projected drawdowns associated with these longer time periods and the amount of drawdown available in the pumping well, the optimum pumping rate can be determined. The step drawdown data can also be evaluated more quantitatively using methods described by Birsoy and Summers (1980) and Lohman (1982).

2.1.3.3 Constant-Discharge Pumping Test

<u>Time Intervals</u>

After the pumping well has fully recovered from the step drawdown test, the constant-discharge pumping test may begin (typically 24 hours after step drawdown testing). At the beginning of the test, the discharge rate shall be set as quickly and accurately as possible. The water levels in the pumping well and observation wells shall be recorded using a data logger according to the following schedules (or an equivalent approximately logarithmic schedule):

Table I-C-7-1
Pumping Well Measurements

Elapsed Time Since Start of Test (Minutes)	Intervals Between Measurements (Minutes)
0-10	.5-1
10-15	1
15-60	5
60-300	30
300-1440	60
1440-termination	480

Note: Similar time intervals shall be used during water level recovery, with short time intervals at the start of recovery.

Table I-C-7-2
Observation Well Measurements

Elapsed Time Since Start or Stop of Test (Minutes)	Intervals Between Measurements (Minutes)
0-60	2
60-120	5
120-240	10
240-360	30
360-1440	60
1440-termination	480

Available data logger measurement schedules vary by data logger manufacturer. During the early part of the test, at least one person shall be stationed at the pumping well and at least one other shall handle other pump test logistics. Readings at the wells need not be taken simultaneously. It is very important that depth to water readings be measured accurately and readings be recorded at the exact time measured. Pressure transducers and electronic data loggers must be used to record water levels in the pumping well and nearby observation wells. Manual checks of the depth to water shall be performed to verify the pressure transducer measurements. In some instances, the pressure transducer may be unstable and "drifting" may occur.

During a pumping test, the following data must be recorded on the aquifer test data form (Attachment I-C-7-1):

1. Site identification - CTO/DO number, site name, well identification number, and indication as to whether the well is an observation or pumping well.

2. Location – A description of the location of the well in which water level measurements are being taken.
3. Distance from Pumping Well - Distance the observation well is from the pumping well in feet.
4. Personnel - The company and individual conducting the pump test.
5. Test Start Date - The date when the pumping test began.
6. Test Start Time - Time, using 24-hour clock, when the pumping test began (e.g., 10:30 hours for 10:30 a.m., and 13:50 hours for 1:50 p.m.).
7. Test End Date - Same as number 5, except for the test end.
8. Test End Time - Same as number 6, except for test end.
9. Depth to water in feet and to an accuracy of 0.01 feet, in the pumping well at the beginning of the pump test and at specified intervals throughout the test.
10. Depth to water in feet and to an accuracy of 0.01 feet, in the observation well at the beginning of the pump test at specified intervals throughout the test.
11. Depth of pressure transducers.
12. Pumping Rate - Flow rate of pump measured from an orifice weir, flow meter, container, or other type of water measuring device in gallons per minute at specified intervals throughout the test.
13. Average Pumping Rate - Summation of all entries recorded in the pumping rate (gal/min) column divided by the total number of pumping rate readings.
14. Measurement Methods - Type of instrument used to measure depth-to-water (this may include steel tape, electric sounding probes, Stevens recorders, or pressure transducers).
15. Comments - Appropriate observations or information including notes on sampling
16. Measurement time – Time using a 24hour clock, at which each field measurement was taken.
17. Elapsed Time - Time elapsed since the start of pumping in minutes, calculated for each measurement from test start time and measurement time.

Water Chemistry Measurements

During the pumping test, portable field-grade water testing equipment should be used to measure general water chemistry parameters at periodic intervals. The parameters measured should include at a minimum pH, electrical conductivity, and temperature of the water. These parameters are used to qualitatively evaluate aquifer conditions. Water testing equipment shall be recalibrated during the pump test on a predetermined schedule with known calibration standards.

Test Duration

The duration of the test depends on the properties of the aquifer that the project seeks to characterize. The duration may be determined by plotting the drawdown data on both log-log and semi-log graphs, and performing a preliminarily evaluation during the pump test. Doing this allows possible identification of recharge boundaries or permeability barriers that might be further evaluated with a longer pump test.

Optimally, flow conditions should approach steady state where the observed drawdowns reach near-constant values prior to terminating the test.

The minimum time necessary for the test is indicated on the semi-log graph when the log-time versus drawdown for the most distant observation well plots as a straight line (assuming $u < 0.01$) (Cooper et. al. 1946). Longer tests tend to produce more reliable results. Longer tests are usually necessary for unconfined aquifers to allow evaluation of delayed yield effects. A pumping duration of 24 to 72 hours is desirable, followed by a similar period of monitoring the recovery of the water level.

Knowledge of the local hydrogeology, combined with a clear understanding of the overall project objectives should be considered in selecting duration of the test and the effect of boundary conditions. There is little need to continue the test once the increase in drawdown in all observation wells becomes insignificantly small. However, delayed yield effects and boundary effects may be observed with continued pumping.

Recovery

Once the pump has been shut down, the recovering water levels shall be recorded in the same manner and using the same time intervals as were used during the beginning of the constant discharge test (i.e., at approximately logarithmic time intervals). Recovery shall be monitored for a period corresponding to the length of the pumping portion of the test or when water levels have recovered to 95% of their original level. Any tidal and barometric monitoring shall be continued during the recovery portion of the test.

2.1.3.4 Post Operation

The following activities shall be performed after completion of water level recovery measurements:

1. Decontaminate and/or dispose of equipment as listed in SOP III-I, *Equipment Decontamination*.
2. For the electronic data logger, use the following procedures:
    a) Stop logging sequence.
    b) Print data, or
    c) Save memory at the end of the day's activities.
3. Replace testing equipment in storage containers.
4. Check sampling equipment and supplies. Repair or replace all broken or damaged equipment.
5. Replace expendable items.
6. Review field forms for completeness.
7. Interpret slug or aquifer test field results with Project Hydrogeologist and/or CTO/DO Manager. Analyze data using an appropriate analytical solution.

2.1.4 Pumping Test Interpretation

There are several accepted methods for determining aquifer properties such as transmissivity, storativity, and hydraulic conductivity. Kruseman and de Ridder (1990) and Freeze and Cherry (1979) present methods of interpretation. However, the appropriate method depends on the characteristics of the aquifer being tested (e.g., confined, unconfined, leaky confining layer). When reviewing pumping test data, both log-log and semi-log plots of drawdown with time shall be generated. However, log-log plots cannot be used for quantitative analysis of data obtained from the pumping well.

The interpretation of pumping test data attempts to match or duplicate the observed field response with a theoretical water level response to pumping. Aquifer parameters can be estimated on the basis of such a match, using commercially available software such as AQTESOLV©.

Ranges of aquifer parameter values are likely to occur at a site. For example, hydraulic conductivities are typically lognormally distributed. The estimate of the values may vary with the interpretation method. It is important to verify that the assumptions used to derive a particular method of solution are reasonable in view of the test conditions. For example, for a confined aquifer, storativity values should be less than 0.005.

2.1.5 Quality Assurance/Quality Control

All gauges, transducers, flowmeters, etc., used in conducting pumping tests shall be calibrated before and after use at the site. Copies of the documentation of instrumentation calibration should be obtained and filed with the test data records. The calibration records shall consist of laboratory measurements and, if necessary, any onsite zero adjustment and/or calibration performed. All flow and measurement meters should be checked onsite using a container of measured volume and a stopwatch. The accuracy of the meters must be verified before testing proceeds. The water levels measured by a pressure transducer-based data logger must also be verified by manual measurements before and after testing.

2.2 SLUG TESTS

2.2.1 Scope and Application

A common procedure for single-well hydraulic testing is a slug test. A slug test is restricted in application because it is a measure of the well and near-well hydrogeologic conditions only. The results of the test provide an order of magnitude estimate of the horizontal hydraulic conductivity of the aquifer, and are most useful in low-permeability materials. Storativity cannot be determined very accurately using this method.

2.2.2 Method Summary

A slug test involves the instantaneous injection or withdrawal of a mass (slug) of water or object displacing a known volume of water into or from a well and measuring the induced water level fluctuation.

The primary advantages of using slug tests to estimate hydraulic conductivities are that (1) estimates can be made *in situ*, thereby avoiding errors incurred in laboratory testing of disturbed soil samples; (2) tests can be performed quickly at relatively low cost because only one observation well is required; and (3) the hydraulic conductivity of small discrete portions of an aquifer can be estimated (e.g., sand layers in a clay). Estimates of storativity or specific storage cannot be reliably established from slug tests. Slug tests should be used only to evaluate water-bearing zones with relatively low hydraulic conductivities. In addition, slug testing shall always be conducted with a data logger coupled to a pressure transducer.

2.2.3 Interferences and Potential Problems

The zone of investigation covered by a slug test is limited to the immediate vicinity of the well bore. Thus, interpretation of the test may be strongly influenced by the hydraulic properties of the well casing, filter pack, and borehole, and may possibly reflect variations in well development. When possible, consistent methods of well construction and development shall be used at a site to minimize the potential for variation in slug test results.

A slug test may be affected by the same interferences as constant-discharge pump tests. Refer to Section 2.1.1 for further discussion.

Water levels within a borehole will often oscillate rapidly after the introduction/withdrawal of a slug volume. This does <u>not</u> indicate a problem with performance of the slug test. If a well is screened above and below the water table, a slug injection method will tend to store water in the filter pack and yield a higher estimate of hydraulic conductivity than would be expected. In these cases, the slug withdrawal method may yield more accurate data.

2.2.4 Field Procedures

2.2.4.1 Preparation

<u>Office Procedures</u>

1. Review the Work Plan and the procedure, including well construction, development, and sampling information on the wells to be tested.
2. Review the operator's manual provided with the electronic data logger.
3. Verify the displacement volume of the slug. This may be accomplished by accurately measuring the dimensions of a solid displacement slug or by accurately measuring the volume of water discharge from a liquid slug.
4. Check out and ensure the proper operation of all field equipment. Ensure that the electronic data logger is fully charged. Test the electronic data logger using a container of water (e.g., sink, bucket of water). Additional transducers should be brought to the site in case of malfunctions.
5. Assemble a sufficient number of field forms to complete the field assignment.
6. Assemble the appropriate testing equipment.

<u>Equipment List</u>

The following equipment is needed to perform slug tests. All of the equipment shall be decontaminated and tested prior to commencing field activities.

- Tape measure (subdivided into tenths of feet)
- Water pressure transducer
- Electronic water level indicator or steel tape (subdivided into hundredths of feet)
- Electronic data logger
- Solid or liquid slug of a known volume (stainless steel, PVC, and ABS plastic are appropriate construction materials)
- Watch or stopwatch with second hand (electronic stopwatch with elapsed time function and a watch with 24 hour format are recommended).

- Semi-log graph paper
- Water proof ink pen and logbook
- Temperature/pH/electrical conductivity meter (optional)
- Appropriate references and calculator
- Electrical tape and duct tape
- Health and safety equipment as required

Data Form

The slug test data form shall be used to record observations. All entries shall be made in indelible ink. The form shall include the following data:

1. Site identification - identification number assigned to the site and the well.
2. Date - the date when the test data were collected: year, month, and day.
3. Slug Volume (ft^3) - manufacturer's specification for the known volume or displacement of the slug device.
4. Logger - the company and person responsible for performing the field measurements.
5. Test Method - either injected (dropped) or withdrawn (pulled out) from the monitoring well.
6. Comments - Observations or information for which no other blanks are provided.
7. Depth to water (ft.) - Depth of water recorded to 0.01 feet, along with time of measurement.
8. Configuration of the data logger (e.g., sample rate, duration, transducer type, etc.).

2.2.4.2 Performing the Slug Test

The following procedures should be used to collect and report slug test data. They may be modified to reflect specific site conditions:

1. Field check and test transducers and data logger prior to testing (record field check/test results in field logbook).
2. Decontaminate the transducer and cable.
3. Collect initial water level measurements from monitoring wells in the immediate vicinity of the well to be tested.
4. Before beginning a slug test, record data logger set-up information and enter it into the electronic data logger. The type of information will vary depending on the data logger model used. Consult the operator's manual for the proper data entry sequence.
5. Test wells from least to most contaminated, if possible.
6. Determine the static water level in the test well by measuring the depth to water periodically for several minutes.
7. Cover sharp edges of the well casing with duct tape to protect the transducer cables.

8. Install the transducer and cable in the well to a depth below the target drawdown estimated for the test but at least 2 feet from the bottom of the well. Be sure this depth of submergence is within the design range stamped on the transducer and appropriate for the test method (inserting or pulling slug). Temporarily tape or clamp the transducer cable to the well to keep the transducer at constant depth.
9. Connect the transducer cable to the electronic data logger.
10. Enter the initial water level and transducer specific set-up information into the data logger according to the manufacturer's instructions (the transducer information will be stamped on the side of the transducer). Compare manual and pressure transducer measurements to check that the transducer is operational and accurate. Thermal drift may occur until the transducer equilibrates with the water in a well. Record the initial water level display by the data logger.
11. "Instantaneously" introduce or remove a known volume (slug) of water to the well. The preferred test method is to introduce a solid cylinder of known volume to displace and raise the water level. Let the water level re-stabilize and remove the cylinder. It is important to remove or add the volumes as quickly as possible because the analysis assumes an "instantaneous" change in volume is created in the well.
12. At the moment of volume addition or removal (assigned time zero), measure and record the depth to water and the time using the data logger. The number of depth-time measurements necessary to complete the test is variable, and can be estimated from previous aquifer tests or based on knowledge of the site-specific geology. It is critical to make as many measurements as possible in the early part of the test.
13. Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a semi-log plot of time versus depth.
14. Retrieve the slug (if applicable) and follow appropriate decontamination procedures.

The time required for a slug test to be completed is a function of the volume of the slug, the hydraulic conductivity of the formation, and the type of well completion. The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several hours.

Precautions should be taken to ensure that the well is not contaminated by material introduced into the well. If water is added to the monitoring well, it should be from an uncontaminated source and transported in a clean container. Bailers, measuring devices, and solid slugs must be cleaned prior to the test. If tests are performed on more than one monitoring well, care must be taken to avoid cross-contamination of the wells.

Slug tests shall be conducted on relatively undisturbed wells. If a test is conducted on a well that has recently been pumped for water sampling purposes, the measured water level must be within 0.1 foot of the static water level prior to testing.

2.2.4.3 Post Operations

Decontaminate and/or dispose of equipment according to SOP III-I, *Equipment Decontamination*.

For the electronic data logger, implement the following procedure:

1. Stop logging sequence.
2. Print the data if possible.
3. Save the data and disconnect the battery (on some models of data logger) at the end of the day's activities.
4. Inventory sampling equipment and supplies. Repair or replace all broken or damaged equipment.
5. Replace expendable items.
6. Review field forms for completeness.
7. Interpret slug test field results with the Project Hydrogeologist and the CTO/DO Manager. Analyze the slug test using appropriate software packages or graphical solutions.

2.2.5 Slug Test Interpretation

The results of slug tests should be viewed as order of magnitude estimates of hydraulic conductivity and should not be performed as a substitute for constant discharge pump tests. The interpretation of the water level response usually requires a number of simplifying assumptions, and the physical properties of the well casing and filter packs are rarely included in the analysis. A limited number of test interpretation methodologies exist. The following two approaches are most commonly used:

2.2.5.1 Cooper et al. Method

A more physically-based model for the slug test was developed by the U.S. Geological Survey. It involves a curve-fitting procedure that may not always produce a unique fit and is the only method discussed herein to produce an estimate of specific storage.

2.2.5.2 Bouwer and Rice Method

This is a popular approach to the interpretation of slug test data obtained from unconfined aquifers. It is a graphical method and relatively straightforward to apply.

2.2.6 QA/QC

Similar to pumping test analysis. Refer to Section 2.1.5.

3.0 DOCUMENTATION

All data collected in the field shall be maintained onsite during field activities, and then transferred to the office project files upon completion of the aquifer test(s). Computerized data (e.g., from data loggers) shall be stored in ASCII format. The CTO/DO Manager or designee shall review all aquifer test forms upon completion of the aquifer test(s).

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5.0 ATTACHMENTS

Attachment I-C-7-1	Constant Discharge Pumping Test/Aquifer Test Data Form

Attachment I-C-7-1
Constant Discharge Pumping Test/Aquifer Test Data Form

CONSTANT DISCHARGE PUMPING TEST/AQUIFER TEST DATA FORM

PROJECT NAME: ____________________ PROJECT NUMBER: ________________ WELL NUMBER: __________________________

LOCATION: ____________________ DATE: ________________ HYDROGEOLOGIST: ______________________________________

PUMPED WELL NO. _____ DISTANCE FROM PUMPING WELL: ________ TYPE OF TEST: _______ TEST NO. ____________________

MEASURING EQUIPMENT ____________________________ TYPE AND DEPTH OF PUMP ____

Time Data Pump on: Date___Time ___ ( ) Pump off: Date___Time___ ( ) Duration of aquifer test: Pumping___Recovery____					Water Level Data Static Water Level _______________ Measuring Point_________________ Elevation of measuring point_______				Discharge Data	Water Quality Data			Comments on factors affecting test data
Date	Clock Time	Time since pump started t (min)	Time since pump stopped t (min)	V t	Depth of Water (feet)	Pressure (PSI)	Accumulated Drawdown (feet)	Corrected Drawdowns (feet)	Flow Rate (gpm)	pH	Specific Conductivity	Temp (°C)	

WATER LEVEL MEASUREMENTS

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish standard protocols for all U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) field personnel for use in making water level measurements.

2.0 PROCEDURE

2.1 EQUIPMENT

Equipment and materials used during liquid level and well-depth measurements:

- Electronic water level indicator with cable marked with 0.01-foot increments
- Electronic oil-water interface probe
- Engineers measuring tape with 0.01-foot increments may be used for water and petroleum reactive pastes as an alternative to an oil-water interface probe
- Weighted steel tape with 0.01-foot increments and chalk may be used as an alternative to a water level indicator
- Decontamination equipment
- Weatherproof, bound field logbook with numbered pages (see SOP III-D, *Logbooks*)
- Health and safety equipment appropriate for site conditions
- Keys for locked well covers
- Wire cutters if well has a security tag
- Turkey baster or hand pump in case flush-mount manhole is filled with water
- Bolt cutters for cutting “frozen” or rusted locks. HWD-40 is used to lubricate a rusted lock, but extreme care should be taken to avoid possible contamination to the well and equipment.
- Extra locks to replace cut locks

2.2 PRELIMINARY STEPS

Follow these steps prior to disturbing the liquid level in the well:

1. Locate the well and, confirm its label (if marked), and verify its position relative to other site features on the site map. Gain access to the top of the well casing.

2. Locate the permanent reference mark at the top of the well casing. This reference point shall be scribed, notched, or otherwise noted on the top of the casing. If no such marks are present, measure depth relative to the top of the highest point of the well casing and note this fact in the field logbook. Determine from the records and record the elevation of the permanent reference point and record it in the logbook.
3. Record any observations and remarks regarding the characteristics and condition of the well, such as evidence of cracked casing or surface seals, security of the well (locked cap), evidence of tampering, missing well cap, surface water entering the well casing, etc.

2.3 OPERATION

Follow these steps when taking depth to liquid level measurements in well suspected to have NAPL present.

1. Sample the air in the wellhead for gross organic vapors if required.
2. If non-aqueous phase liquid (NAPL) contamination is suspected, use an oil-water interface probe to determine the existence and thickness of the NAPL.
3. Open interface probe housing, turn probe on, and test the alarm. Ground the probe, because the slight electric charge from the probe could set off an explosion of highly flammable vapors. Slowly lower the probe into the well until the alarm sounds. A continuous alarm indicates light non-aqueous phase liquid (LNAPL), while an intermittent alarm indicates water. If LNAPL is detected, record depth of the initial (first) alarm. Mark the spot by grasping the cable with the thumb and forefingers at the top of the casing. Determine the depth to liquid relative to the permanent reference point on the well casing. Withdraw cable sufficiently to record the depth from the scale on the interface probe cable.
4. Continue to slowly lower the probe until it passes into the water phase (intermittent alarm). Slowly retract the probe until the NAPL continuous alarm sounds and record that level in the same manner as described above.
5. Record the depth to NAPL and the depth to water readings independently in the logbook. The thickness of the LNAPL can be calculated by subtracting depth to LNAPL reading from depth to water measurement.
6. Continue to slowly lower the interface probe through the water column to check for the presence of dense non-aqueous phase liquid (DNAPL) if suspected.
7. Measure and record the depths of the DNAPL layer (if any) as described above.
8. Slowly raise the interface probe, recording the depth to each interface as the probe is withdrawn. If there is a discrepancy in depths, clean the probe sensor and recheck the depth measurements.
9. Always lower and raise the interface probe slowly to minimize mixing of media.
10. Always perform a NAPL check in wells installed in areas with suspected NAPL contamination. Always perform a NAPL check if headspace test reveals presence of volatiles. Always perform a NAPL check the first time depth to liquid is measured in a well. If a well has been measured previously, with no NAPLs present, and none of the preceding conditions are met, the NAPL check may be omitted.

11. Decontaminate interface probe as appropriate.

For wells where NAPL is not suspected to be present, an electronic water level indicator or steel tape can be used as described below:

1. Remove the water level indicator probe from the case, turn on the sounder, and test the battery and sensitivity scale by pushing the test button. Adjust the sensitivity scale until you can hear the alarm.
2. Slowly lower the probe and cable into the well, allowing the cable reel to unwind. Continue lowering the probe until the alarm sounds. Very slowly raise and lower the probe until the point is reached where the meter just beeps. Mark the spot by grasping the cable with thumb and forefingers at the top of the casing. Record the depth to water relative to the permanent reference point. If no mark is present, use the highest point on the casing as a reference point. Withdraw the cable and record the depth.
3. Alternately, use a steel tape with an attached weight if the aquifer gradients are lower than 0.05 ft./ft. Due to the possibility of adding unknown contaminants from chalk colorants, only white chalk is permitted as a level indicator.
4. Rub chalk onto the end (first 1 foot) of the steel tape and slowly lower the chalked end into the well until the weighted end is below the water surface. (A small splash can be heard when the weighted end hits the water surface.)
5. Mark the spot on the tape by grasping the tape with the thumb and forefingers at the top of the casing as described in the subsection (2) above. Record this spot on the tape in the logbook as the “HOLD”. Ensure not to retract the tape from the well until after the depth measurement (HOLD) is recorded.
6. Remove the steel tape from the well. The chalk will be wet or absent where the tape was below the water surface. Locate, read, and record this length in the logbook as the “CUT”. Subtract the “CUT” length from the ”HOLD” length and record the difference in the logbook. This is the depth to water table.
7. Decontaminate water level indicator or steel tape as appropriate

2.4 PRECAUTIONS

- Depending on the device used, correction factors may be required for some measurements. For example, if the water level indicator has been shortened during its repair.
- Check instrument batteries prior to each use.
- Exercise care not to break the seals at the top of the electric water level indicator probe.
- It is important to note that when measuring total well depth (bottom of casing), using an interface probe or water level indicator, the increments of measure are ticked off from the alarm sensor on the probe. On some meters there is a portion of the probe that sticks out beyond the alarm sensor. This needs to be accounted for when reading the bottom of casing measurement (i.e., added onto the reading). A potential problem arises if it is unknown whether this has been done on previous readings or not.

3.0 DOCUMENTATION

This section describes the documentation necessary for depth to liquid and well-depth measurements. All information shall be recorded in the field logbook using indelible ink in accordance with SOP III-D, *Logbooks*. At a minimum, the following information must be recorded:

- Date
- Time
- Weather
- Field personnel
- Well location and label
- Well condition
- Monitoring equipment type and readings
- Depth to Liquid measurements obtained
- Any other observations

All entries in the field logbook must be printed in black ink and legible. The actual readings measured should be recorded directly in the logbook. If calculations are necessary to determine the depth to liquid or liquid elevation, they should be performed using direct readings documented in the logbook.

Water level measurements must also be submitted electronically using the appropriate Naval Electronic Data Deliverable (NEDD) format for loading into NIRIS as defined in the NAVFAC NW SOPs (V5.0 or more current).

4.0 REFERENCES

SOP III-D, *Logbooks*

Thornhill, Jerry T. 1989. “Accuracy of Depth to Groundwater Measurements.” In *EPA Superfund Groundwater Issue*. EPA/504/4-89/002.

5.0 ATTACHMENTS

None.

FIELD PARAMETER MEASUREMENTS

1.0 PURPOSE

This standard operating procedure (SOP) provides instructions for the calibration, use, and checking of instruments and equipment for field measurements.

2.0 PROCEDURES

2.1 WATER QUALITY MEASUREMENTS

All field water quality meters shall be calibrated daily following the manufacturers' specifications. Calibration shall be performed prior to using the instrument for collecting parameters. In addition, the meter's calibration should be checked at mid-day and the end of the day to determine if measurements have drifted from the original calibration numbers. These checks are not intended to be a recalibration of the instrument. All calibration and measurement data shall be recorded in the project logbook. Fluids used for calibration shall be changed at regular intervals to ensure its integrity. Since different fluids have different shelf lives and tolerances, manufacturers' specifications should be checked as appropriate.

Most multi-probe water quality meters utilize a flow-through cell. If the unit being used does not have a flow-through cell, a large enough vessel (i.e. polypropylene beaker) in which the probes will be submerged shall be used. The water to be measured will be pumped continuously through the beaker from the bottom, overflowing the top. The flow-through cells will usually allow for quicker stabilization of dissolved oxygen and oxidation-reduction potential readings.

Water shall be allowed to flow continuously through the cell or beaker with water quality measurements being collected at regular intervals, every three to five minutes, until stabilization of the parameters has occurred. A minimum number of seven sets of readings should be collected or as otherwise outlined in the field sampling plan. Stabilization is considered to have occurred when three consecutive readings meet the following guidelines:

pH	+ 0.2 Scientific Units
Specific Conductance	+ 3 % mS/cm
Turbidity	+ 10% or < 10 NTUs
Dissolved Oxygen	+ 10% mg/cm
Salinity	+ 10%
Oxidation-Reduction Potential	+ 10 mV
Temperature	+ 10% °C

In addition to recording the above listed parameters the following information shall also be documented: date, time of measurement, flow rates, purge volumes, total volume purged, and other relative information (i.e. odors, sheen, comments on turbidity, water color)

2.2 ORGANIC VAPORS

Various organic vapor monitors have differing requirements for equipment warm-up and operation. Ensure that all organic vapor monitors are calibrated and operated according to the manufacturer’s specification.

For measuring vapors present in soils, expose the monitor to a sample of soil by collecting a sample in sealable plastic baggy and placing the probe tip into the closed bag. In cold weather, the soil may need to be warmed prior to testing.

For measuring breathing zone vapors, hold the probe tip in the area of the breathing zone while field activities are being conducted. Take representative measurements from each different work or sampling area.

For monitoring well head space, place the probe tip just inside of the monitoring well casing immediately after removing the cap.

All readings including calibration information shall be recorded in the field logbook.

3.0 DOCUMENTATION

Record all observations and analysis in the field logbook as defined in SOP III-D, *Logbooks*. If required by the SAP, also complete the Field Measurement Data Form.

Field measurements must also be submitted electronically using the appropriate Naval Electronic Data Deliverable (NEDD) format for loading into NIRIS as defined in the NAVFAC NW SOPs (V5.0 or more current).

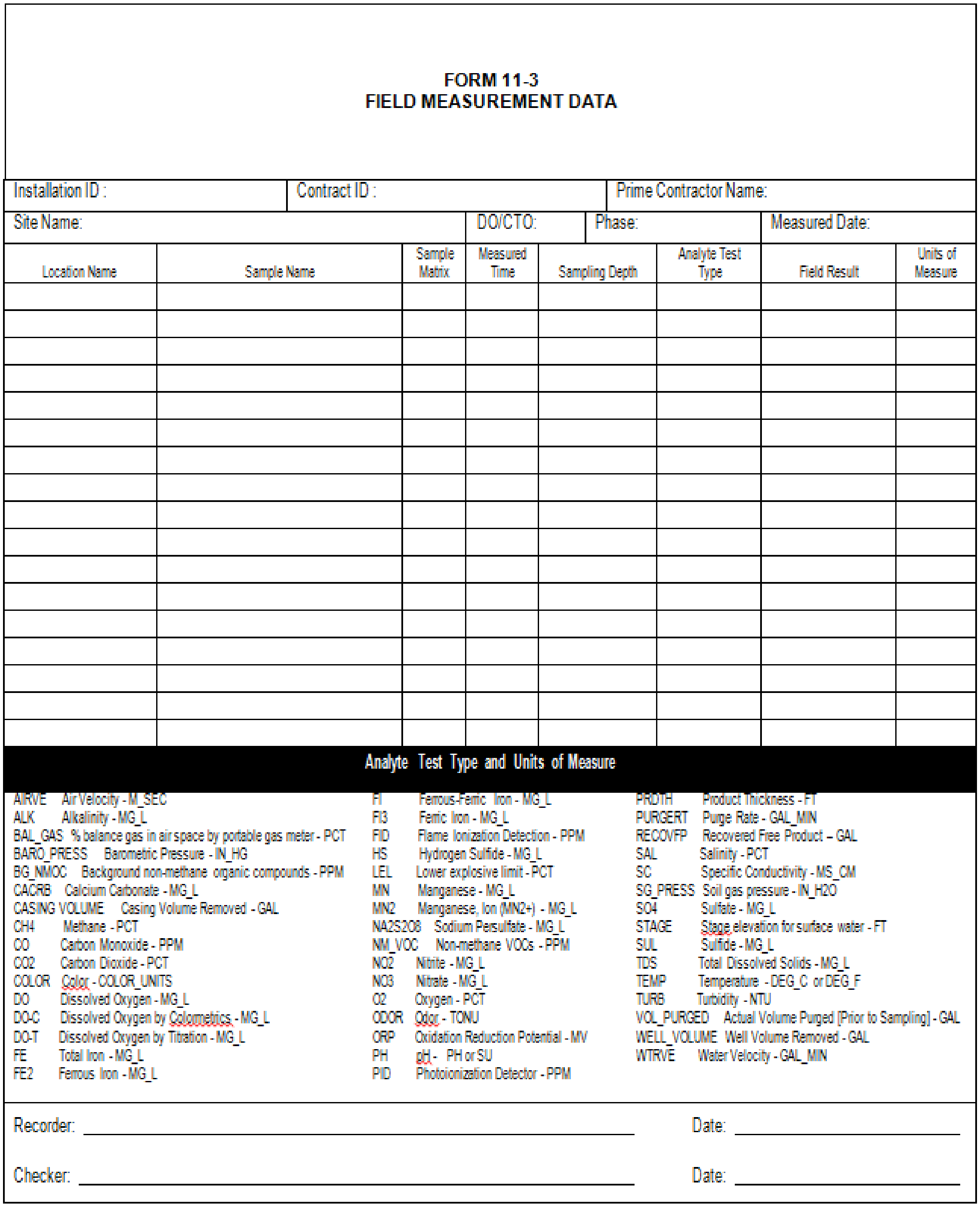
4.0 REFERENCES

ASTM International. 2003. D6771-02 Standard Practice for Low-flow Purging and Sampling Wells and Devices Used for Groundwater Quality Investigations

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

Attachment I-D-7-1 Example Field Measurement Data form



FORM 11-3
FIELD MEASUREMENT DATA

Installation ID :
Contract ID :
Prime Contractor Name:
Site Name:
DO/CTO:
Phase:
Measured Date:

Location Name	Sample Name	Sample Matrix	Measured Time	Sampling Depth	Analyte Test Type	Field Result	Units of Measure

Analyte Test Type and Units of Measure

AIRVE	Air Velocity - M_SEC
ALK	Alkalinity - MG_L
BAL_GAS	% balance gas in air space by portable gas meter - PCT
BARO_PRESS	Barometric Pressure - IN_HG
BG_NMOC	Background non-methane organic compounds - PPM
CACRB	Calcium Carbonate - MG_L
CASING VOLUME	Casing Volume Removed - GAL
CH4	Methane - PCT
CO	Carbon Monoxide - PPM
CO2	Carbon Dioxide - PCT
COLOR	Color - COLOR_UNITS
DO	Dissolved Oxygen - MG_L
DO-C	Dissolved Oxygen by Colometrics - MG_L
DO-T	Dissolved Oxygen by Titration - MG_L
FE	Total Iron - MG_L
FE2	Ferrous Iron - MG_L
FI	Ferrous-Ferric Iron - MG_L
FI3	Ferric Iron - MG_L
FID	Flame Ionization Detection - PPM
HS	Hydrogen Sulfide - MG_L
LEL	Lower explosive limit - PCT
MN	Manganese - MG_L
MN2	Manganese, Ion (MN2+) - MG_L
NA2S2O8	Sodium Persulfate - MG_L
NM_VOC	Non-methane VOCs - PPM
NO2	Nitrite - MG_L
NO3	Nitrate - MG_L
O2	Oxygen - PCT
ODOR	Odor - TONU
ORP	Oxidation Reduction Potential - MV
PH	pH - PH or SU
PID	Photoionization Detector - PPM
PRDTH	Product Thickness - FT
PURGERT	Purge Rate - GAL_MIN
RECOVFP	Recovered Free Product – GAL
SAL	Salinity - PCT
SC	Specific Conductivity - MS_CM
SG_PRESS	Soil gas pressure - IN_H2O
SO4	Sulfate - MG_L
STAGE	Stage elevation for surface water - FT
SUL	Sulfide - MG_L
TDS	Total Dissolved Solids - MG_L
TEMP	Temperature - DEG_C or DEG_F
TURB	Turbidity - NTU
VOL_PURGED	Actual Volume Purged [Prior to Sampling] - GAL
WELL_VOLUME	Well Volume Removed - GAL
WTRVE	Water Velocity - GAL_MIN

Recorder: ______________________ Date: __________

Checker: ______________________ Date: __________

SOIL AND ROCK CLASSIFICATION

1.0 PURPOSE

This section sets forth standard operating procedures (SOPs) for soil and rock classification to be used by U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) personnel and their contractors.

2.0 PROCEDURES

2.1 SOIL CLASSIFICATION

The basic purpose of the classification of soils is to thoroughly describe the physical characteristics of the sample and to classify it according to an appropriate soil classification system for the NAVFAC NW. The Unified Soil Classification System (USCS) was developed so that soils could be described on a common basis by different investigators and serves 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 soils on a common basis is essential so that soils described by different site qualified personnel are comparable. Site individuals describing soils, as part of NAVFAC NW 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 at NAVFAC NW sites.

The site geologist or other qualified individual shall describe the soil and record the description in a boring log or logbook. 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, structure, etc.
- USCS classification symbol

The USCS serves as a "shorthand" for classifying soil into 15 basic groups:

GW[1]	Well graded (poorly sorted) gravel (>50% gravel, <5% fines)
GP[1]	Poorly graded (well sorted) gravel (>50% gravel, <5% fines)
GM1	Silty gravel (>50% gravel, >15% silt)

GC1	Clayey gravel (>50% gravel, >15% clay)
SW1	Well graded (poorly sorted) sand (>50% sand, <5% fines)
SP1	Poorly graded (well sorted) sand (>50% sand, <5% fines)
SM1	Silty sand (>50% sand, >15% silt)
SC1	Clayey sand (>50% sand, >15% clay)
ML2	Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness and plasticity)
L2	Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)
MH2	Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)
CH2	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 soils

1 If percentage of fines is 5% to 15%, a dual identification shall be given (e.g., a soil with more than 50% poorly sorted gravel and 10% clay is designated GW-GC.

2 If the soil is estimated to have 15% to 25% 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% or more sand or gravel, or both, the words "sandy" or "gravelly" (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."

Figure I-E-1 defines the terminology of the USCS. Flowcharts presented in Figures I-E-2 and I-E-3 indicate the process for describing soils. 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.

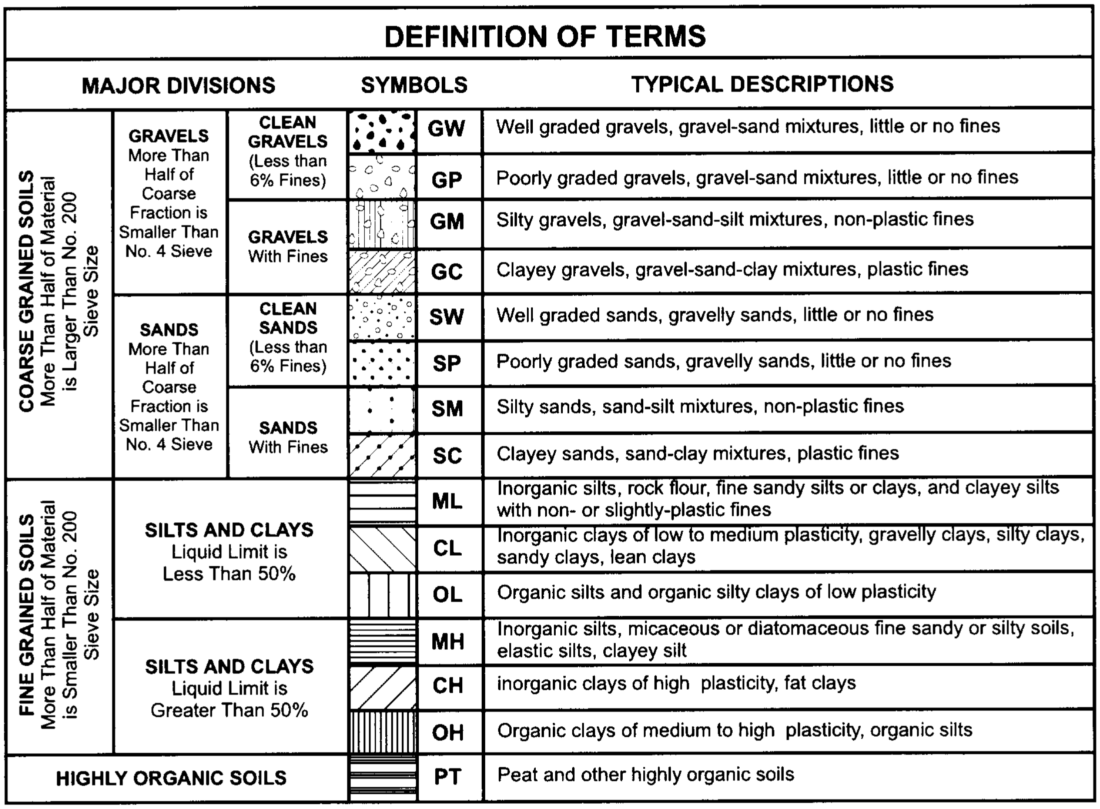
2.1.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. To become 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%. If one of the components is present in a quantity considered less than 5%, indicate its presence by the term "trace".
7. The percentages of gravel, sand, and fines must add up to 100%. "Trace" is not included in the 100% total.

Figure I-E-1
Unified Soil Classification System (USCS)



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

Figure I-E-2
Flow Chart for Fine Grain Soils Classification

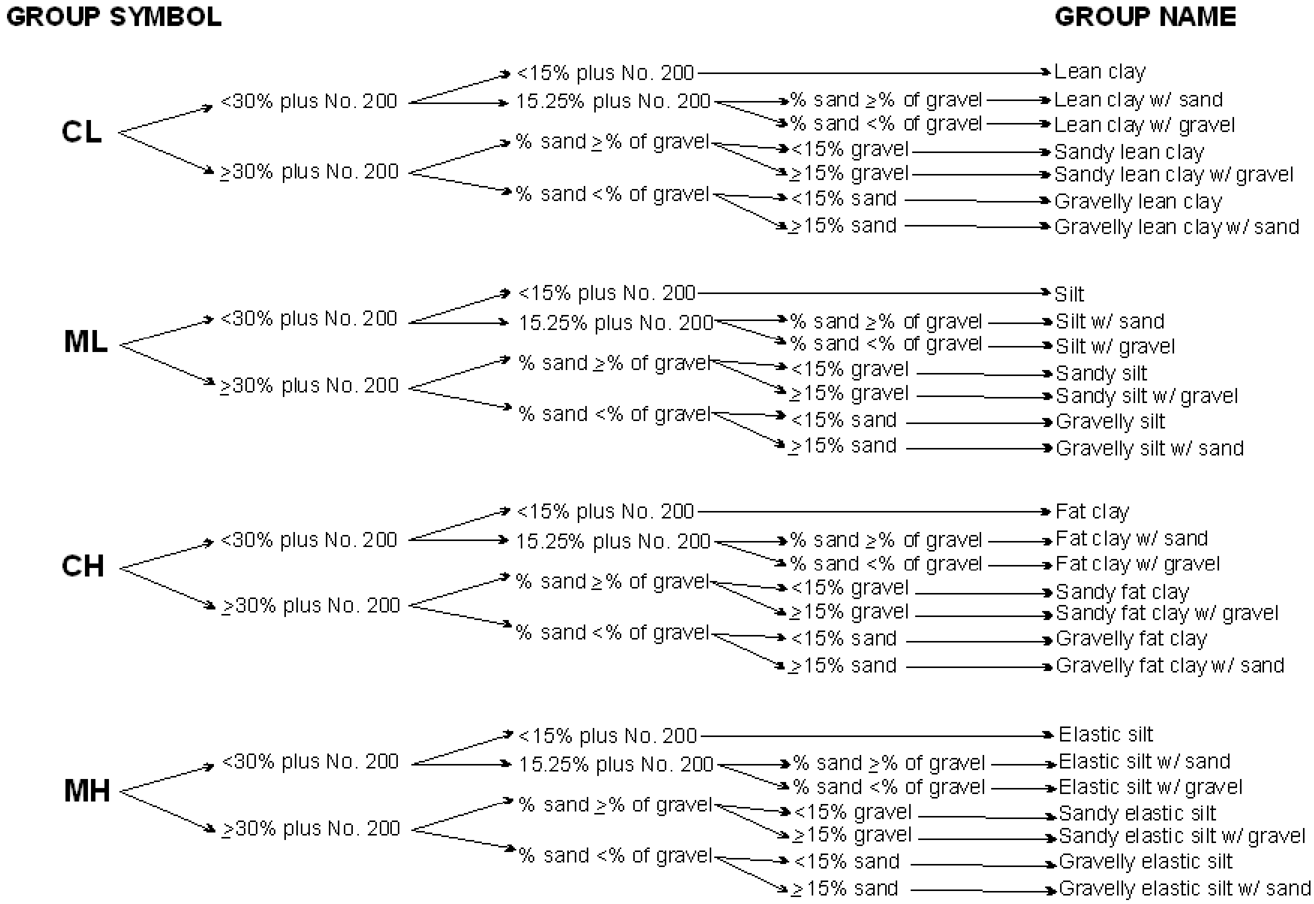
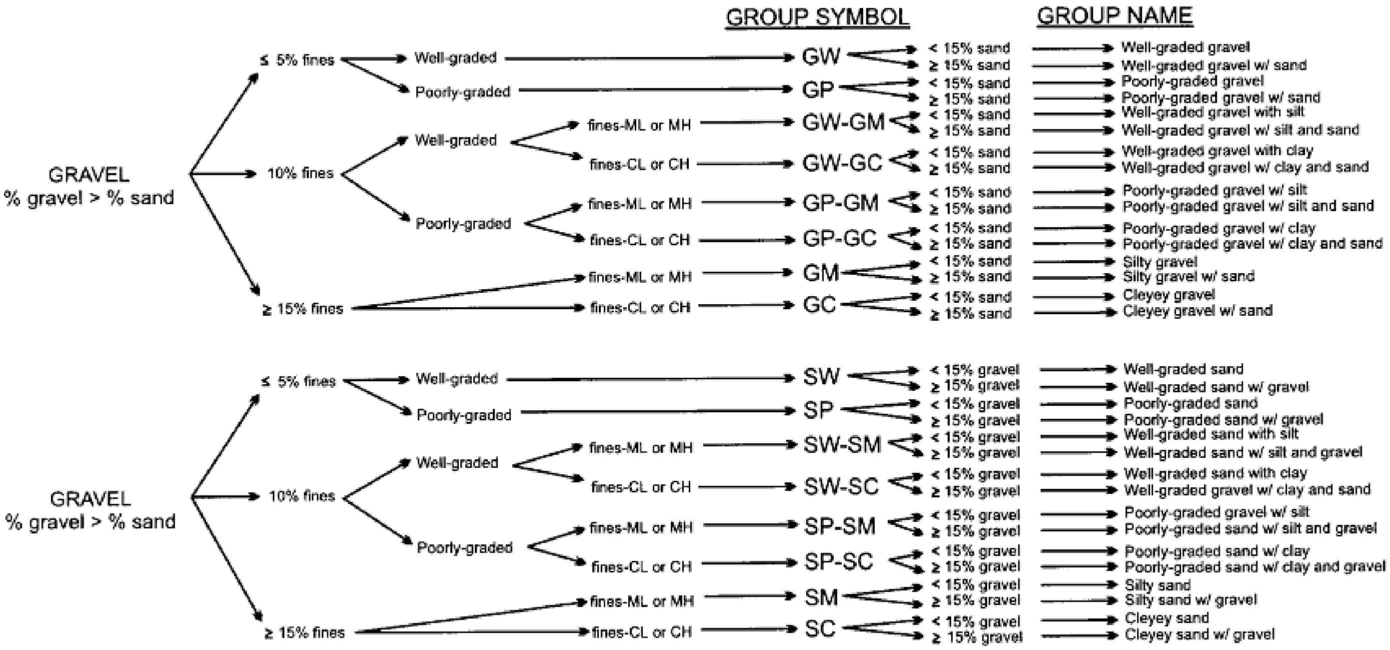


Figure I-E-3
Flow Chart for Soils with Gravel



2.1.2 Soil Dilatancy, Toughness, and Plasticity

2.1.2.1 Dilatancy

To evaluate dilatancy, the following procedures shall be followed:

1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 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 I-E-1. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Table I-E-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.

2.1.2.2 Toughness

Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled 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, it should be spread into a thin layer and allowed 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, the pieces should be lumped together and kneaded 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 I-E-2.

Table I-E-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 to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

2.1.2.3 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 are 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, water should be added prior to performing classification. If a soil sample is too sticky, the sample should be spread thin and allowed to lose some soil moisture.

The criteria for describing plasticity in the field, using the rolled thread method, are presented in Table I-E-3.

Table I-E-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

2.1.3 Angularity

The angularity of the coarse sand and gravel particles is described according to the following criteria:

- 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; and
- Angular—particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

2.1.4 Color, Moisture, and Odor

The natural moisture content of soils is very important information. The terms for describing the moisture condition and the criteria for each are shown in Table I-E-4.

Table I-E-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. For the sake of 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". Mottling or banding of colors should be noted. It is particularly important to note and describe staining because it may indicate contamination.

If odors are noted, they should be described 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 (OVA) may be used to detect the presence of volatile organic contaminants. In general, respirators should be worn if strong organic odors are present.

2.1.5 In-place Conditions

The conditions of undisturbed soil samples shall be described in terms of their density/consistency (i.e., compactness), cementation, and structure utilizing the following guidelines:

2.1.5.1 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 kg) dropped over a distance of 30 inches (0.76 m). The number of blows required to penetrate each 6 inches of soil is recorded 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 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.

The sampler should be driven and blow counts recorded 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, the number of blows per partial increment shall be recorded 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. Representative descriptions of soil density/consistency vs. N-values are presented in Table I-E-5.

Table I-E-5a
Measuring Soil Density with A California Sampler
Relative Density (Sands, Gravels)

	Field Criteria (N-Value)	
Description	**1 3/8" I.D. Sampler**	**2" I.D. 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 I-E-5b
Measuring Soil Density with a California Sampler Consistency:
Fine-Grained Cohesive Soils

	Field Criteria (N-Value)	
Description	**1 3/8" I.D. Sampler**	**2" I.D. 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 I-E-6
Measuring Soil Consistency with a Hand-held Penetrometer

Description	Pocket Penetrometer Reading (PSF)
Very Soft	0 to 250
Soft	250 to 500
Medium Stiff	500 to 1000
Stiff	1000 to 2000
Very Stiff	2000 to 4000
Hard	>4000

Consistency can also be estimated using thumb pressure using the following table:

Table I-E-7
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

2.1.5.2 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.

2.1.5.3 Structure

This variable is used to qualitatively describe physical characteristics of soils that are important to incorporate into hydrogeological or geotechnical descriptions of soils 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 soils, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soils 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.

2.1.5.4 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)

2.1.6 Development of Soil Description

Standard soil descriptions will be developed according to the following examples. There are three principal categories under which all soils can be classified. They are described below.

2.1.6.1 Coarse-grained Soils

Coarse-grained soils are divided into sands and gravels. A soil is classified as a sand if over 50% of the coarse fraction is "sand-sized." It is classified as a gravel if over 50% 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, etc.) in parentheses.

Example: Poorly-sorted SAND with SILT, medium- to coarse-grained, light olive gray, 5Y 6/2, saturated, loose, poorly sorted, subrounded clasts, SW/SM (minor silt with approximately

20% coarse-grained sand-sized shell fragments, and 80% medium-grained quartz sand, and 5% to 15% ML).

2.1.6.2 Fine-grained Soils

Fine-grained soils are further subdivided into clays and silts according to their 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: SANDY Lean CLAY, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70% fines, 30% sand, with minor amounts of disarticulated bivalves (about 5%)).

2.1.6.3 Organic Soils

For highly organic soils, the types of organic materials present will be described 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 soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, 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.

Example: ORGANIC CLAY, black, 2.5Y, 2.5/1, wet, soft, low plasticity, organic odor, OL (100% fines), weak reaction to HCl.

2.2 ROCK CLASSIFICATION

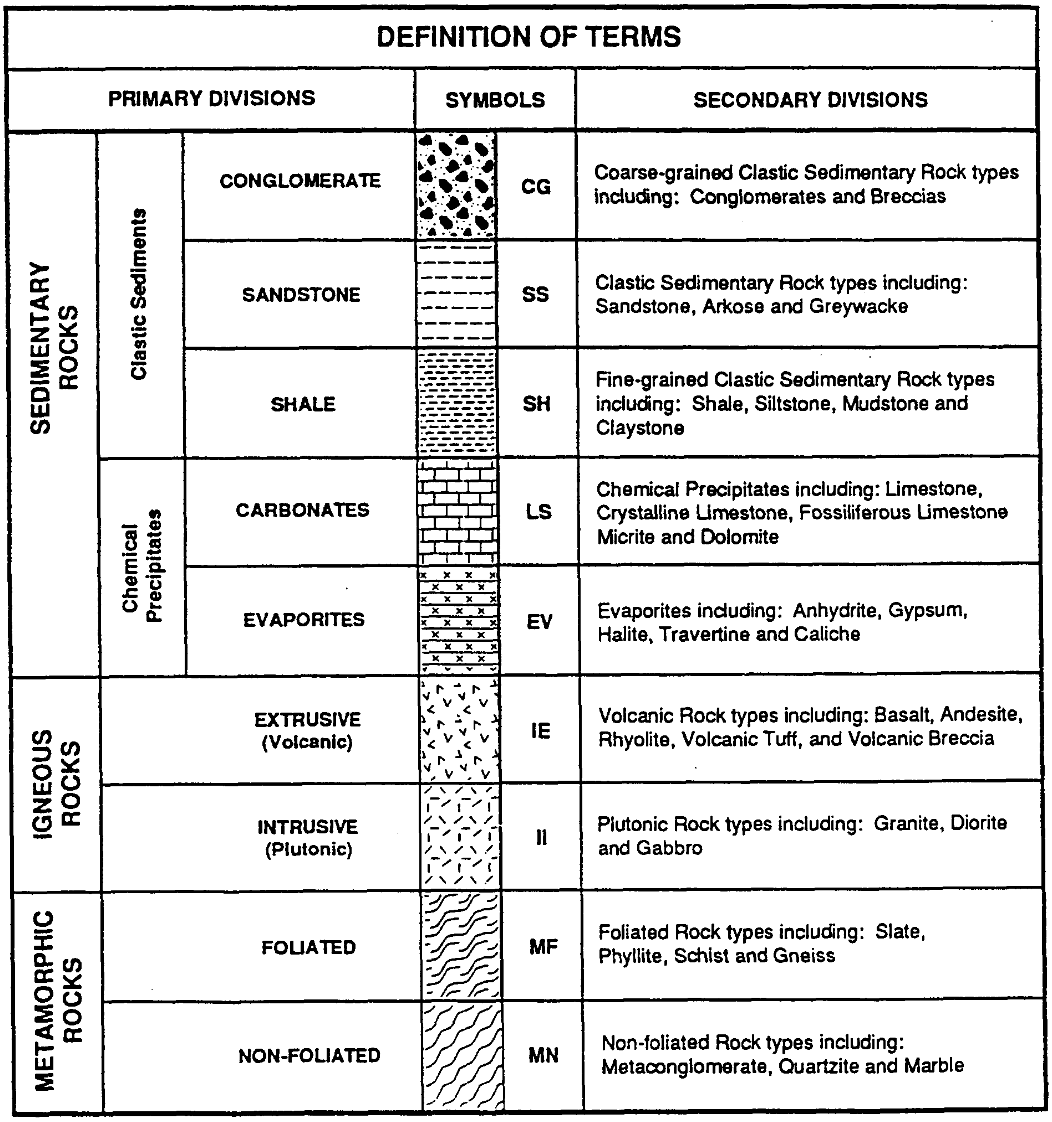
The purpose of rock classification is to thoroughly describe the physical and mineralogical characteristics of a specimen and to classify it according to an established system. The generalized rock classification system described below was developed for NAVFAC NW because, unlike the USCS for soils, there 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 and Field Sampling Plan. Both the Project Manager and the Technical Director/QA Program Manager must approve 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 NAVFAC NW 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 at NAVFAC NW sites.

In order to provide a more consistent rock classification between geologists, a rock classification template has been designated as shown in Figure I-E-4. The template includes classification of rocks by origin and mineralogical composition. All site geologists when classifying rocks shall use this template.

The site geologist shall describe the rock specimen and record the description in a borehole log or logbook. The items essential in any written rock description are as a Classification group (i.e., metamorphic foliated).

Figure I-E-4
Rock Classification System



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

- Classification Name (i.e., schist)
- Color
- Mineralogical composition and percent
- Texture/Grain size (i.e., fine-grained, pegmatitic, aphlitic, glassy, etc.)
- Structure (i.e., foliated, fractured, lenticular, etc.)
- 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) and
- Classification symbol (i.e., MF).

Example: <u>Metamorphic foliated schist</u>: Olive gray, 5Y, 3/2, Garnet 25%, Quartz 45%, Chlorite 15%, Tourmaline 15%, Fine-grained with Pegmatite garnet, highly foliated, slightly wavy, MF

3.0 DOCUMENTATION

Soil classification information collected during soil sampling should be documented onto the field boring logs, field trench logs, and into the field notebook. Copies of the field boring log form are presented in SOP I-B-1, *Soil Sampling*. Copies of this information shall be placed in the project files and reviewed by the Project Manager on a monthly basis at a minimum. If specified in the project SAP, lithologic data should also be submitted electronically in the appropriate Naval Environmental Data Deliverable (NEDD) format as defined in the NAVFAC NW SOPs (V5.0 or more current).

4.0 REFERENCES

ASTM, 1990. Standard Practice for Description and Identification of Soils (Visual, Manual Procedure) Designation D 2488-90.

Birkeland, Peter W. 1984. Soils and Geomorphology. Oxford University Press.

Compton, Robert R. 1985. Geology in the Field. John Wiley & Sons, Inc.

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Huang, Walter T. 1962. Petrology. McGraw-Hill Book Company.

McCarthy, David F. 1988. Essentials of Soil Mechanics and Foundations: Basic Geotechnics. Prentice Hall.

Munsell Soil Color Chart, 1990 Edition (Revised).

Pettijohn, F.J. 1957. Sedimentary Rocks. Harper, New York.

Rahn, Perry H. 1986. Engineering Geology. Elsevier Science Publishing Company, Inc.

SOP I-B1, *Soil Sampling*

U.S. EPA Environmental Response Team. 1988. Response Engineering and Analytical Contract Standard Operating Procedures. U.S. EPA, Research Triangle Park, NC.

5.0 ATTACHMENTS

None.

LAND SURVEYING

1.0 PURPOSE

This standard operating procedure (SOP) sets forth protocols 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.

2.0 PROCEDURES

The procedures listed below shall be followed during land surveying conducted for NAVFAC Northwest.

- All surveying work shall be performed under the direct supervision of a land surveyor registered in the state or territory in which the work is being performed (i.e. a Professional Land Surveyor, PLS).
- Survey instruments shall be calibrated in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall have been calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration (NOAA) standards and at the minimum accuracy standards set forth below. The horizontal accuracy for location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be one in ten thousand 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.
- Surveys shall be referenced to the local established coordinate systems and all elevations and benchmarks established shall be based on North American Vertical Datum of 1988.
- Surveyed points shall be referenced to Mean Sea Level (Mean Lower Low Water Level).
- Appropriate horizontal and vertical control points shall be jointly determined 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. All surveyed locations shall be mapped using a base map or other site mapping specified by the Project Manager.
- All surveys shall begin and end 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. Pins shall be driven 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. They shall be clearly marked with brightly colored weatherproof flagging and paint.
- The point on a monitoring well casing that is surveyed shall be clearly marked by filing grooves into the casing on either side of the surveyed point.

3.0 DOCUMENTATION

Using generally accepted practices, field notes shall be recorded daily by the surveyor in paper or electronic format. The data shall be neat, legible and easily reproducible. Copies of the surveyor's field notes and calculation forms generated during the work shall be obtained and submitted to the Navy or designee.

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
- Field book designations, including page numbers.

Drawings and calculations submitted by the surveyor shall be signed, sealed and certified by a land surveyor registered (PLS stamped) in the state or territory in which the work was done.

Dated records of land surveying equipment calibration shall be provided by the surveyor along with equipment serial numbers and calibration records.

4.0 REFERENCES

The detailed requirements in the Geographic Data, Survey Specifications subsection of the parent compendium (NAVFAC Northwest SOPs V5.0) also apply and are not repeated here in this field procedure. These should be consulted as part of any Land Surveying effort. In addition, NAVFAC Northwest Cadastral Team, Record of Survey or other requirements may apply to the project, an example of their requirements can be found with the Survey Specifications referenced above.

5.0 ATTACHMENTS

None.

FIELD QC SAMPLES (WATER, SOIL, SEDIMENT, TISSUE)

1.0 PURPOSE

This standard operating procedure (SOP) describes the number and types of field Quality Control (QC) samples that will be collected during U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) site field work. Quality control samples are controlled samples introduced into the analysis stream, whose results are used to review data quality and to calculate the accuracy and precision of the chemical analysis program. The purpose of each type of QC sample collection is described in this procedure. Collection and analysis frequency for quality control samples vary by project and are found in the project QA plan. Note that project-specific or contract requirements may supersede the requirements presented in this SOP.

2.0 PROCEDURES

The equipment required for the collection of QC samples is identical to the equipment required for the collection of environmental samples.

Field QC checks may include submission of trip blank, equipment rinsate, field blank, duplicate, and reference samples to the laboratory. Suggested frequency and types of QC check samples are discussed in the following guidance documents: *RCRA Technical Enforcement Guidance Document*, Section 4.6.1 (EPA 1986); the use and frequency of these field QC samples should be incorporated as appropriate. Types of field QC samples are discussed in general below. The frequency at which field QC samples should be collected for each QC level is provided in Table III-B-1.

The use of performance evaluation (PE) samples is discussed in SOP III-H, *Performance Evaluation Sample Procedures.*

2.1 TRIP BLANK

One trip blank is prepared off site by the laboratory using ASTM Type I organic-free water and included in each shipping container with samples scheduled for analysis of VOCs, regardless of the environmental medium. Trip blanks are placed in sample coolers by the laboratory prior to transport to the site so that they accompany the samples throughout the sample collection/ handling/ transport process. Once prepared, trip blanks remain unopened throughout the transportation and storage processes and are analyzed along with the associated environmental samples. Trip blanks are analyzed for VOCs and reported as water samples, even though the associated environmental samples may be from a matrix such as soil, tissue, or product.

One set of two 40 milliliter vials will constitute a trip blank and will accompany each cooler containing samples to be analyzed for volatile organics (VOCs) by methods such as CLP VOCs, 8010/601, 8020/602, 8240/624, modified 8015 (only if purge and trap analysis is performed, e.g., for gasoline, not for extraction and analysis for diesel fuel), and equivalent state-specific methods. Trip blanks will be analyzed for VOCs only (EPA 1987).

Trip banks are not typically analyzed in association with tissue samples and are therefore not required for tissue sampling programs.

Table III-B-1
Field QC Samples per Sampling Event

	Level C2		Level D2		Level E2	
Type of Sample	Metal	Organic	Metal	Organic	Metal	Organic
Trip blank (for volatiles only)	NA1	1/cooler	NA1	1/ cooler	NA[1]	1/cooler
Equipment rinsate[3]	1/day	1/day	1/day	1/day	1/day	1/day
Field blank	1/decontamination water source/event/for all QC levels and all analytes					
Field duplicates[4]	10%	10%	10%	10%	5%	5%

Background samples at least 1/sample media/sample event[5]

Notes:

[1] NA means not applicable.

[2] QC levels are discussed in Section 2.8, Quality Control (QC) Levels.

[3] Samples are collected daily; however, only samples from every other day are analyzed. Other samples are held and analyzed only if evidence of contamination exists.

[4] The duplicate must be taken from the same sample that will become the laboratory matrix/spike duplicate for organics or for the sample used as a duplicate in inorganic analysis.

[5] Sample event is defined from the time sampling personnel arrive at the site until they leave the site for more than a period of one week; the use of controlled-lot source water makes one sample per lot rather than per event an option.

Source: NFESC. 1999. Navy Installation and Restoration Chemical Data Quality Manual.

2.2 EQUIPMENT RINSATE SAMPLES

Equipment rinsate samples are collected by pumping organic-free, analyte-free water over and/or through the sampling equipment (such as a bailer, sampling pump, or mixing bowl) following its final decontamination rinse. This rinse water is collected into the sample containers directly or with the use of a funnel if necessary. The rinse water may be poured by use of an electric or hand submersible pump by tipping the jug of water upside down, or by use of a stopcock.

Equipment rinsate samples are collected daily for sampling equipment used repetitively to collect environmental samples. One equipment rinsate sample shall be collected per day per sampling technique utilized that day (NFESC 1999 and EPA 1986). At least one equipment rinsate sample is analyzed for each group of 20 samples of a similar matrix type and concentration. Equipment rinsate samples are preserved, handled, and analyzed in the same manner as all environmental samples. Analytical results of equipment rinsate samples are used to access equipment cleanliness and the effectiveness of the decontamination process.

When disposable or dedicated sampling equipment is utilized, only one equipment rinsate sample will be collected per equipment lot or project phase. Disposable and/or dedicated sampling equipment may include stainless steel bowls or trowels that will be used for collection of only one soil sample, disposable bailers for ground-water sampling, dedicated submersible pumps for ground-water sampling, or other such equipment. This disposable and/or dedicated sampling equipment is typically pre-cleaned and individually wrapped by the manufacturer prior to delivery to the site. In this case, the equipment rinsate sample is used to provide verification that contaminants are not being introduced to the samples via sampling equipment.

Sampling devices (e.g., gloved hands, dip nets, or traps) for collection of tissue samples are generally non-intrusive into the organisms collected, so equipment rinsate samples will not be collected as long as the devices have been properly cleaned following SOP III-I, *Equipment Decontamination*, and the devices appear clean.

2.3 FIELD BLANKS

Field blanks are generally prepared on site during the sampling event by pouring American Society for Testing and Materials (ASTM) Type I organic-free water into randomly selected sample containers. Commercially available distilled water may be a satisfactory substitute for the ASTM organic-free water depending specific project requirement. At least one field blank is analyzed for each group of 20 samples of a similar matrix type and concentration.

Field blanks, consisting of samples of the source water used as the final decontamination rinse water, will be analyzed to assess whether the wash or rinse water contained contaminants that may have been carried over into the site samples.

The final decontamination rinse water source, the field blank source water, and equipment rinsate source water should all be from the same purified water source. Tap water used for steam cleaning augers or used in the initial decontamination buckets need not be collected and analyzed as a field blank, because augers typically do not touch the actual samples and because the final decontamination rinse water should be from a purified source.

Field blanks are collected at a frequency of one per sampling event per each source of water for all levels of QC. A sampling event is considered to be from the time sampling personnel arrive at a site until they leave for more than a week. Field blanks will be analyzed for the same analyses as the samples collected during the period that the water sources are being used for decontamination. If the same lot of the water source is used, a field blank needs to be collected only once per lot.

2.4 FIELD DUPLICATE

At least one duplicate sample is analyzed from each group of 10 samples of a similar matrix type and concentration. Field duplicate samples should be collected from areas most likely to be contaminated and are preserved, handled, and analyzed in the same manner as all environmental samples. Field duplicates have the same location identification, sampling date and time, and depth interval as the associated environmental sample, but are assigned a unique sample number that is associated with the environmental sample number by virtue of the identical timestamp and location information.

Field duplicates for groundwater and surface water samples will generally consist of replicates. Field duplicates for soil samples will consist primarily of collocates. Soil field duplicates that are to be analyzed for volatile constituents will consist only of collocates; no soil samples that are to be analyzed for volatiles will be replicated (i.e., homogenized or otherwise processed or split) in the field. A separate sample will be collected to provide duplicates for non-volatile analyses. The sample may be homogenized and split in the field to form an original and duplicate (replicate) sample, or an additional volume into a separate sample container may be collected to form a duplicate (collocate) sample. Alternatively, replicates may be formed by homogenization in the laboratory. Duplicates will be analyzed for the same analytical parameters as their associated original sample.

Field duplicates for biological tissue samples will consist of splits of the original sample. Twice the required volume of organisms for one sample will be collected and placed into one food-grade self-sealing bag. The sample will later be homogenized in the laboratory and split, producing an original and a replicate sample. Replicates will be analyzed for the same analytical parameters as their associated original samples.

2.5 REFERENCE SAMPLES

There are two types of background levels of chemicals:

- Naturally occurring levels, which are concentrations of chemicals present in the environment that have not been influenced by humans (e.g., iron, aluminum)
- Anthropogenic levels, which are concentrations of chemicals that are present in the environment due to human-made, non-site sources (e.g., industry, automobiles)

Reference samples are samples taken from media similar to site media, but that are collected outside the zone of contamination, usually offsite.

Reference samples will be collected for each medium sampled at a site. Site-specific conditions will dictate the number of reference samples necessary to characterize background concentrations of contaminants of concern. However, at least one reference sample from each medium will be collected during each sampling event at a site. The samples will be analyzed for all the analytes for which site samples of that medium are analyzed. Background analysis, especially for metals, should be performed to assess the typical naturally occurring levels.

At least one reference sample will be collected for each biological species collected at a site. It may be difficult to find a nearby offsite location similar enough to the project site that has the same biological species available for offsite reference sample collection. Therefore, reference sample locations may need to be more distant from the site than for soil or water offsite reference samples. Collection methods will be identical for site and reference samples.

State-specific procedures may be required to establish background conditions for the site. This SOP is not intended to address such procedures and they should be consulted as necessary.

2.6 TEMPERATURE BLANKS

Temperature blanks are used to measure cooler temperatures upon receipt of the coolers at the laboratory. One temperature blank will be prepared and submitted to the project laboratory with each cooler. The temperature blank will consist of a sample jar containing water, which will be packed in the cooler in the same manner as the rest of the samples and labeled “temperature blank.”

2.7 LABORATORY QUALITY CONTROL SAMPLES

The analytical laboratory uses a series of QC samples specified in each standard analytical method and laboratory SOP to assess laboratory performance. Analyses of laboratory QC samples are performed for samples of similar matrix type and concentration and for each sample batch. The types of laboratory QC samples are matrix spike/matrix spike duplicates, laboratory control standards, laboratory duplicates, method blanks, and surrogates. In addition, there may be other project-specific technical QC requirements.

2.7.1 Matrix Spike/matrix Spike Duplicate

Matrix spike/matrix spike duplicates (MS/MSDs) are used to assess sample matrix interferences and analytical errors, as well as to measure the accuracy and precision of the analysis. For MS or MSD samples, known concentrations of analytes are added to the environmental samples; the samples are then processed through the entire analytical procedure and the recovery of the analytes is calculated. Results are expressed as percent recovery of the known spiked amount for matrix spikes and the relative percent difference (RPD) for MS/MSDs. The MS/MSDs will be collected and analyzed at a rate of 5 percent of the field samples for each matrix and analytical method or at least one for each analytical batch, whichever frequency is greater.

Generally, a specific sampling location is used to collect field QC samples; however, it may not be possible to collect MS/MSD samples for all analyses at the same sampling location because of a limited volume of available material. In those instances, MS/MSD samples designated for various analyses will be collected from different locations (for example a MS/MSD for metals is collected at location X and an MS/MSD for PCBs is collected at location Y). Additionally, samples designated for MS/MSD analyses will not be collected from locations with potentially high concentrations of target analytes that may mask the added spike compounds. MS/MSD samples have the same location identification, sampling time, depth interval, and sample number as the associated environmental sample.

2.8 QUALITY CONTROL (QC) LEVELS

NAVFAC NW QC Levels III, IV are defined in SOP I-A-8 and Data Validation Procedure SOPs II-A through II-O. Level IV QC is appropriate to use for laboratory analysis for sites where cleanup decisions will be based on risk assessment. Sites on or eligible for the National Priorities List (NPL) will also have laboratory analyses conducted at Level IV QC. The QC level selected for laboratory analyses for many sites, therefore, will be NAVFAC NW Level IV. Other QC levels may be appropriate for certain types of samples or analyses; criteria for selection of the appropriate QC level for individual projects and field work activities are discussed in SOP I-A-8, *Data Validation Planning and Coordination*.

3.0 DOCUMENTATION

Records of the collection of field QC samples should be kept in the sample logbook by the methods discussed in SOPs III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* and III-D, *Logbooks*.

4.0 REFERENCES

EPA. 1987. Data Quality Objectives for Remedial Response Activities: Development Process

NFESC. 1999. Navy Installation and Restoration Chemical Data Quality Manual.

EPA. 1992. RCRA Technical Enforcement Guidance Document.

SOP III-I, Equipment Decontamination

SOP, III-D, *Logbooks*

5.0 ATTACHMENTS

None.

LOGBOOKS

1.0 PURPOSE

This standard operating procedure (SOP) describes the activities and responsibilities of U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) personnel and/or their contractors pertaining to the identification, use, and control of logbooks and associated field data records. This SOP establishes a standard format for recording field observations and describes the methods for use and maintenance of field logbooks.

2.0 PROCEDURE

2.1 EQUIPMENT

- Waterproof hardbound field logbook (typically 4-inch by 7-inch to 8-inch by 10.5-inch) with numbered pages
- Waterproof/indelible marking pen
- Ruler/straight edge
- Clipboard

2.2 LOGBOOK MAINTENANCE

Prior to commencement of field work, logbooks will be assigned to field personnel by the Project Manager. If personnel changes must be made during a project, the successor may use the same logbook. In this case, the logbook cover page will indicate all persons who have made entries and the dates. This may be inappropriate if there are a large number of people involved.

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 safeguard of the logbook while having custody of it.

Individuals performing specific tasks associated with a field project may keep a separate logbook; however, these logbooks must conform to this procedure and will become a permanent part of the central project file. The Project Manager is responsible for reviewing and signing all field logbooks associated with the project.

2.3 RECORDING FIELD ACTIVITIES

The field team provides a permanent record of daily activities, observations, and measurements through the use of a field logbook. All logbook entries will be made in indelible black or blue ink. No erasures are permitted. If an incorrect entry is made, the data will be crossed out with a single line and initialed and dated by the originator. Entries can be organized into easily understood tables if possible.

All logbook pages will be signed and dated at the bottom. Times will be recorded next to each entry. If a full page is not used during the course of a workday, a diagonal line will be drawn through the unused portion of the page and signed (in this case, it would not be necessary to sign the bottom of the page). If the project is completed and the logbook has not been completely filled, a diagonal line will be drawn across the first blank page after the last entry, and "no further entries" written before the page is signed and dated.

Daily entries will be made during field activities by, at a minimum, one field team member to provide daily records of all significant events, observations, and measurements during field operations. Notes will start at the beginning of the first blank page and extend through as many pages as necessary. All page numbers will be consecutively numbered as the logbook is filled.

The inside cover page of each logbook will contain the following information:

- Book number
- Project name
- Contract number
- Project number
- Navy Activity/Installation
- Site name
- Start date
- End date
- Person to whom the logbook is assigned
- Agency/Company name
- Agency/Company address
- Agency/Company phone number

The field logbook serves as the primary record of field activities. When possible, the field book should be dedicated to a singular Navy Activity/Installation to facilitate long-term records archiving. Entries shall be made chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct the applicable events. 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, names of all samples collected shall be included in the logbook even if recorded elsewhere.

All field descriptions and observations are entered into the logbook, as described in Attachment III-D-1.

Typical information to be entered includes, but is not limited to, the following:

- Date and time of all onsite activities

- Site location and description
- Weather conditions
- Field work documentation
- Descriptions of and rationale for approved deviations from the Work Plan or Field Sampling Plan
- Field instrumentation readings
- Personnel present
- Photograph references
- Sample locations
- Sample identifications, as described in SOP I-A-11, Sample Naming
- Field QC sample information
- Field descriptions, equipment used, and field activities accomplished to reconstruct field operations
- Meeting information
- Daily health and safety meeting notes
- Important times and dates of telephone conversations, correspondence, or deliverables
- Field calculations
- PPE level
- Calibration records
- Subcontractors present
- Equipment decontamination procedures and effectiveness
- Procedures used for containerization of investigative-derived waste

Logbook page numbers shall appear on each page to facilitate identification of photocopies.

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

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.

A technical review of each logbook shall be performed by a knowledgeable individual such as the Project Manager.

3.0 DOCUMENTATION

The field logbook shall be retained as a permanent project record. If a particular Task Order requires submittal of photocopies of logbooks, this shall be performed as required.

4.0 REFERENCES

SOP I-A-11, *Sample Naming*

5.0 ATTACHMENTS

Attachment III-D-1 Description of Logbook Entries

Attachment 1
Description of Logbook Entries

Logbook entries shall 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 specified in the Field Sampling Plan. Record valid Navy Installation/Active and Site, at a minimum.
Weather	Indicate general weather and precipitation conditions.
Level of Personal Protective Equipment	The level of personal protective equipment (PPE), e.g., Level D, should be recorded.
Methods	Indicate method or procedure number employed for the activity.
Sample IDs	Indicate the unique identifier associated with the physical samples. Identify QC samples. Value can be numeric or alphanumeric and must not already exist in the database.
Sample Type and Volume	Indicate the medium, container type, preservative, and the volume for each sample.
Sample Collection Information	Indicate the location of sample, date and time of collection, sample matrix, sample depth interval, sample methods, sample handling, including filtration and preservation, analysis required and packaging and shipping information.
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 Field Sampling Plan.
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 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 any 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 to the work schedule, requested 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.

RECORD KEEPING, SAMPLE LABELING, AND CHAIN-OF-CUSTODY PROCEDURES

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish standard protocols for all U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) field personnel and their contractors 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.

2.0 PROCEDURES

Standards for documenting field activities, labeling the samples, documenting sample custody, and completing chain-of-custody and analytical request forms are provided in this procedure. 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.

2.1 RECORD KEEPING

The field logbook serves as the primary record of field activities. Entries shall be made 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 SOP III-D, *Logbooks*.

2.2 SAMPLE LABELING

A sample label with adhesive backing shall be affixed to each individual sample container. Clear tape shall be placed over each label (preferably prior to sampling) to prevent the labels from tearing off, falling off, or being smeared, and to prevent loss of information on the label. The following information shall be recorded with a waterproof marker on each label:

- Project name or number (optional)
- Sample ID
- Date and time of collection
- Sampler's initials
- Matrix (optional)
- Sample preservatives (if applicable)
- Analysis to be performed on sample. This shall be identified by the method number or name identified in the subcontract with the laboratory. For water samples, a separate container is

typically used for each separate test method, whereas with soil samples, multiple analyses can be performed on the soil obtained from one sample container. In order to avoid lengthy lists on each container and confusion, soil sample containers may not list every analysis to be performed.

These labels may be obtained from the analytical laboratory or printed from a computer file onto adhesive labels. The adhesive glue used on the labels must be such that it does not contaminate the sample.

2.3 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. Custody of samples shall be maintained in accordance with EPA chain-of-custody guidelines as prescribed in EPA's *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.

2.3.1 Sample Collection Custody Procedures

According to EPA's *NEIC Policies and Procedures*, a sample is considered to be in custody if:

- 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
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal

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

- Sampler's name or initials
- 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 III-E-1.

Field personnel shall also log individual samples onto carbon copy chain-of-custody forms when a sample is collected. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 2.4 indicating sample 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 III-E-2. An example of a completed COC form is provided in Attachment III-E-3 and described in Section 2.4.

2.3.2 Laboratory Custody Procedures

The following are custody procedures to be followed by an independent laboratory receiving samples for chemical analysis; the procedures in their Laboratory Quality Assurance Plan (LQAP) 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 samples in the coolers upon arrival. The custodian shall also note the condition of the samples including:

- If the samples show signs of damage or tampering.
- If the containers are broken or leaking.
- If headspace is present in sample vials.
- Proper preservation of samples (made by pH measurement, except VOCs and purgeable TPH). The pH of these samples will be checked by the laboratory analyst, after the sample aliquot has been removed from the vial for analysis.
- If any sample holding times have been exceeded.

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

Any discrepancy 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 III-E-4.

The custodian shall then assign a unique laboratory number to each sample and distribute the samples to secured storage areas maintained at 4°C. The unique laboratory number for each sample, contractor sample ID, client name, date and time received, analysis due date, and storage details shall also be manually logged onto a sample receipt record and later entered into the laboratory's computerized data management system. The custodian shall also 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.

2.4 COMPLETING CHAIN-OF-CUSTODY/ANALYTICAL REQUEST FORMS

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

Attachment III-E-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 III-E-3 is an example of a completed site-specific COC/analytical request form, with box numbers identified and discussed in text below.

Box 1 Project Manager: This name shall be the name that will appear on the report. Do not write the name of the Project Coordinator or point of contact for the project instead of the Project Manager.

Project Name: Write it, as it is to appear on the report.

Project Number: Write it as it is to appear on the report. It shall include the project number, task number, and general ledger section code. The laboratory subcontract number should also be included.

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 Basic Ordering Agreement (BOA) or each Task Order statement of work with each laboratory.

Shipment Method: State the method of shipment, e.g., hand carry; air courier via FEDEX, AIRBORNE, DHL or equivalent.

Comment: 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. For example: a specific metals list, explanation of Mod 8015, Mod 8015 + Kerosene, samples expected to contain high analyte concentrations.

Box 4 Cooler Number: This will be written somewhere 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 VOC samples. 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/QC requirements, e.g., NAVFAC NW QC Level C, D, or E.

Turnaround time (TAT): TAT for contract work will be determined by a sample delivery group (SDG), which may be formed over a 14-day period, not to exceed 20 samples. Standard turnaround time once the SDG has been completed is 35 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: 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 number: Five-character alpha-numeric identifier to be used by the laboratory to identify samples. The use of this identifier is important since the labs are restricted to the number of characters they are able to use. See SOP I-A-11, Sample Naming.

Description (sample identification): This name will be determined by the location and description of the sample, as described in SOP I-A-11, Sample Naming. 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 sample number and sample identification must be maintained separately.

Date Collected: Collection date must be recorded 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 Identification: This is for laboratory use only.

Box 7 Matrix and 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. When requesting metals that are modifications of the standard lists, define the list in the comment section. This would not be necessary when requesting standard list metals such as priority pollutant metals (PPM), target compound list from ILM03.0, and Title 22 metals which are groups of metals commonly requested and should not cause any confusion as to what metals are being analyzed. Whenever possible, list the parameters as they appear in the laboratory subcontract to maintain consistency and avoid confusion.

In the boxes below the analytical parameter, indicate the number of containers collected for each parameter by marking an "X". If more than one container is used for a sample, write a number in the desired box to indicate a request for analysis and to indicate the number of containers sent for that analysis.

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

Relinquished By: This space shall contain the signature of the person who turned over the custody of the samples to a second party other than an express mail carrier such as FEDEX, DHL or Air Borne Express.

Received By: Typically, this is a written signature by a representative of the receiving laboratory, or a field crewmember who delivered the samples in person from the field to the laboratory. A courier such as FedEx or DHL does not sign because they do not open the coolers. It must also be used by the prime contracting laboratory when samples are sent to a subcontractor.

Relinquished By: In the case of subcontracting, the primary laboratory will sign 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).

Box 10 Lab Number 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 sample number in a cooler, or contained on a COC. This control number must be unique and never used twice. Record the date the COC is completed. It should be the same date the samples are collected.

Box 12 Total No. of Containers/row: Sum the number of containers in that row.

Box 13 Total No. of Containers/column: Sum the number of containers in that column.

Because COC forms contain different formats based upon 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.

COC forms tailored to each Task Order 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, reduce the number of trip blanks by placing all samples to be analyzed for VOA, gasoline, and BTEX compounds into one cooler. 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.

3.0 DOCUMENTATION

The COC/analytical request form shall be faxed daily, if possible, to the Task Order Laboratory Coordinator for accuracy verification. Following the completion of sampling activities, the sample logbook and COC forms will be transmitted to the Project Manager for storage in project files. The Project Manager shall review COC forms on a monthly basis at a minimum. The data validators shall also receive a copy. Along with the data delivered, the original COC/analytical request form shall be submitted by the laboratory. 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.

4.0 REFERENCES

SOP I-A-11, *Sample Naming*

SOP III-D, *Logbooks*

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

USEPA. 1986. EPA NEIC Policies and Procedures, National Enforcement Investigations Center, Denver, Colorado.

USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA OSWER Directive 9355 3-01).

USEPA. 1992. RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD).

USEPA. 1995 and as updated. Test Methods for Evaluating Solid Waste (SW-846), Third edition.

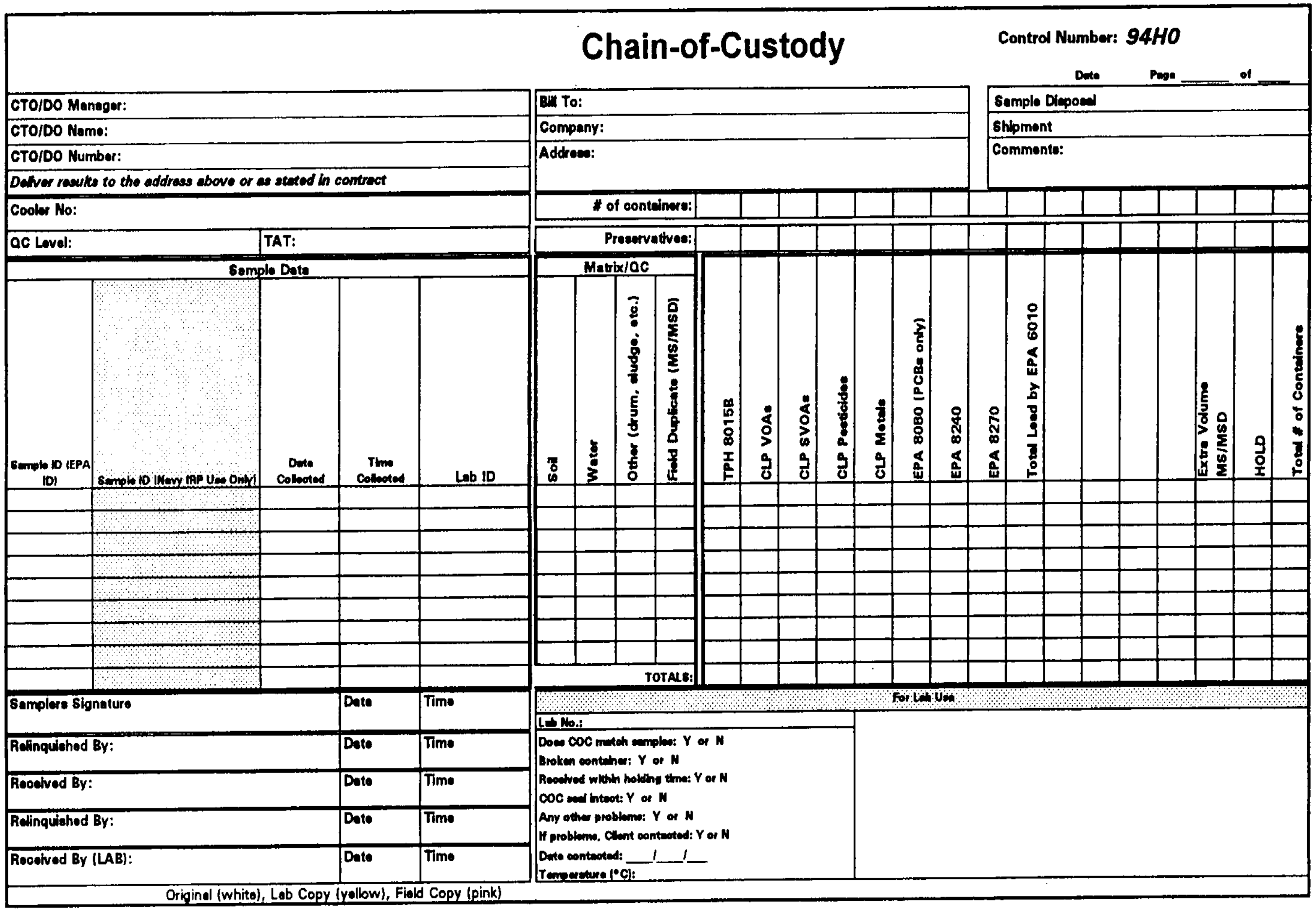
5.0 ATTACHMENTS

Attachment III-E-1	Chain-of-Custody Seal
Attachment III-E-2	Generic Chain-of-Custody/Analytical Request Form
Attachment III-E-3	Sample Completed Chain-of-Custody/Analytical Request Form
Attachment III-E-4	Sample Out-of-Control Form

Attachment III-E-1
Chain-of-Custody Seal

[LABORATORY]	SAMPLE NO.	DATE	SEAL BROKEN BY
	SIGNATURE		DATE
	PRINT NAME AND TITLE (Inspector, Analyst or Technician		

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



Chain-of-Custody

Control Number: 94H0

Date Page ____ of ____

CTO/DO Manager:
CTO/DO Name:
CTO/DO Number:
Deliver results to the address above or as stated in contract
Cooler No:
QC Level: TAT:

Bill To:
Company:
Address:

Sample Disposal
Shipment
Comments:

\# of containers:
Preservatives:

Sample Data					Matrix/QC																	
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
					TOTALS:																	

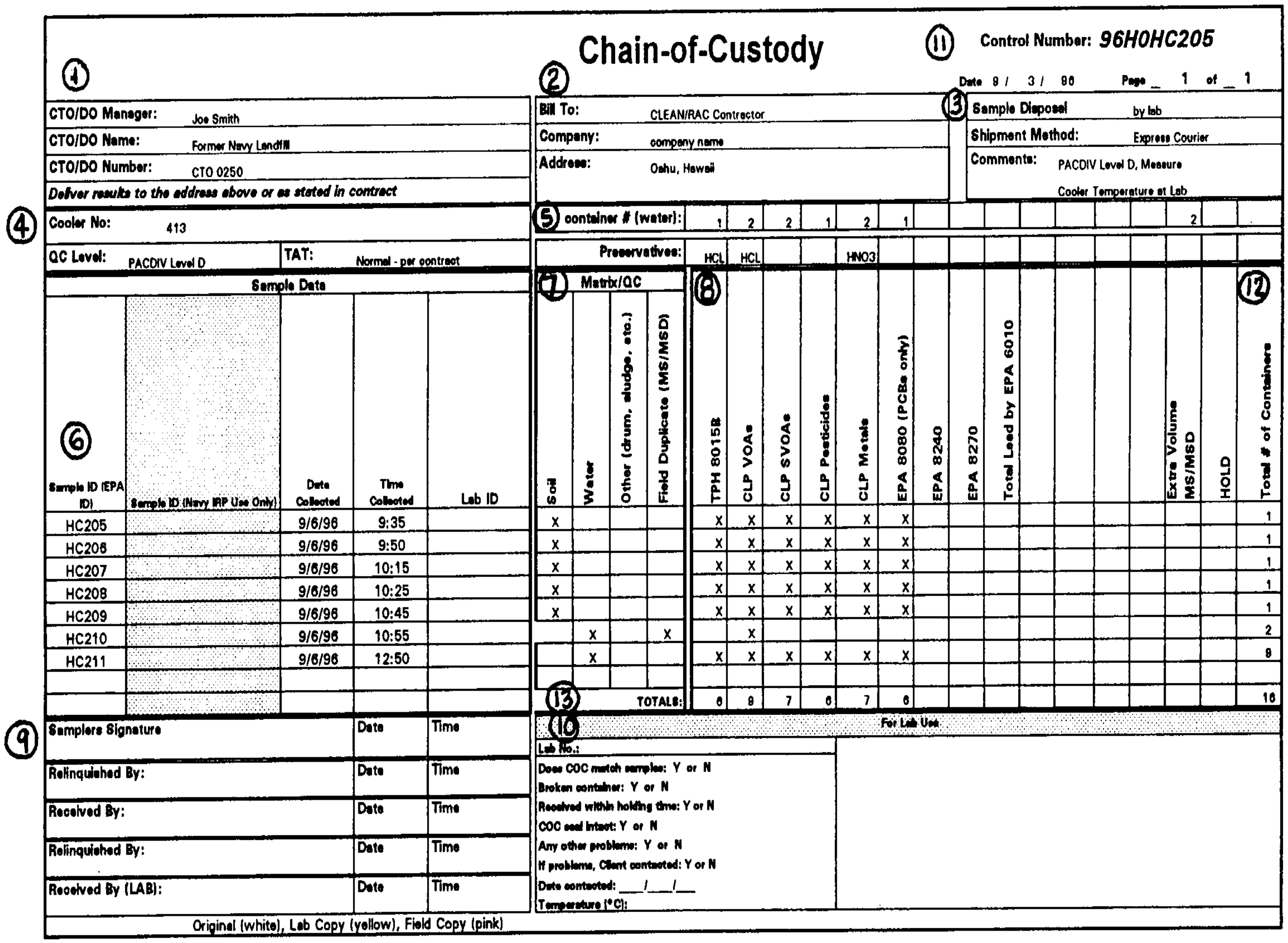
Samplers Signature	Date	Time
Relinquished By:	Date	Time
Received By:	Date	Time
Relinquished By:	Date	Time
Received By (LAB):	Date	Time

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)

Attachment III-E-3
Sample Completed Chain-Of-Custody/ Analytical Request Form



Chain-of-Custody

⑪ Control Number: 96H0HC205

Date 9 / 3 / 96 Page _ 1 of _ 1

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

②
Bill To: CLEAN/RAC Contractor
Company: company name
Address: Oahu, Hawaii

③
Sample Disposal by lab
Shipment Method: Express Courier
Comments: PACDIV Level D, Measure Cooler Temperature at Lab

④
Cooler No: 413
QC Level: PACDIV Level D
TAT: Normal - per contract

⑤ container # (water): TPH 8015B 1; CLP VOAs 2; CLP SVOAs 2; CLP Pesticides 1; CLP Metals 2; EPA 8080 (PCBs only) 1; Extra Volume MS/MSD 2

Preservatives: TPH 8015B HCL; CLP VOAs HCL; CLP Metals HNO3

Sample Data ⑥ — ⑦ Matrix/QC — ⑧ — ⑫

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													2
HC211		9/6/96	12:50			X			X	X	X	X	X	X									9
					⑬			TOTALS:	6	9	7	6	7	6									16

⑨

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

⑩ 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)

Attachment III-E-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:	Samples Affected
Dated Occurred:	Matrix	(List by Accession
Parameter (Test Code):	Method:	AND Sample No.)
Analyst:	Supervisor:	

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:

SAMPLE HANDLING, STORAGE, AND SHIPPING

1.0 PURPOSE

This standard operating procedure (SOP) sets forth the methods for use by U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) field personnel and their contractors engaged in handling, storing, and transporting water, soil and/or sediment samples.

2.0 PROCEDURE

2.1 HANDLING AND STORAGE

Immediately following collection, all samples will be labeled according to the procedures in SOP III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures*. The lids of the containers shall not be sealed with duct tape, but may be covered with custody seals or placed directly into sealed plastic bags. The sample containers shall be placed in an insulated cooler with frozen gel packs (such as "blue ice") or ice in double, self-sealing bags. Samples should occupy the lower portion of the cooler, while the ice should occupy the upper portion. An absorbent material (e.g., proper absorbent cloth material) may be placed on the bottom of the cooler to contain liquids in case of spillage. All empty space between sample containers shall be filled with bubble wrap, Styrofoam "peanuts," or other appropriate material. Prior to shipping, glass sample containers should be wrapped on the sides, tops, and bottoms with bubble wrap or other appropriate padding and/or surrounded by packing material to prevent breakage during transport. Prior to shipment, the ice or cold packs in the coolers may require replacement to maintain samples as close to 4°C as possible during transport of the samples to the analytical laboratory. Samples shall be shipped as soon as possible to allow the laboratory to meet holding times for analyses. The procedures for maintaining sample temperatures at 4°C, pertains to all water, soil, and sediment field samples.

2.2 SHIPPING

All appropriate U.S. Department of Transportation (DOT) regulations (e.g., 49 Code of Federal Regulations (CFR), Parts 171-179) shall be followed in shipment of air, soil, water, and other samples.

2.2.1 Hazardous Materials Shipment

Field personnel must state whether any sample is suspected to be a hazardous material. A sample should be assumed to be hazardous unless enough evidence exists to indicate it is nonhazardous. If not suspected to be hazardous, shipments may be made as described in the Section 2.2.2 for non-hazardous materials. If hazardous, the procedures summarized below must be followed.

Any substance or material that is capable of posing an unreasonable risk to life, health, or property when transported is classified as hazardous. Hazardous materials identification should be performed 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 III-G-2.

All persons offering for shipment any hazardous material must be properly trained in the appropriate regulations, as required by HM-126F, Training for Safe Transportation of Hazardous Materials. 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.

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 III-G-1 shows an example of proper package markings. A copy of 49 CFR should be referred to each time a hazardous material or potentially hazardous samples are shipped.

According to Section 2.7 of the International Air Transport Association (IATA) 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 III-G-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 III-G-3). Certain dangerous goods are not allowed on certain airlines in any quantity.

As stated in item 4 of Attachment III-G-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 percentages by weight criteria are met. These samples may be shipped as non-hazardous materials as discussed below.

2.2.2 Nonhazardous Materials Shipment

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

When a cooler is ready for shipment to the laboratory, copies of the chain-of-custody form shall be placed inside a sealed plastic bag and placed inside of an insulated cooler. The coolers will then be sealed with waterproof tape and labeled "Fragile," "This-End-Up" (or directional arrows pointing up), or other appropriate notices. Custody seals will be placed on the coolers as discussed in SOP III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures*.

2.2.3 Shipments from Outside the Continental United States

Shipment of sample coolers to the U.S. from locations outside the continental U.S. is controlled by the USDA and is subject to their inspection and regulation. Documentation is required to prove that the analytical laboratory receiving samples is certified. The laboratory must have certification by USDA to receive and properly dispose of soil; this is called a "USDA Soil Import Permit." In addition, all sample coolers must be inspected by a USDA representative, affixed with a label indicating that the coolers contain environmental samples, and shipping forms stamped by the USDA inspector prior to shipment. In addition, samples shipped from U.S. territorial possessions or foreign countries, must be cleared by the U.S. Customs Service upon entry into the United States. As long as the commercial invoice is properly completed (see below), shipments typically pass through U.S. Customs without the need to open coolers for inspection.

Completion and use of proper paperwork will, in most cases, minimize or eliminate the need of the USDA and U.S. Customs to inspect the contents. Attachment III-G-5 shows an example of how paperwork may be placed on the outside of coolers for nonhazardous materials. For hazardous materials, refer to Section 2.2.1.

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

1. **Courier Shipping Form & Commercial Invoice -** See Attachments III-G-6, III-G-7, and III-G-8 for examples of the information to be included on these forms. Both forms should be placed inside a clear plastic adhesive-backed pouch, which adheres to the package (typically supplied by the courier) and placed on the cooler lid as shown in Attachment 5.

2. **Soil Import Permit and USDA Letter** (soil only) - See Attachments III-G-9 and III-G-10 for examples. The laboratory shall supply these documents prior to mobilization. The USDA in Hawaii often <u>does</u> stop shipments of soil without these documents. The 2" x 2" USDA label (described below), the USDA letter, and soil impact permit should be stapled together and placed inside a clear plastic pouch. Clear plastic and adhesive-backed pouches are typically supplied by the mailing courier.

3. The analytical laboratory should supply the Soil Import Permit. Although original labels are preferred, copies of this label, which are cut out to the 2" x 2" dimensions, are acceptable. Placing one label (as shown in Attachment III-G-5) covered with clear packing tape and one stapled to the actual permit is suggested.

4. The USDA does not control water samples, thus the requirements for soils listed above do not apply.

5. **Custody Seals**. Task Order personnel must sign and date custody seals. At least two seals should be placed in such a manner that they stick to both the cooler lid and body. The seals shall be placed so the cooler/container cannot be opened without breaking the seal. The custody seals are then covered with clear packing tape. This prevents the seal from coming loose and enables detection of tampering.

6. **Address Label**. A label stating the destination (the sending and laboratory, company, or location address) should be affixed to each cooler. The label should also include both telephone numbers.

7. **Special Requirements for Hazardous Materials -** see Section 2.2.1.

Upon receipt of sample coolers at the laboratory, the sample custodian shall inspect the sample containers as discussed in SOP III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures*. 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.

3.0 DOCUMENTATION

Records shall be maintained as required by implementing these procedures.

4.0 REFERENCES

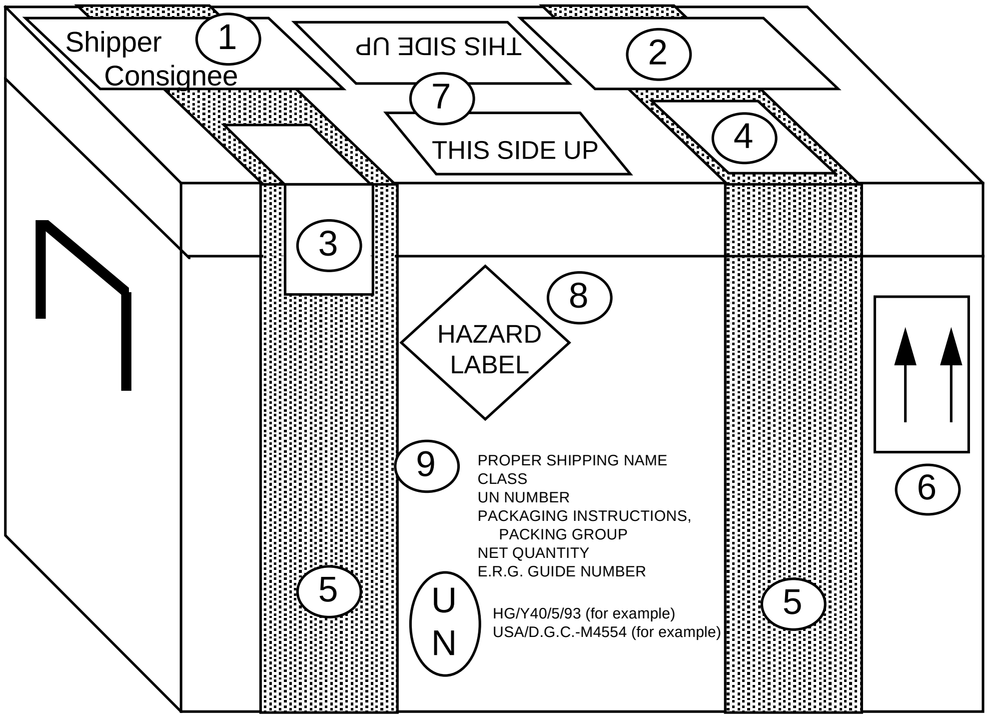
HM-126F, Training for Safe Transportation of Hazardous Materials

SOP III-E, Record Keeping, Sample Labeling, and Chain-of-Custody Procedures

5.0 ATTACHMENTS

Attachment III-G-1	Example Package Marking
Attachment III-G-2	Packing Groups
Attachment III-G-3	Label for Dangerous Goods in Excepted Quantities
Attachment III-G-4	SW-846 Preservative Exception
Attachment III-G-5	Sample Cooler Marking Figure
Attachment III-G-6	Example Courier Form
Attachment III-G-7	Commercial Invoice - Soil
Attachment III-G-8	Commercial Invoice - Water
Attachment III-G-9	Soil Import Permit
Attachment III-G-10	Soil Samples Restricted Entry Labels

Attachment III-G-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**

Attachment III-G-2
Packing Groups

Packing Group of the Substance	Packing Group I		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.

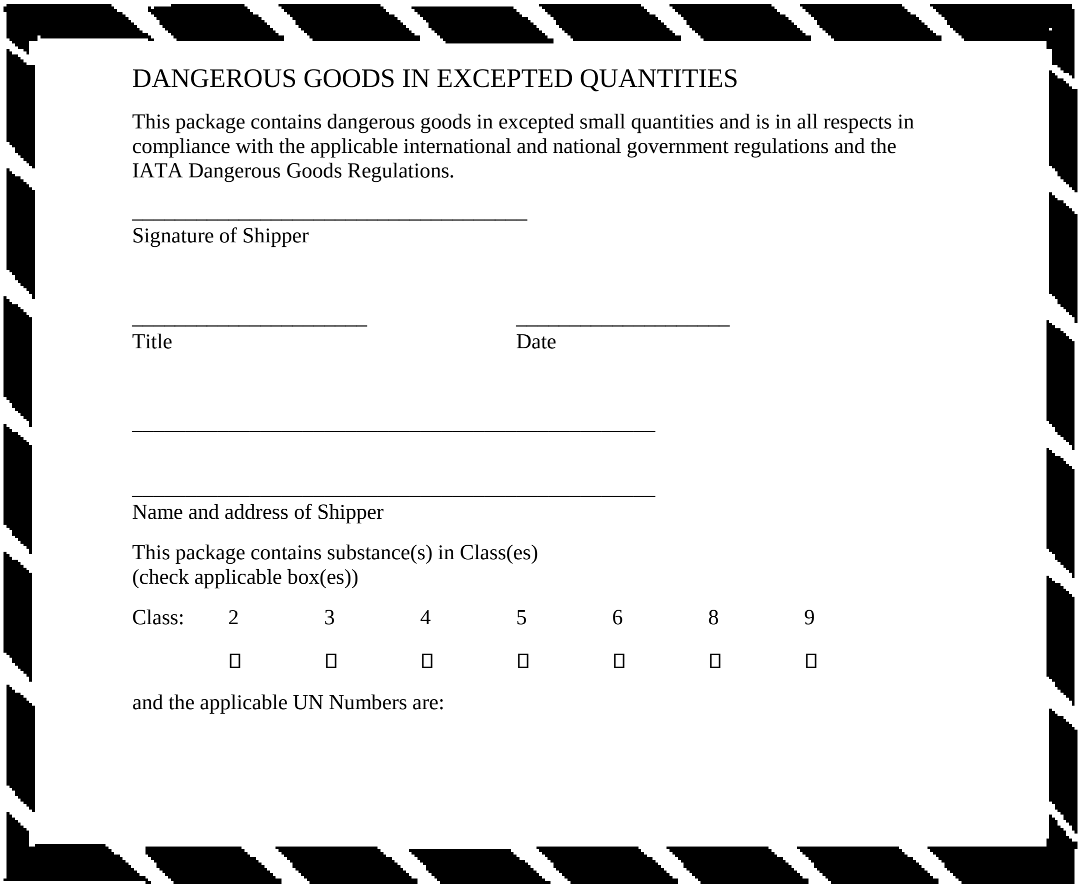
Note B: For inner packagings, the quantity contained in receptacle with a water capacity of 30 mL. For outer packagings, the sum of the water capacities of all the inner packagings contained must not exceed 1 L.

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.

Attachment III-G-3
Label For 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:

ATTACHMENT III-G-4
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.

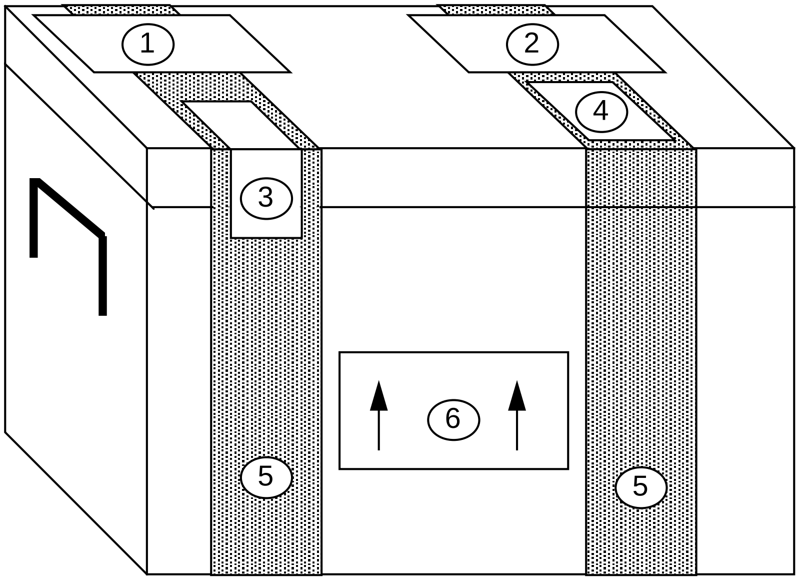
4. When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. for the 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 grater); 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.

Attachment III-G-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**

Attachment III-G-6
Example Courier Form

FedEx USA Airbill FedEx Tracking Number 801704855619 0200 Form I.D. No.

SPL11

Sender's Copy

1 From (please print and press hard)

Date ____ Sender's FedEx Account Number [redacted] Account Number

Sender's Name Joe Smith Phone (808) 545-2462

Company OGDEN ENVIRONMENTAL/CRC ACCT

Address 680 IWILEI RD STE 660 Dept./Floor/Suite/Room

City HONOLULU State HI ZIP 96817

2 Your Internal Billing Reference Information
(Optional) (First 24 characters will appear on invoice)

3 To (please print and press hard)

Recipient's Name Sample Receipt Phone ( ) Lab Phone #

Company Lab Name

☐ Check here if residence
(Extra charge applies for FedEx Express Saver)

Address Lab Address
(To "HOLD" at FedEx location, print FedEx address here) (We Cannot Deliver to P.O. Boxes or P.O. ZIP Codes) Dept./Floor/Suite/Room

City ____ State ____ ZIP ____

For HOLD at FedEx Location check here
☐ Hold Weekday (Not available with FedEx First Overnight)
☐ Hold Saturday (Not available at all locations) (Available for FedEx Priority Overnight and FedEx 2Day only)

For Saturday Delivery check here
☐ (Extra Charge. Not available to all locations) (Available for FedEx Priority Overnight and FedEx 2Day only)

Service Conditions, Declared Value, and Limit of Liability – By using this Airbill, you agree to the service conditions in our current Service Guide or U.S. Government Service Guide. Both are available on request. SEE BACK OF SENDER'S COPY OF THIS AIRBILL FOR INFORMATION AND ADDITIONAL TERMS. We will not be responsible for any claim in excess of $100 per package whether the result of loss, damage, or delay, non-delivery, misdelivery, or misinformation, unless you declare a higher value, pay an additional charge, and document your actual loss in a timely manner. Your right to recover from us for any loss includes intrinsic value of the package, loss of sales, interest, profit, attorney's fees, costs, and other forms of damage, whether direct, incidental, consequential, or special, and is limited to the greater of $100 or the declared value but cannot exceed actual documented loss. The maximum declared value for any FedEx Letter and FedEx Pak is $500. Federal Express may, upon your request, and with some limitations, refund all transportation charges paid. See the FedEx Service Guide for further details.

Questions?
Call 1·800·Go·FedEx (800)463-3339

The World On Time

4a Express Package Service *Packages under 150 lbs.* Delivery commitment may be later in some areas.
☐ FedEx Priority Overnight (Next business morning)
☐ FedEx Standard Overnight (Next business afternoon)
☐ FedEx 2Day* (Second business day)
☐ FedEx Express Saver* (Third business day)
☐ FedEx First Overnight (Earliest next business morning delivery to select locations) (Higher rates apply)
*FedEx Letter Rate not available. Minimum charge: One pound rate.

4b Express Freight Service *Packages over 150 lbs.* Delivery commitment may be later in some areas.
☐ FedEx Overnight Freight (Next business day)
☐ FedEx 2Day Freight (Second business day)
☐ FedEx Express Saver Freight (Up to 3 business days)
(Call for delivery schedule. See back for detailed descriptions of freight services.)

5 Packaging
☐ FedEx Letter
☐ FedEx Pak
— Declared value limit $500. —
☐ FedEx Box
☐ FedEx Tube
☐ Other Pkg.

6 Special Handling
Does this shipment contain dangerous goods? ☐ Yes (As per attached Shipper's Declaration) ☐ Yes (Shipper's Declaration not required)
☐ Dry Ice
Dry Ice, 9, UN 1845 III ____ x ____ kg. 904
(Dangerous Goods Shipper's Declaration not required)
CA ☐ Cargo Aircraft Only

7 Payment
Bill to: ☐ Sender (Account no. in section 1 will be billed) ☐ Recipient ☐ Third Party ☐ Credit Card ☐ Cash/Check
(Enter FedEx account no. or Credit Card no. below)

FedEx Account No. ____
Credit Card No. ____ Exp. Date ____

Total Packages	Total Weight	Total Declared Value*	Total Charges
		$ .00	$

*When declaring a value higher than $100 per shipment, you pay an additional charge. See **SERVICE CONDITIONS, DECLARED VALUE, AND LIMIT OF LIABILITY** section for further information.

8 Release Signature *Sign to authorize delivery without obtaining signature.*

Your signature authorizes Federal Express to deliver this shipment without obtaining a signature and agrees to indemnify and hold harmless Federal Express from any resulting claims.

287

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Part #150364
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003520091 4

RETAIN THIS COPY FOR YOUR RECORDS

Attachment III-G-7
Commercial Invoice - Soil

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CTO #>
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)

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

ATTACHMENT III-G-8
Commercial Invoice - Water

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CTO #>
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.

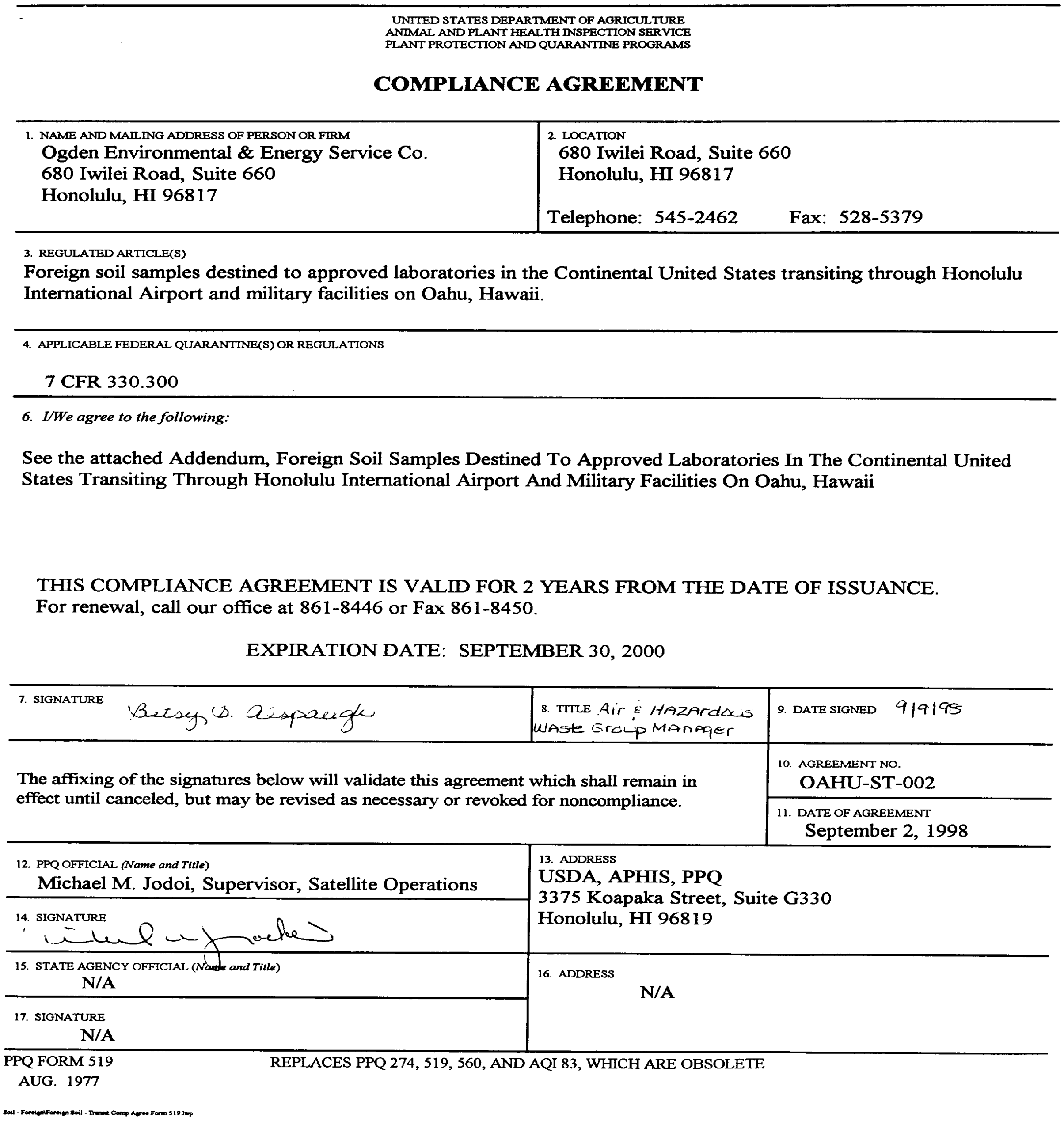
DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

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
Name/Title	Signature	Date

Attachment III-G-9
Soil Import Permit



UNITED STATES DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE PROGRAMS

COMPLIANCE AGREEMENT

1. NAME AND MAILING ADDRESS OF PERSON OR FIRM
Ogden Environmental & Energy Service Co.
680 Iwilei Road, Suite 660
Honolulu, HI 96817

2. LOCATION
680 Iwilei Road, Suite 660
Honolulu, HI 96817
Telephone: 545-2462 Fax: 528-5379

3. REGULATED ARTICLE(S)
Foreign soil samples destined to approved laboratories in the Continental United States transiting through Honolulu International Airport and military facilities on Oahu, Hawaii.

4. APPLICABLE FEDERAL QUARANTINE(S) OR REGULATIONS
7 CFR 330.300

6. *I/We agree to the following:*

See the attached Addendum, Foreign Soil Samples Destined To Approved Laboratories In The Continental United States Transiting Through Honolulu International Airport And Military Facilities On Oahu, Hawaii

THIS COMPLIANCE AGREEMENT IS VALID FOR 2 YEARS FROM THE DATE OF ISSUANCE.
For renewal, call our office at 861-8446 or Fax 861-8450.

EXPIRATION DATE: SEPTEMBER 30, 2000

7. SIGNATURE Betsy D. Aispaugh
8. TITLE Air & Hazardous Waste Group Manager
9. DATE SIGNED 9/9/98

The affixing of the signatures below will validate this agreement which shall remain in effect until canceled, but may be revised as necessary or revoked for noncompliance.

10. AGREEMENT NO. OAHU-ST-002
11. DATE OF AGREEMENT September 2, 1998

12. PPQ OFFICIAL (*Name and Title*)
Michael M. Jodoi, Supervisor, Satellite Operations
13. ADDRESS
USDA, APHIS, PPQ
3375 Koapaka Street, Suite G330
Honolulu, HI 96819
14. SIGNATURE
15. STATE AGENCY OFFICIAL (*Name and Title*) N/A
16. ADDRESS N/A
17. SIGNATURE N/A

PPQ FORM 519
AUG. 1977
REPLACES PPQ 274, 519, 560, AND AQI 83, WHICH ARE OBSOLETE

Soil - Foreign\Foreign Soil - Transit Comp Agree Form 519.wp

Attachment III-G-10
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)

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)

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)

EQUIPMENT DECONTAMINATION

1.0 PURPOSE

The standard operating procedure (SOP) describes general methods of equipment decontamination (decon) for use by U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) field personnel and their contractors during field sampling activities. Some sites may require additional steps (e.g. nitric rinses for metals, hexane for chlorinated pesticides) to insure equipment is properly deconned. These should be identified and addressed in the Work Plans and/or the Quality Assurance Project Plans (QAPPs)

2.0 PROCEDURES

Decontamination of equipment is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program should include consideration of the following factors:

- The location where the decon procedures will be conducted
- The types of equipment requiring decon
- The frequency of equipment decontamination
- The cleaning technique and types of cleaning solutions appropriate to the contaminants of concern
- The method for containing the residual contaminants and wash water from the deconning process
- The use of a quality control measure to determine the effectiveness of the decontamination procedure (e.g. equipment rinsate samples)

This subsection describes standards for decontamination, including the techniques to be used, frequency of decontamination, cleaning solutions, and effectiveness.

2.1 DECONTAMINATION AREA

An appropriate location for the decontamination area at a site shall be selected on the basis of the ability to control access to the area, control residual material removed from equipment, the need to store dirty and clean equipment, and the ability to restrict access to the area being investigated. The decontamination area shall be located an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

2.2 TYPES OF EQUIPMENT

Examples of drilling equipment that must be deconned includes drill bits, auger sections, split spoon samplers, and hand tools. Decontamination of monitoring well development and ground-water sampling equipment includes submersible pumps, non-disposable bailers, interface probes, water level meters, bladder pumps, airlift pumps, and lysimeters. Other sampling equipment that may require decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless steel spoons and bowls, soil sample liners and caps, wipe sampling templates, COLIWASA samplers, and dippers. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and should be properly disposed of after one use.

2.3 FREQUENCY OF EQUIPMENT DECONTAMINATION

Down-hole drilling equipment and equipment used in monitoring well development and purging shall be decontaminated prior to initial use and between each borehole or well. However, down hole drilling equipment 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, the drilling tools shall be decontaminated prior to drilling deeper. Groundwater sampling should be initiated by sampling ground water from the monitoring well where the least contamination is suspected. This is more important when not using disposable equipment. All groundwater, surface water, and soil sampling devices shall be decontaminated prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

2.4 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, pump drop-pipe, etc., is steam cleaning. Steam cleaning is accomplished using a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, equipment shall be thoroughly steam washed and rinsed 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 (Citrinox®, Liquinox®, or other suitable phosphate free detergent) and potable water solution, (2) rinse with potable water, and (3) rinses with deionized or distilled water. Equipment shall be disassembled as much as is practical, prior to cleaning. An initial gross wash scrub down and quick rinse should be completed at the beginning of the process if equipment is heavily soiled. After decontamination, care needs to be taken that the cleaned equipment does not become contaminated. This may require wrapping items in foil or plastic and storing the equipment in a specified “clean” area.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. The pumps shall be decontaminated by circulating fluids through the pump while it is operating. This circulation can be done using a clean 4-inch or greater diameter pipe equipped with an end cap. The pipe shall be filled with enough decon fluid to submerge the pump, the pump placed within the capped pipe, and the pump operated while circulating the fluids within the pipe. The decontamination sequence shall include (1) detergent and potable water, (2) potable water rinse, and (3) deionized or distilled water rinse. The decontamination fluids shall be changed after each cycle. Changing of the fluids may include dumping of the detergent water, mixing detergent in the potable water rinse, using the deionized water as the potable rinse and renewing the distilled/deionized water. All decon water shall be disposed of as outlined in the field work plans.

Decontamination solvent(s) to be used during field activities will be specified in Project Work Plans or QAPPs. If solvents are used, sufficient time must be allowed to insure the solvent has evaporated from the equipment prior to reuse.

Equipment used for measuring field parameters such as pH, temperature, specific conductivity, and turbidity shall be rinsed with deionized or distilled water. New, unused soil sample liners and caps will be cleaned using the three step process, outlined above, to remove any dirt or cutting oils that may be on them prior to use.

2.5 CONTAINMENT OF RESIDUAL CONTAMINANTS AND CLEANING SOLUTIONS

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. This may require setting up a containment area with a system for pumping the water generated decontamination water into proper containers.

Clean equipment should be stored in a separate location to prevent recontamination. Decontamination fluids contained within the bermed area shall be collected and disposed of as outlined in the field sampling plan.

Containment of fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices shall be accomplished using wash buckets or tubs. The decontamination fluids shall be collected and disposed of as outlined in the field sampling plan.

2.6 EFFECTIVENESS OF DECONTAMINATION PROCEDURES

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment rinsate samples or wipe testing. Equipment rinsates 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. Further descriptions of these samples and their required frequency of collection are provided in SOP III-B, *Field QC Samples (Water, Soil)*. 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.

3.0 DOCUMENTATION

The decontamination process shall be recorded in the field logbook.

4.0 REFERENCES

SOP III-B, *Field QC Samples (Water, Soil).*

5.0 ATTACHMENTS

None.

EQUIPMENT CALIBRATION, OPERATION, AND MAINTENANCE

1.0 PURPOSE

This standard operating procedure (SOP) describes the activities and responsibilities of the U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) personnel pertaining to the operating, calibration, and maintenance of equipment used to collect environmental data. Reliable measurements of data required by the field sampling plan are necessary because the information recorded may be the basis for development of remedial action and responses.

2.0 PROCEDURES

2.1 EQUIPMENT CALIBRATION

All water quality monitoring equipment will be calibrated and adjusted to operate within the manufacturers' specifications. Water quality instruments and equipment that require calibration are to be calibrated to specifications prior to field use. In addition, a one-point calibration check is made at midday and at intervals outlined in the field sampling plan. A final check is conducted at the end of each field day. This is not a recalibration of the meter but a check of the calibration to ensure the continued accuracy of the meter. All calibration information shall be recorded in the project logbook.

Special attention shall be paid to instruments that may be affected by the change in the ambient temperature or humidity. Calibration checks should also be performed when sampling conditions change significantly, a change of sample matrix, and/or readings are unstable or there is a change of parameter measurements that appear unusual.

2.2 EQUIPMENT MAINTENANCE

All field monitoring equipment, field sampling equipment, and accessories are to be maintained in accordance with the manufacturer's recommendations and specifications and/or established field practices. All maintenance will be performed by qualified personnel and documented in the field logbook.

Equipment requiring battery charging shall be charged as recommended by the manufacturer. Backup batteries for meters requiring them shall be included as part of the meters accessories. Care must be taken to protect meters from adverse elements. This may involve placing the meter in a large plastic bag to shield it from the weather.

3.0 DOCUMENTATION

All field equipment calibration, maintenance, and operation information shall be recorded within the field logbook. This is to document that appropriate procedures have been followed and to track the equipment operation. All entries in the field logbook must be written accurately and legibly as outlined in the SOP III-D, *Logbooks*.

Logbook entries shall contain, but are not necessarily limited to, the following:

- Equipment model and serial numbers
- Date and time of calibration or maintenance performed
- Calibration standard used
- Calibration lot number and expiration date if listed on bottle
- Calibration procedure used if there are multiple options
- Calibration and calibration check readings including units used
- Problems and solutions regarding use, calibration or maintenance of the equipment
- And other pertinent information

4.0 REFERENCES

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

None.

DRAFT FINAL STANDARD OPERATING PROCEDURE – Navy CLEAN PROGRAM

Groundwater Sampling for Per- and Polyfluoroalkyl Substances (PFAS)

I. Purpose and Scope

This SOP provides guidelines for groundwater sample collection for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15. This SOP should be used in conjunction with approved region-specific groundwater sampling SOPs which provide methods for general and low-flow groundwater sampling. In cases in which information in this SOP conflicts with region-specific groundwater sampling SOPs, this SOP will supersede the information in the general SOPs.

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- If installing wells, ensure driller does not use polytetrafluoroethylene (PFTE)-containing drill lube or other drilling lubes containing PFAS. Biolube has been determined to be an acceptable drilling lube for installing wells where PFAS may be of concern. Additionally, Waterra surge blocks have been confirmed to not contain PFAS and may be used for development.
- Groundwater sampling equipment
  - PFAS-free tubing (avoid Teflon, Viton, PTFE and other fluorinated compounds)
    - High density polyethylene tubing (unlined)
    - If Masterflex tubing is needed for peristaltic pumps, Cole Parmer C-Flex (06424 series) and Tygon E-3603 (06509 series) are suitable options
  - PFAS-free Bailer (if using a bailer[1])
  - PFAS-free Pump such as:
    - Geotech PFAS-free Portable Bladder Pump (note, most bladder pumps include a Teflon-lined bladder, but Geotech currently has one model which is Teflon-free).
    - Panacea P120 or P125. The P200 Stainless Steel Pump may also be used, but the standard model contains Teflon at the tube connection. If you are using this Panacea model, you must request one with the "PTFE-free thread sealant option."
    - Waterra stainless foot-valve
    - QED Sample Pro

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[1] Geotech and Waterra offer PFAS free bailer options

    - Monsoon or Mega Monsoon submersible pump
    - Grundfos Rediflo2 (this pump contains small Teflon components, but has not been shown to leach, it is less preferable than the other options)
    - Peristaltic pump (may be suitable for shallow locations)
- Groundwater sample containers (high density polyethylene [HDPE] bottle with HDPE screwcap), sample bottles should not be glass as glass may sorb PFAS. Sample bottle caps should not contain Teflon. Notify your project manager (PM) if bottles provided by the lab are glass or contain Teflon parts.
- Laboratory prepared deionized, certified PFAS-free water for field blank collection
- PFAS-free shipping supplies (labels [if available][2], coolers, and ice)
- Loose leaf paper without waterproof coating or a spiralbound notebook (not waterproof)
- Metal clip board (if using loose-leaf paper)
- Pen (not Sharpie)
- Nitrile or latex gloves

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect groundwater samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

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[2] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine

Follow Navy CLEAN SOPs for low-flow or conventional groundwater sample collection, depending on site requirements.

Sample Collection

Once water quality parameters have stabilized for low-flow purging, samples can be collected. For conventional purging, if water quality parameters do not stabilize, a minimum of 3 well volumes must be purged prior to sample collection.

The steps to be followed for sample collection are as follows:

1. Ensure that the end of the tubing does not touch the ground or equipment. Remove the cap from the sample bottle. Position the sample bottle under the end of the tubing.
2. Fill the bottle. Samples do not need to be collected headspace free.
3. Affix labels after bottles have been closed; collect only one sample at a time to avoid mislabeling. Pack the sample on ice immediately for shipment to the offsite laboratory. Avoid packing materials that may contain fluorine. Unpublished research has allowed us to generate a list of packing materials which do not contain fluorine. Please contact Bill Diguiseppi or Laura Cook for recommendations (because the research is not ours, it cannot be released externally at this time).

Equipment Decontamination

Whenever possible, use disposable equipment when collecting groundwater samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

Use of Water Quality Equipment and Water Level Indicators

Water quality meters typically do not contain PFAS. However, consistent with general sampling SOPs, disconnect the water quality meter prior to sampling. Some water level indicators do contain small polyvinylidene fluoride (a PFAS constituent for which we do not currently monitor) or less frequently, Teflon, components, but we have not noted cross contamination from water level indicators at any sites. The Durham Geoslope Water Level Indicators have been shown to be fluorine free.

V. References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/ Tandem Mass Spectrometry (LC/MS/MS).* September.

United States Navy, 2017. *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs).* September

United States Navy, 2015. *Navy Drinking Water Sampling Policy for Perfluorochemicals: Perfluorooctane Sulfonate and Perfluorooctanoic acid.* September.

DRAFT FINAL STANDARD OPERATING PROCEDURE – Navy CLEAN PROGRAM

Rotosonic Groundwater Sample Collection for Per- and Polyfluoroalkyl Substances

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I. Purpose and Scope

This SOP provides guidelines for groundwater sample collection using rotosonic drilling technology for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15.

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- Sonic drill sampling rods and retractable stainless-steel screen without PFAS-containing components (Avoid Teflon, Viton, PTFE and all other fluorinated compounds)
- PFAS-free tubing (avoid Teflon, Viton, PTFE and other fluorinated compounds)
  - High density polyethylene tubing (unlined)
  - Masterflex tubing, Cole Parmer C-Flex (06424 series) and Tygon E-3603 (06509 series) are suitable options
- Water quality meter (Horiba® or YSI®)
- PFAS-free bladder pump
- Pre-cleaned sample containers
- Air monitoring and water quality instruments (as needed)
- Personal protective equipment
- Groundwater sample containers (high density polyethylene [HDPE] with HDPE screw cap [no Teflon caps])
- PFAS-free shipping labels (if available[1]) materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard
- Pen (not Sharpie)
- Nitrile or Latex gloves
- Laboratory prepared deionized, certified PFAS-free water for field blank collection
- PVC casing and screen for temporary well

Ensure the driller has not used and will not use drilling lube containing polytetrafluoroethylene (PFTE) or any other fluorine-containing substance. Biolube has been determined to be an acceptable substitute.

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[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect groundwater samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine.

Once the area has been determined to be free of materials potentially containing PFAS, these steps can be followed to collect the sonic groundwater sample:

1. Decontaminate slotted lead rod and other downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment* and this SOP.
2. Drive lead probe rod to the desired sampling depth, and withdraw rods 2 to 3 feet to expose the retractable screen to the aquifer formation. Ensure that the screened lead rod has been inserted to the desired sampling depth. If using temporary well casing, deploy PVC screen and casing to desired sampling depth.
3. Insert the stainless-steel foot valve into the end of the polyethylene sampling tubing and insert tubing through the rods or insert peristaltic pump tubing through rods, depending on which method is used.
4. Collect and record one set of water quality parameters prior to sampling.

5. Fill all sample containers. Samples should be collected in accordance with SOP *Groundwater Sampling when Analyzing for Per- and Polyfluoroalkyl Substances (PFAS)***.** Affix labels after bottles have been closed; collect only one sample at a time to avoid mislabeling.
6. Remove and discard polyethylene sampling tubing from the rods. Withdraw PVC temporary PVC screen and casing.

Equipment Decontamination

Ensure that the sonic rig operator thoroughly completes the decontamination process between sampling locations. Do not use water from the facility (e.g. fire hydrants) if there is a possibility that the water available is contaminated with PFAS.

Whenever possible, use disposable equipment when collecting groundwater samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

Use of Water Quality Equipment

Water quality meters typically do not contain PFAS. However, consistent with general sampling SOPs, disconnect the water quality meter prior to sampling.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

United States Navy, 2015. *Navy Drinking Water Sampling Policy for Perfluorochemicals: Perfluorooctane Sulfonate and Perfluorooctanoic acid.* September*.*

STANDARD OPERATING PROCEDURE

Soil Sampling for Per- and Poly-fluoroalkyl Substances

I. Purpose

To provide general guidelines for the collection and handling of soil samples collected in support of per- and poly-fluorinated alkyl substance (PFAS) investigations.

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000.

II. Scope

The method described applies to soil sampling for PFAS constituents using a variety of collection tools (hand auger, split spoon, direct push technology [DPT] sampling, and trowel collection).

III. Equipment and Materials

- Sample jars (sample jars should be made of polyethylene as glass jars may sorb PFAS, please notify the project manager [PM] if glass jars are provided by the lab). Sample containers should not contain Teflon lids.
- A hand auger or other device that can be used to remove the soil from the ground. Stainless steel tools, carbon steel tools, or steel DPT tooling with acetate sleeves are preferred for PFAS sampling. Avoid any sampling materials containing Teflon. Any plastic sampling materials should be evaluated thoroughly before selection to ensure they are fluorine-free
- A stainless steel spatula or fluorine-free disposable plastic scoop should be used to remove material from the sampling device.
- Unpainted wooden stakes or pin flags
- Fiberglass measuring tape (at least 200 feet in length)
- GPS Unit
- PFAS-free shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Clipboard (if using loose-leaf paper)
- Pen (not Sharpie)
- Nitrile or Latex gloves

Equipment and materials used to collect soil samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton).

Specifically, the following material should be avoided during sampling:

- Gore-tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistent clothing with fluorochemical treatment or anything advertised as a water repellent.

- Weatherproof logbooks with fluorochemical coatings
- New clothing that has been washed fewer than six times

If a driller is supporting collection of soil samples in split spoons or acetate DPT sleeves, ensure the driller has not used and will not use drilling lube containing polytetrafluoroethylene (PFTE) or any other fluorine-containing substance. Biolube has been determined to be an acceptable substitute.

IV. Procedures and Guidelines

Prior to initiating soil sampling activities, steps should be taken to ensure the sampling area is free of pre-packaged food wrappers, microwave popcorn bags, blue ice containers, aluminum foil, Kim-wipes, sunscreen, insect repellent, and other personal hygiene products unless these products have been confirmed to be fluorine-free.

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

Once the area has been determined to be free of materials potentially containing PFAS, these steps can be followed to collect the soil samples:

A. Wear protective gear, as specified in the Health and Safety Plan.

B. To locate samples, identify the correct location using the pin flags or stakes. Proceed to collect a sample from the undisturbed soil adjacent to the marker following steps C and D. If markers are not present, the following procedures will be used.

   1. For samples on a grid:

      a. Use measuring tape to locate each sampling point on the first grid line as prescribed in the sampling plan. As each point is located, drive a numbered stake in the ground and record its location on the site map and in the field notebook/clipboard.
      b. Proceed to sample the points on the grid line.
      c. Measure to location where next grid line is to start and stake first sample. For subsequent samples on the line take two orthogonal measurements: one to the previous grid line, and one to the previous sample on the same grid line.
      d. Proceed to sample the points on the grid line as described in Section C below.
      e. Repeat 1c and 1d above until all samples are collected from the area.

    - f. Or, a GPS unit can be used to identify each location based on map coordinated, if available.
  2. For non-grid samples:
    - a. Use measuring tape to position sampling point at location described in the sampling plan by taking two measurements from fixed landmarks (e.g., corner of house and fence post).
    - b. Note measurements, landmarks, and sampling point on a sketch in the field notebook, and on a site location map.
    - c. Proceed to sample as described in Section C below.
    - d. Repeat 2a through 2c above until all samples are collected from the area.
    - e. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

C. To the extent possible, differentiate between fill and natural soil. If both are encountered at a boring location, sample both as prescribed in the field sampling plan. Do not locate samples in debris, tree roots, or standing water. In residential areas, do not sample in areas where residents' activities may impact the sample (e.g., barbecue areas, beneath eaves of roofs, driveways, garbage areas). If an obstacle prevents sampling at a measured grid point, move as close as possible, but up to a distance of one half the grid spacing in any direction to locate an appropriate sample. If an appropriate location cannot be found, consult with the Field Team Leader (FTL). If the FTL concurs, the sampling point may be deleted from the program. The FTL will contact the CH2M HILL PM immediately. The PM and Navy Technical Representative (NTR) will discuss whether the point should be deleted from the program. If it is deleted, the PM will follow-up with the NTR in writing.

D. To collect samples using standard methods:

1. Use a decontaminated stainless steel scoop/trowel or disposable plastic scoop to scrape away surficial organic material (grass, leaves, etc.) adjacent to the stake. New disposable scoops or trowels may also be used to reduce the need for equipment blanks if the disposable scoops have been confirmed by your project PFAS subject matter expert (SME) to be PFAS free.

2. If sampling:
    - a. Surface soil: Obtain soil sample by scooping soil using the augering scoop/trowel, starting from the surface and digging down to a depth of about 6 inches, or the depth specified in the workplan.
    - b. Subsurface soil: Obtain the subsurface soil sample using an auger down to the depths prescribed in the field sampling plan.

3. Record lithologic description and any pertinent observations (such as discoloration) in the field notebook/clipboard.

4. Empty the contents of the scoop/trowel into a decontaminated stainless steel pan or dedicated sealable bag.

5. Repeat this procedure until sufficient soil is collected to meet volume requirements.

6. Homogenize cuttings in the pan using a decontaminated stainless steel utensil.
7. Transfer sample for analysis into appropriate containers with a decontaminated utensil.
8. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.
9. Backfill the hole with soil removed from the borehole. To the extent possible, replace topsoil and grass and attempt to return appearance of sampling area to its pre-sampled condition. For samples in non-residential, unmowed areas, mark the sample number on the stake and leave stake in place. In mowed areas, remove stake.

E. To collect Samples Using DPT Methods

1. Decontaminate sampling tubes and other non-dedicated downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment*. Ensure that decontamination water used is PFAS free (do not use water from fire hydrants on-base for steam cleaning unless the water has been demonstrated to be free of PFAS).
2. Drive sampling tube to the desired sampling depth using the truck-mounted hydraulic percussion hammer. If soil above the desired depth is not to be sampled, first drive the lead rod, without a sampling tube, to the top of the desired depth.
3. Remove the rods and sampling tube from the borehole and remove the sampling tube from the lead rod.
4. Cut open the acetate liner using a specific knife designed to slice the acetate liners (see below).

5. Fill all sample containers, using a decontaminated or dedicated sampling implement. Label the containers and immediately place samples on ice for shipment to the laboratory.
6. Decontaminate all non-dedicated downhole equipment (rods, sampling tubes, etc.) in accordance with SOP Decontamination of Personnel and Equipment and ensure decontamination water is from a PFAS-free water source.

7. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

V. Attachments

None.

VI. Key Checks and Items

- Decontaminate utensils before reuse with the last rinse using laboratory-provided certified PFAS-free water or use dedicated, disposable utensils which are PFAS-free.
- Field blank and field reagent blank procedures for PFAS sampling vary based on the lab's Method 537 Modified SOP. When using a Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) accredited laboratory, follow any procedures specified in the approved method.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

United States Navy, 2015. *Field Sampling Protocols to Avoid Cross-Contamination during Water Sampling for Perfluorinated Compounds (PFCs).*

STANDARD OPERATING PROCEDURE – Navy CLEAN PROGRAM

Management of Liquid Waste Containing Per- and Polyfluoroalkyl Substances (PFAS)

I. Purpose and Scope

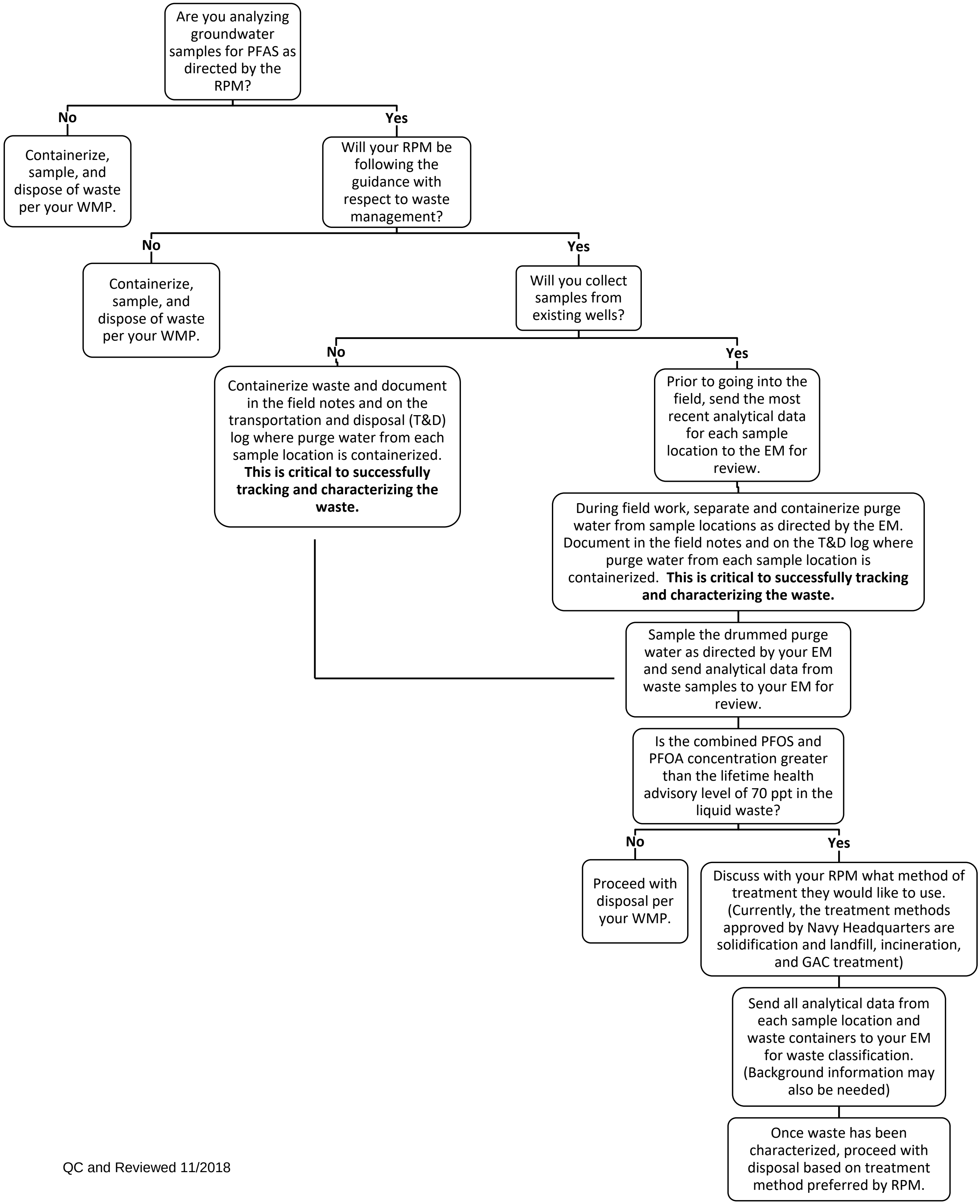
This SOP provides guidelines for managing waste containing per- and polyfluoalklyl substances (PFAS) in accordance with the *Interim Per- and Polyfluoralkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update* (guidance). This SOP should be used in conjunction with an Environmental and/or Waste Management Plan (EMP and/or WMP) approved by your Environmental Manager (EM). If you do not have a site-specific EMP, please contact your EM.

Standard procedures for managing liquid waste during PFAS investigation are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000.

Currently, PFAS are not regulated as a hazardous waste in US EPA regulations (state and territory rules may vary). Treatment of liquid waste containing PFAS, as recommended by the guidance, is a client directed action. When and how it is implemented will be left to the discretion of the individual RPMs. These project specific actions will be communicated with the Project Manager (PM) and/or Activity Manager (AM).

II. Procedures and Guidelines

The following flowchart outlines the procedures required to manage liquid waste during PFAS investigations. Any deviations from this procedure must be approved by the EM.



Are you analyzing groundwater samples for PFAS as directed by the RPM?

Containerize, sample, and dispose of waste per your WMP.

Will your RPM be following the guidance with respect to waste management?

Containerize, sample, and dispose of waste per your WMP.

Will you collect samples from existing wells?

Containerize waste and document in the field notes and on the transportation and disposal (T&D) log where purge water from each sample location is containerized. **This is critical to successfully tracking and characterizing the waste.**

Prior to going into the field, send the most recent analytical data for each sample location to the EM for review.

During field work, separate and containerize purge water from sample locations as directed by the EM. Document in the field notes and on the T&D log where purge water from each sample location is containerized. **This is critical to successfully tracking and characterizing the waste.**

Sample the drummed purge water as directed by your EM and send analytical data from waste samples to your EM for review.

Is the combined PFOS and PFOA concentration greater than the lifetime health advisory level of 70 ppt in the liquid waste?

Proceed with disposal per your WMP.

Discuss with your RPM what method of treatment they would like to use. (Currently, the treatment methods approved by Navy Headquarters are solidification and landfill, incineration, and GAC treatment)

Send all analytical data from each sample location and waste containers to your EM for waste classification. (Background information may also be needed)

Once waste has been characterized, proceed with disposal based on treatment method preferred by RPM.

QC and Reviewed 11/2018

DRAFT FINAL STANDARD OPERATING PROCEDURE – NAVY CLEAN PROGRAM

Surface Water Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose and Scope

This SOP provides guidelines for surface water sample collection for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Materials and Equipment

Equipment and Materials Required

- Open tube sampler
- Dip sampler
- Weighted bottle sampler (no glass)
- Hand pump without Teflon components
- Van Dorn sampler (Kemmerer cannot be used as it has Teflon caps)
- Depth-integrating sampler
- Peristaltic pump and PFAS-free tubing
    - High density polyethylene tubing (unlined)
    - Masterflex tubing such as Cole Parmer C-Flex (06424 series) and Tygon E-3603 (06509 series) are suitable options
- Sample containers (high density polyethylene [HDPE] with HDPE screw cap [no Teflon caps])
- PFAS-free labels (if available[1]) and shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard
- Pen (not Sharpie)
- Nitrile or Latex gloves (Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine)
- Meters for specific conductance, temperature, pH, and dissolved oxygen

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[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

Equipment and materials used to collect surface water samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton). Neoprene and rubber waders should not be an issue, however, check with your PFAS subject matter expert (SME) during field preparation to ensure all equipment is free of fluorine-containing components.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect groundwater samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine.

Before surface water samples are taken, all sampler assemblies and sample containers are cleaned and decontaminated as described in SOP *Decontamination of Personnel and Equipment* as well as this SOP (see below). Surface water samples collected from water bodies tidally influenced should be collected at low tide and under low flow conditions to minimize the dilution of potential contaminants. Once the area has been determined to be free of materials potentially containing PFAS, follow the methods for surface water sample collection described below.

Surface water samples are collected manually by submerging a clean stainless steel or polypropylene container into the water body. Samples may be collected at depth with a covered bottle that can be removed with a tripline provided the bottle or bottle cap does not contain Teflon. The most common sampler types are sealable bottles, pond samplers, peristaltic pumps, and weighted bottle samplers. Pond samplers have a fixed or telescoping pole attached to the sample container. Weighted bottle samplers are lowered below water surface, where the attached bottle is opened, allowed to fill, and pulled out of the water. When retrieved, the bottle is tightly capped and removed from the sampler assembly. A specific type of weighted bottle sampler is the Van Dorn and is acceptable in most instances. The Kemmerer weighted bottle sampler cannot be used for PFAS sampling due to the Teflon caps.

A sample is taken with the following specific steps:

1. The location and desired depth for water sampling are selected.
2. The sample site is approached from downstream in a manner that avoids disturbance of bottom sediments as much as possible. The sample bottle is gently submerged with the mouth pointed upstream and the bottle tilted slightly downstream. Bubbles and floating materials should be prevented from entering the bottle. If using a Peristaltic pump, lower the tubing into the water to the desired depth.
3. For weighted bottle samplers, the assembly is slowly lowered to the desired depth. The bottle stopper is unseated with a sharp tug and the bottle is allowed to fill until bubbles stop rising to the surface.
4. When the bottle is full, it is gently removed from the water. If sample transfer is required, it should be performed at this time. Fill all sample containers. Affix labels after sample containers are closed; collect only one sample at a time to avoid mislabeling.
5. Measure dissolved oxygen, specific conductance, temperature, and pH at the sampling location.

Equipment Decontamination

Whenever possible, use disposable equipment when collecting surface water samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

Use of Water Quality Equipment

Water quality meters typically do not contain PFAS. However, consistent with general sampling SOPs, disconnect the water quality meter prior to sampling.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

United States Navy, 2015. *Navy Drinking Water Sampling Policy for Perfluorochemicals: Perfluorooctane Sulfonate and Perfluorooctanoic acid.* September.

STANDARD OPERATING PROCEDURE

Sediment Sampling

I. Purpose

These general outlines describe the collection and handling of sediment samples during field operations.

II. Scope

The sediment sampling procedures generally describe the equipment and techniques needed to collect representative sediment samples. Operators manual, if available, should be consulted for specific details

III. Equipment and Materials

- Sample collection device (hand corer, scoop, dredge, grab sampler, or other suitable device)
- Stainless steel spoon or spatula or plastic disposable scoop for media transfer
- Measuring tape
- Log book
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.)
- Materials for classifying soils, particularly the percentage of fines
- Sample jars, including jars for Total Organic Carbon and pH, as appropriate

IV. Procedures and Guidelines

1. Field personnel will start downstream and work upstream to prevent contamination of unsampled areas. In surface water bodies that are tidally influenced, sampling will be performed at low tide and under low flow conditions to minimize the dilution of possible contaminants. Sediment sampling activities will not occur immediately after periods of heavy rainfall.
2. Make a sketch of the sample area that shows important nearby river features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features. Also include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (along shore, mid-channel, etc).

3. Note in the field book any possible outside sources of contamination; for example, the outlet to a drainage culvert in the water body near your sampling location.

4. Transfer sample into appropriate sample jars with a stainless-steel utensil or plastic disposable scoop. Be especially careful to avoid the loss of the very fine clay/silt particles when collecting the sample. The fine particles have a higher adsorption capacity than larger particles. Minimize the amount of water that is collected within the sample matrix. Decant the water off of the sample slowly and carefully to maximize retention of the very fine particles. The sampler's fingers should never touch the sediment since gloves may introduce organic interference into the sample. Classify the soil type of the sample using the Unified Soil Classification System, noting particularly the percentage of silt and clay.

5. Samples for volatile organics should immediately be placed in jars. Rocks and other debris should be removed before placement in jars.

6. For channel sampling, be on the alert for submerged hazards (rocks, tree roots, drop-offs, loss silt and muck) which can make wading difficult.

7. Sample sediment for TOC and pH also, to give context to organic and inorganic data during the risk assessment.

8. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.

9. Follow the site safety plan designed for the specific nature of the site's sampling activities and locations.

10. Decontaminate all sampling implements and protective clothing according to prescribed procedures.

V. Attachments

None.

VI. Key Checks and Items

- Start downstream, work upstream.
- Log exact locations using permanent features.
- Beware of hidden hazards.

DRAFT FINAL NAVY CLEAN STANDARD OPERATING PROCEDURE

Sediment Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose and Scope

This SOP provides guidelines for sediment sample collection and handling for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- Sample collection device (hand corer, scoop, dredge, grab sampler, or other suitable device). Check with your PFAS subject matter expert (SME) during field preparation to ensure all equipment is free of fluorine-containing components.
- Stainless steel spoon or spatula or fluorine-free plastic disposable scoop for media transfer
- Measuring tape
- GPS Unit
- PFAS-free labels (if available[1]) shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard (if using loose-leaf paper)
- Pen (not Sharpie)
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.). Check with your SME prior to selecting PPE to ensure there are no fluorine-containing components.
- Materials for classifying soils, particularly the percentage of fines
- Sample jars (high density polyethylene [HDPE] with HDPE screw cap [no Teflon caps])
- Laboratory prepared deionized, certified PFAS-free water for field blank collection

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[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect soil samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine.

Once the area has been determined to be free of materials potentially containing PFAS, these steps can be followed to collect the sediment samples:

1. Field personnel will start downstream and work upstream to prevent contamination of unsampled areas. In surface water bodies that are tidally influenced, sampling will be performed at low tide and under low flow conditions to minimize the dilution of possible contaminants. Sediment sampling activities will not occur immediately after periods of heavy rainfall.
2. Make a sketch of the sample area that shows important nearby river features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features.

Also include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (along shore, mid-channel, etc).

3. Note in the field book any possible outside sources of contamination; for example, the outlet to a drainage culvert in the water body near your sampling location.

4. Transfer sample into appropriate sample jars with a stainless steel utensil or plastic disposable scoop confirmed to be fluorine-free. Be especially careful to avoid the loss of the very fine clay/silt particles when collecting the sample. The fine particles have a higher adsorption capacity than larger particles. Minimize the amount of water that is collected within the sample matrix. Decant the water off the sample slowly and carefully to maximize retention of the very fine particles. The sampler's fingers should never touch the sediment. Classify the soil type of the sample using the Unified Soil Classification System, noting particularly the percentage of silt and clay. Affix the sample label to the container after the container has been closed; collect only one sample at a time to avoid mislabeling.

5. Rocks and other debris should be removed before placement in jars.

6. For channel sampling, be on the alert for submerged hazards (rocks, tree roots, drop-offs, loess silt and muck) which can make wading difficult.

7. Immediately upon collection, all samples are to be placed in a closed container on ice. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.

Equipment Decontamination

Whenever possible, use disposable equipment when collecting sediment samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

United States Navy, 2015. *Navy Drinking Water Sampling Policy for Perfluorochemicals: Perfluorooctane Sulfonate and Perfluorooctanoic acid.* September.

Appendix B

Department of Defense Environmental Laboratory Accreditation Program Accreditation Letters

PERRY JOHNSON LABORATORY ACCREDITATION, INC.

Certificate of Accreditation

Perry Johnson Laboratory Accreditation, Inc. has assessed the Laboratory of:

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061

(Hereinafter called the Organization) and hereby declares that Organization has met the requirements of ISO/IEC 17025:2017 "General Requirements for the competence of Testing and Calibration Laboratories" and the DoD Quality Systems Manual for Environmental Laboratories Version 5.3 February 2018 and is accredited is accordance with the:

United States Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP)

This accreditation demonstrates technical competence for the defined scope:

Environmental Testing

(As detailed in the supplement)

Accreditation claims for such testing and/or calibration services shall only be made from addresses referenced within this certificate. This Accreditation is granted subject to the system rules governing the Accreditation referred to above, and the Organization hereby covenants with the Accreditation body's duty to observe and comply with the said rules.

For PJLA:

Initial Accreditation Date:	*Issue Date:*	*Expiration Date:*
November 17, 2016	December 20, 2018	February 28, 2021
Revision Date:	*Accreditation No.:*	*Certificate No.:*
July 17, 2020	91667	L18-588-R4

Tracy Szerszen
President

Perry Johnson Laboratory
Accreditation, Inc. (PJLA)
755 W. Big Beaver, Suite 1325
Troy, Michigan 48084

The validity of this certificate is maintained through ongoing assessments based on a continuous accreditation cycle. The validity of this certificate should be confirmed through the PJLA website: www.pjlabs.com

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Drinking Water	EPA 537.1	LC/MS/MS	4,8-dioxa-3H-perfluorononanoic acid (ADONA)
Drinking Water	EPA 537.1	LC/MS/MS	9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)
Drinking Water	EPA 537.1	LC/MS/MS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)
Drinking Water	EPA 537.1	LC/MS/MS	Hexafluoropropylene oxide dimer acid (HFPO-DA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-hexanoic acid (PFHxA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-heptanoic Acid (PFHpA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-octanoic Acid (PFOA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluorononanoic acid (PFNA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-decanoic Acid (PFDA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-undecanoic acid (PFUnA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-dodecanoic acid (PFDoA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-tridecanoic acid (PFTrDA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-tetradecanoic acid (PFTeDA)
Drinking Water	EPA 537.1	LC/MS/MS	N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)
Drinking Water	EPA 537.1	LC/MS/MS	N-ethylperfluoro-octanesulfonamidoacetic acid (NEtFOSAA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-1-butanesulfonic Acid (PFBS)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-1-hexanesulfonic Acid (PFHxS)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-1-octanesulphonic Acid (PFOS)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	3-Perfluoropropyl propanoic Acid (3:3 FTCA)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	3-Perfluoropropyl propanoic acid (5:3 FTCA)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	3-Perfluoropropyl propanoic acid (7:3 FTCA)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-octanesulfonamide (PFOSA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	4,8-dioxa-3H-perfluorononanoic acid (Adona)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9CI-PF3ONS)

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11CI-PF3OUdS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Hexafluoropropylene oxide dimer acid (HFPO-DA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Sodium perfluoro-1-pentanesulfonate (PFPeS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-nonanesulfonate (PFNS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-heptanesulfonate (PFHpS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	N-ethylperfluoro-octanesulfonamidoacetic acid (NEtFOSAA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorohexane sulfonate (4:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorooctane sulfonate (6:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorodecane sulfonate (8:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-butanoic Acid (PFBA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-pentanoic acid (PFPeA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-hexanoic acid (PFHxA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-heptanoic Acid (PFHpA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-octanoic Acid (PFOA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluorononanoic acid (PFNA)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-decanoic Acid (PFDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-undecanoic acid (PFUnA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-dodecanoic acid (PFDoA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-tridecanoic acid (PFTrDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-tetradecanoic acid (PFTeDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-butanesulfonic Acid (PFBS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-hexanesulfonic Acid (PFHxS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-octanesulphonic Acid (PFOS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-decanesulfonate (PFDS)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,3',4,5-Hexachlorobiphenyl (BZ 129)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',6,6'-Heptachlorobiphen yl (BZ 184)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,5'-Tetrachlorobiphenyl (BZ 49)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',5-Trichlorobiphenyl (BZ 18)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3,3',4,4'-Pentachlorobiphenyl (BZ 105)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3',4,4',5-Pentachlorobiphenyl (BZ 118)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4,4'-Trichlorobiphenyl (BZ 28)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDD
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDE
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDT
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-Dichlorobiphenyl (BZ 8)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4',5,5'-Hexachlorobiphenyl (BZ 169)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4',5-Pentachlorobiphenyl (BZ 126)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4'-Tetrachlorobiphenyl (BZ 77)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDD
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDE
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDT
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Aldrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	alpha-BHC (alpha-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	alpha-Chlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	beta-BHC (beta-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Chlorpyrifos
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	cis-Nonachlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Decachlorobiphenyl (BZ 209)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	delta-BHC
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Dieldrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan II
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan I
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan sulfate
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin aldehyde
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin ketone
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	gamma-Chlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Heptachlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Heptachlor epoxide
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Hexachlorobenzene

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Methoxychlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Mirex
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Oxychlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	trans-Nonachlor
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	1,4-Dichlorobenzene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	1-Methylnaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	1-Methylphenanthrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (BZ 206)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5,5'-Octachlorobiphenyl (BZ 194)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl (BZ 207)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5,6-Octachlorobiphenyl (BZ 195)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5-Heptachlorobiphenyl (BZ 170)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',6,6'-Octachlorobiphenyl (BZ 197)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',6-Heptachlorobiphenyl (BZ 171)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (BZ 208)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,5',6-Octachlorobiphenyl (BZ 198)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,5',6'-Octachlorobiphenyl (BZ 199)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,5'-Heptachlorobiphenyl (BZ 172)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,6,6'-Octachlorobiphenyl (BZ 200)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5',6,6'-Octachlorobiphenyl (BZ 201)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,6-Heptachlorobiphenyl (BZ 173)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,6'-Heptachlorobiphenyl (BZ 174)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5',6-Heptachlorobiphenyl (BZ 175)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5',6'-Heptachlorobiphenyl (BZ 177)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5'-Hexachlorobiphenyl (BZ 130)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,6,6'-Heptachlorobiphenyl (BZ 176)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,6-Hexachlorobiphenyl (BZ 131)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4-Pentachlorobiphenyl (BZ 82)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,5',6,6'-Octachlorobiphenyl (BZ 202)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,5',6-Heptachlorobiphenyl (BZ 178)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,6,6'-Heptachlorobiphenyl (BZ 179)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,6-Hexachlorobiphenyl (BZ 134)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,6'-Hexachlorobiphenyl (BZ 135)

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5-Pentachlorobiphenyl (BZ 83)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',6,6'-Hexachlorobiphenyl (BZ 136)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',6-Pentachlorobiphenyl (BZ 84)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3'-Tetrachlorobiphenyl (BZ 40)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5,5',6-Octachlorobiphenyl (BZ 203)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5-Hexachlorobiphenyl (BZ 137)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',6,6'-Heptachlorobiphenyl (BZ 184)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',6-Hexachlorobiphenyl (BZ 139)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',6'-Hexachlorobiphenyl (BZ 140)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4'-Pentachlorobiphenyl (BZ 85)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,5,5',6-Heptachlorobiphenyl (BZ 185)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,5,5'-Hexachlorobiphenyl (BZ 141)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5,5'-Hexachlorobiphenyl (BZ 146)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5,6,6'-Heptachlorobiphenyl (BZ 188)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5',6-Hexachlorobiphenyl (BZ 149)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,5',6-Hexachlorobiphenyl (BZ 144)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5'-Pentachlorobiphenyl (BZ 97)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',6-Pentachlorobiphenyl (BZ 91)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4-Tetrachlorobiphenyl (BZ 41)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4'-Tetrachlorobiphenyl (BZ 42)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5,5',6-Hexachlorobiphenyl (BZ 151)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5,5'-Pentachlorobiphenyl (BZ 92)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5',6-Pentachlorobiphenyl (BZ 95)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5-Tetrachlorobiphenyl (BZ 43)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,6'-Tetrachlorobiphenyl (BZ 46)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,6-Tetrachlorobiphenyl (BZ 45)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3-Trichlorobiphenyl (BZ 16)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',5,6'-Hexachlorobiphenyl (BZ 154)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',5-Pentachlorobiphenyl (BZ 99)

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',6,6'-Hexachlorobiphenyl (BZ 155)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',6-Pentachlorobiphenyl (BZ 100)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4'-Tetrachlorobiphenyl (BZ 47)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,5-Tetrachlorobiphenyl (BZ 48)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,5'-Tetrachlorobiphenyl (BZ 49)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,6,6'-Pentachlorobiphenyl (BZ 104)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,6'-Tetrachlorobiphenyl (BZ 51)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,6-Tetrachlorobiphenyl (BZ 50)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4-Trichlorobiphenyl (BZ 17)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',5,6'-Tetrachlorobiphenyl (BZ 53)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',5-Trichlorobiphenyl (BZ 18)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',6,6'-Tetrachlorobiphenyl (BZ 54)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',6-Trichlorobiphenyl (BZ 19)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2'-Dichlorobiphenyl (BZ 4)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5,5',6-Octachlorobiphenyl (BZ 205)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5,5'-Heptachlorobiphenyl (BZ 189)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5,6-Heptachlorobiphenyl (BZ 190)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5',6-Heptachlorobiphenyl (BZ 191)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5-Hexachlorobiphenyl (BZ 156)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5'-Hexachlorobiphenyl (BZ 157)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',6-Hexachlorobiphenyl (BZ 158)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4'-Pentachlorobiphenyl (BZ 105)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4',5,5',6-Heptachlorobiphenyl (BZ 193)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4',5,6-Hexachlorobiphenyl (BZ 163)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4',5',6-Hexachlorobiphenyl (BZ 164)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4'-Tetrachlorobiphenyl (BZ 56)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,4',5,5'-Hexachlorobiphenyl (BZ 167)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4,4',5,6-Hexachlorobiphenyl (BZ 166)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4,4',5-Pentachlorobiphenyl (BZ 114)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,4',5-Pentachlorobiphenyl (BZ 118)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,4',5'-Pentachlorobiphenyl (BZ 123)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4,4',6-Pentachlorobiphenyl (BZ 115)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4,4'-Tetrachlorobiphenyl (BZ 60)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4',5,5'-Pentachlorobiphenyl (BZ 124)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4',5',6-Pentachlorobiphenyl (BZ 125)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4',5-Tetrachlorobiphenyl (BZ 63)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,5-Tetrachlorobiphenyl (BZ 67)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4',5-Tetrachlorobiphenyl (BZ 70)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4',6-Tetrachlorobiphenyl (BZ 64)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4',6-Tetrachlorobiphenyl (BZ 71)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4'-Trichlorobiphenyl (BZ 22)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4-Trichlorobiphenyl (BZ 25)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4'-Trichlorobiphenyl (BZ 33)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',5-Trichlorobiphenyl (BZ 26)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,5-Trimethylnaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,6-Trichlorobiphenyl (BZ 24)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',6-Trichlorobiphenyl (BZ 27)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3-Dichlorobiphenyl (BZ 5)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3'-Dichlorobiphenyl (BZ 6)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,4',5-Tetrachlorobiphenyl (BZ 74)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,4',6-Tetrachlorobiphenyl (BZ 75)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,4'-Trichlorobiphenyl (BZ 28)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,5-Trichlorobiphenyl (BZ 29)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4',5-Trichlorobiphenyl (BZ 31)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,6-Trichlorobiphenyl (BZ 30)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4',6-Trichlorobiphenyl (BZ 32)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4'-DDD
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4'-DDE
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4'-DDT
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4-Dichlorobiphenyl (BZ 7)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4'-Dichlorobiphenyl (BZ 8)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,5-Dichlorobiphenyl (BZ 9)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,6-Dimethylnaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2-Chlorobiphenyl (BZ 1)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2-Chloronaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2-Methylnaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2-Methylphenanthrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',4,4',5,5'-Hexachlorobiphenyl (BZ 169)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',4,4',5-Pentachlorobiphenyl (BZ 126)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',4,4'-Tetrachlorobiphenyl (BZ 77)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',4,5,5'-Pentachlorobiphenyl (BZ 127)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',5,5'-Tetrachlorobiphenyl (BZ 80)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3'-Dichlorobiphenyl (BZ 11)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,4,4',5-Tetrachlorobiphenyl (BZ 81)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,4,4'-Trichlorobiphenyl (BZ 37)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,4-Dichlorobiphenyl (BZ 12)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,4'-Dichlorobiphenyl (BZ 13)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,6-Dimethylphenanthrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	4,4'-Dichlorobiphenyl (BZ 15)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	4-Chlorobiphenyl (BZ 3)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Acenaphthene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Acenaphthylene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Anthracene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(a)anthracene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(a)pyrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(b)fluoranthene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(b)thiophene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(e)pyrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(g,h,i)perylene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(k)fluoranthene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Biphenyl
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Chrysene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	cis-Decalin
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Decachlorobiphenyl (BZ 209)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Dibenz(a,h)anthracene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Dibenzofuran
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Dibenzothiophene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Fluoranthene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Fluorene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Indeno(1,2,3-cd)pyrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Naphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Perylene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Phenanthrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Pyrene

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270DE MOD	GC-MS	trans-Decalin
Aqueous	EPA 3510 C	Separatory Funnel	Prep
Aqueous	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Aqueous	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Solid	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Solid	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Solid	NOAA NOS ORCA 71	Orbital Shaker	Prep
Tissue	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Tissue	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Tissue	NOAA NOS ORCA 71	Tissuemizer	Prep

Appendix C
Laboratory Standard Operating Procedures

Battelle
Standard Operating Procedure

for

ANALYSIS OF POLY AND PERFLUOROALKYL SUBSTANCES IN ENVIRONMENTAL SAMPLES BY LIQUID CHROMATOGRAPHY AND TANDEM MASS SPECTROMETRY (LC-MS/MS)

Summary of changes in this version: Added seven new analytes to the method. Updated the example chromatograms for branched isomers. With the exception of the new analytes, this SOP is considered technically equivalent to the previous SOP version based on the summary of changes to this version and therefore IDCs and ODCs performed under the previous SOP version also demonstrate proficiency in this version.

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the identification and quantification of perfluoroalkyl substances (PFASs) in environmental samples by liquid chromatography and tandem mass spectrometry (LC-MS/MS). This method was developed with consideration given to ASTM method 7968 (ASTM, 2014), EPA Method 537 (Shoemaker, Grimmett, & Boutin, 2009), and Sciex application notes for PFAS extraction and analysis (Simon, et al., 2016).

2.0 METHOD SUMMARY

PFAS compounds are extracted and prepared for analysis utilizing the appropriate technique dependent on matrix (SOP 5-370). The extracts are analyzed by LC-MS/MS monitoring the primary transition for each target analyte, when available, a secondary transition is monitored for confirmation. The analytes are identified by the primary transition and retention time. The identified analytes are quantified using an isotopic dilution approach (where an isotopically labelled compound was not available for a target analyte, the labelled analog with the closet retention time (RT) is used for quantification). A data system interfaced to the LC-MS/MS is used to control acquisition and to store, retrieve, and manipulate LC-MS/MS data. This method provides specific procedures for the identification and measurement of the PFAS listed in **Attachment 1**. Individual projects may analyze all or a subset of the target analytes presented in this attachment.

3.0 EQUIPMENT AND SUPPLIES

The following equipment is required to perform the analytical method. Equivalent apparatus and materials may be substituted if approved by the laboratory and project managers.

- HPLC (Shimadzu LC20ADXR, Agilent 1260 SL, or equivalent)
- Tandem Mass Spectrometer (Sciex 6500, Sciex 5500, or equivalent)
- Analytical column (Phenomenex Gemini® C18 3 µm; 50 x 2 mm, part No. 00B-4439-B0, or equivalent)
- Delay Column (Phenomenex Luna® C18(2) 5 µm; 30 x 2 mm, part No. 00A-4252-B0, or equivalent)

4.0 REAGENTS AND STANDARDS

4.1 Reagents and Consumable Materials

The following Battelle SOPs outline reagent login, labeling, and storage that are applicable to this method:

5-015 (Solvent/Reagent Inventory and Contaminant Residue Checks)
5-027 (Analytical Standards in the Organics Laboratory)
5-217 (Labeling of Chemical Materials in the Laboratory)

4.1.1 Solvents and Reagents

- Methanol (HPLC grade, or equivalent)
- Ammonium Acetate (reagent grade, or equivalent)
- Reagent water (Millipore or equivalent)
- 20 mM Ammonium Acetate in Millipore water (mobile phase) – bring 1,540 mg of ammonium acetate to a final volume of 1 L with Millipore water. Due to potential volatility losses, this solution expires one week after preparation.

4.1.2 Consumables

- Polypropylene vials (Environmental Express part No. SC475, or equivalent)
- 1 mL Polypropylene LC extract vials (Thermo Fisher part No. 22-294325, or equivalent)
- Snap caps (Thermo Fisher part No. 03-345-24G, or equivalent)

4.2 Standards and Solutions

Standard preparation procedures for all calibration solutions are detailed in SOP 5-027. All prepared standards must be stored refrigerated and can be kept in screw-cap polypropylene vials. Standards are stored separately from samples. All stock solutions are prepared in 96% methanol in reagent water

4.2.1 Calibration Standards

Calibration standards should contain all individual target compounds. Primary stock solutions that contain the target analytes are purchased and used to prepare the Initial Calibration (ICAL), Continuing Calibration Verification (CCV), and Independent Calibration Check (ICC) standards. Most standards used for this method are purchased from standard providers (e.g., Sigma Aldrich and Wellington) in neat or solution form. Equivalent standards may be substituted if approved by the laboratory and project manager. All final calibration standards for this method are made in 80% methanol in reagent water. The ICC must be independent of the ICAL standards and thus should be made using either a standard from a different vendor or a standard from the same vendor with a lot number different from the ICAL standard. When commercially available, the calibration curve will contain both branched and linear isomers. Technical grade standards cannot be used for quantitative analysis.

The recommended calibration levels for the ICAL standards are presented in **Table 1** below. The concentration of the IS does not vary with each level. The lowest point of the calibration curve will be at or below the LOQ for all target analytes. The remaining concentration levels should not exceed the working range of the LC-MS/MS system. If concentrations of samples are above the calibration range, the extract will be diluted and re-analyzed.

***Table 1**: Nominal Calibration Concentrations (ng/L)*

	L1	L2	L3	L4	L5	L6	L7	L8	L9
Targets	25	50	100	250	500	1,000	2,500	10,000	20,000
Labeled Analogues	100	100	100	100	100	100	100	100	100
Internal Standard	100	100	100	100	100	100	100	100	100

4.2.2 ICC Spiking Solution

The ICC spiking solution should include all target compounds proposed for analysis from a source independent from the initial calibration (if commercially available). The concentration should be at or near the midpoint of the initial calibration.

5.0 PROCEDURES

5.1 Sample Analysis

The extracts were analyzed under the conditions presented in **Table 2**.

***Table 2**: Analytical Parameters*

Column:	Phenomenex Gemini® C18 – 3 µm; 50 x 2 mm (analytical) Phenomenex Lina® C18(2) – 5 µm; 30 x 2 mm (delay)		
Column Temperature:	40 ºC (analytical), delay column installed between the pump mixing chamber and the column, outside of the column oven		
Injection Volume:	10 µL		
Flow Rate:	600 µL/min		
Mobile Phase A:	Millipore water with 20 mM ammonium acetate		
Mobile Phase B:	Methanol		
Analytical Run Time (end)	7.00 minutes		
	Time – minutes	% A	% B
	0.00	90	10
	0.10	45	55
	4.50	1	99
	4.95	1	99
	7.00	90	10
Ion Source:	Turbo Ion Spray		
Polarity:	Negative		
Ion Spray Voltage (IS):	-4500 v		
Collision Gas (CAD):	Medium		
Temperature (TEM):	450 °C		
Curtain Gas (CUR):	35 PSI		
Ion Source Gas 1 (GS1):	50 PSI		
Ion Source Gas 2 (GS2):	50 PSI		
Entrance Potential (EP):	10		

Multiple Reaction Monitoring (MRM) transitions are monitored for each analyte, labeled analogue, and internal standard using the scheduled MRM™ algorithm in the data acquisition software. The MRM transitions are collected inside of a 60 second window around the expected retention time to maximize the spectra scans collected.

The following quality control checks are required for analysis.

5.1.1 Mass Calibration

Prior to initial use and after performing major maintenance, calibrate the mass scale of the MS with calibration compounds as described by the instrument manufacturer. The entire mass range must be calibrated. This is performed during the scheduled 6-month preventative maintenance (PM) by an outside vendor.

5.1.2 Tune Check

When the masses fall outside of the +/- 0.5 amu of the true values (as determined by the product ion formulas) the instrument must be retuned and verified. Sample analysis shall not proceed until the masses are within +/- 0.5 amu of the true values. This is performed after instrument re-tuning and during the scheduled 6-month PM by an outside vendor.

5.2 Calibration

Demonstration and documentation of acceptable initial calibration is required before any samples are analyzed. The ICAL must be verified by analysis of an ICC immediately following the ICAL. A CCV is required at the beginning of each sample analysis sequence and after ten injections during the sample analysis sequence.

5.2.1 Initial Calibration

Analyze a minimum of five calibration standards that will represent the expected concentration range of the samples. Suggested standard concentrations are outlined in **Table 1** above.

For each level of calibration, calculate the correlation coefficient (r) with a weighting of 1/x for each analyte of interest in the calibration standard using the software supplied with the LC-MS/MS data system. The formula is provided in Section 7.0.

ICAL acceptance criteria

The ICAL criteria are:

- $r^2 > 0.99$ for each analyte
- Minimum of 5 points for a linear curve fitting
- Minimum of 6 points for a quadratic curve fitting
- Each target compound must be within 70% – 130% of their true value
- Labeled analyte concentrations must be within 70% – 130% of their true value
- Internal standard area must be within +/- 50% of the L5 of the calibration curve

If these requirements are not met for the ICAL, corrective action is performed and the calibration is repeated.

5.2.2 Independent Calibration Check

Verify the ICAL with an ICC immediately after the ICAL is completed. The ICC is analyzed under the same analytical conditions used in the ICAL and for the analysis of samples.

ICC Target Analyte Performance Criteria

The ICC criteria are:

- Individual %DIFF ≤ 30%
- Labeled analyte concentrations must be within 70% – 130% of their true value
- Internal standard area must be within +/- 50% of the L5 of the calibration curve

If ICC meets the above criteria, then the ICAL is assumed to be valid. If the criteria are not met, reanalyze the ICC. If the second ICC fails, a new ICAL must be performed or justification for continuing must be documented.

5.2.3 Continuing Calibration Verification

The ICAL is verified at least at the beginning and end of each 12-h period during which analyses are to be performed. The CCV is analyzed under the same analytical conditions used for the ICAL and ICC. The appropriate CCV solution is analyzed, quantified, and assessed as described below.

CCV Target Analyte Performance Criteria

The CCV criteria are:

- Frequency: beginning of each sample analysis sequence (if not preceded by and ICC) and after 10 injections during sample analysis sequence
- Individual % DIFF ≤ 30%
- Labeled analyte concentrations must be within 50% of their true value

If CCV meets the above criteria, then the ICAL is assumed to be verified. Proceed with the analysis of samples. When a CCV fails to meet any of the above criteria, two additional CCV's are analyzed consecutively. If both additional CCV's pass criteria, the samples can be reported. If either of the two additional CCV's fail criteria or cannot be analyzed all samples that were analyzed after the prior acceptable CCV must be re-analyzed. If a CCV fails because a target analyte exceeded the acceptance limit defined above (over response only) and that analyte was not detected in any samples, then the samples do not need to be reanalyzed. In all other cases, the sample must be reanalyzed after an acceptable CCV has been established or justification for continuing is approved by the project manager and documented.

For successive continuing calibrations, vary the CCV standard concentration.

5.2.4 Instrument Blank (IB)

An instrument blank must be analyzed immediately following the highest calibration standard analyzed and daily prior to sample analysis. Any concentration that can be determined for each analyte must be ≤ ½ of the LOQ. If acceptance criteria are not met, additional IB samples will be analyzed until acceptance is met.

5.2.5 Post Spike and Matrix Duplicate Samples

Post spike and Matrix Duplicate (MD) sample analysis will not be performed as this analytical method does not allow for direct injection of aqueous samples. If direct injection analysis is required for high level samples (i.e. AFFF formulations, the post spike and MD samples will be addressed in the Project Plan.

5.2.6 Branched Isomer Verification

A standard containing commercially available branched isomers is run after the ICAL to verify that potential branched ion transitions are collected during analysis. Branched isomers will be quantified vs. the linear isomer unless the calibration contains branched isomers. Examples of branched isomers can be found in **Attachment 4**.

5.2.7 Instrument Sensitivity Check (ISC)

An instrument sensitivity check at a concentration no greater than the LOQ value is analyzed to verify instrument sensitivity. The analyte concentrations must be within 30% of their true values. An ISC must be analyzed prior to sample analysis and at least every twelve hours during sample analysis. No samples can be analyzed until the ISC has met criteria. The ISC can be used as a CCV during analysis.

5.2.8 Labeled Analogues (Extracted Internal Standards)

The labeled analogues used for quantification must me added prior to extraction (extractions detailed in SOP 5-370). Recoveries must be between 50% – 150% of their true value. If the recoveries are acceptable in QC samples but not field samples, the field samples must be repreped and reanalyzed as a greater dilution may be needed. If recoveries of the QC samples are not acceptable, the problem must be corrected and all associated samples must be reanalyzed. The data will be qualified and discussed in the case narrative only if the reanalysis confirms the failures.

5.2.9 Internal Standard Area (Injection Internal Standards)

The internal standard area for all injections must be within +/- 50% of the internal standard area of the L5 of the ICAL. When the calibration is not performed on the same day as the analysis, the area must be within +/- 50% of the area of the daily initial CCV. If the area of a sample extract fails criteria, corrective action must be taken. Corrective action includes analyzing a second aliquot of sample, if available, or reanalysis of the original extract. If the second analysis passes criteria, the second analysis will be reported. If the IS are fails after additional analysis, either value can be reported with the appropriate data qualifier and discussed in the case narrative.

5.2.10 Retention Time Windows

A default RT window for an analyte is +/- 10 s. The ICC and CCV analytes must fall within the established RT window. If the RT of these compounds does not fall within the window, evaluation for acceptable identification by an experienced analyst shall be considered or corrective action can be taken to restore the system.

Because of the variable patterns of target compounds in many samples, pattern recognition and analyst experience should weigh heavily in the interpretation of chromatograms. A narrative must accompany any target analyte selected that falls outside its RT window.

DoD Projects:
A retention time study will be performed prior to the start of a DoD project and will be valid until a major change in the analysis system occurs (e.g., column changed).

5.3 Sequence of Analysis

An analysis sequence is initiated with an acceptable ICAL and ICC (if necessary) or an acceptable CCV followed by the appropriate number of samples to be analyzed and ending with a CCV. The sequence may be continued with another group or groups of samples and CCVs provided the CCV results remain within the acceptance criteria (reference Section 5.2.3). All QC and authentic samples must be bracketed by acceptable CCVs or ICAL.

The order of calibration and analysis is as follows (if a new ICAL is needed):

a. Methanol
b. ICAL
c. IB
d. ICC
e. Branched Standard
f. Methanol
g. Sample analysis sequence
h. CCV or ISC (ISC required every 12 hours, otherwise CCV is varied from L2 –L7 of calibration curve; ISC is any standard between L2 and L5 of the calibration curve)
i. Methanol

Repeat g, h, and i for continued analysis of QC and authentic samples if g and h continue to pass criteria.

When a new ICAL is not needed, analysis must start with an ISC and IB sample.

5.4 Sample Analysis

Samples are run under the same conditions as the ICAL. Start the analysis of samples with quality control samples.

5.4.1 Qualitative Identification of Individual Target Compounds

Sample peaks are identified visually using the MultiQuant™ display program. Sample peaks should fall within the established retention time window. A narrative must accompany any target analyte selected that falls outside its retention time window. For peak identification, the experience of the analysts should weigh heavily in the interpretation of data.

Identify the target compounds (**Attachment 2**) based on retention time established during the calibration and the transitions presented in **Attachment 3**. Comparison of both retention times and transitions to reference standard is also useful in compound identification.

5.4.2 Mass Spectral Acquisition Rate

A minimum of 10 spectra scans are acquired for each peak.

5.4.3 Ion Transitions

With the exception of PFBA and PFPeA, two transitions and the ion transition ratio will be monitored for each target analyte and reported. Transitions are defined in **Attachment 3**. Two transitions are not required for labeled analogues and internal standards.

5.4.4 Signal to Noise Ratio

A minimum signal to noise ratio of 10:1 is required for all ion transitions used for quantification. Analytes that have a health advisory (HA) level or other action level, must have a signal to noise ratio of at least 3:1 for the confirmatory transition.

5.4.5 Quantification of Analytes

Identify target analyte peaks that match retention times and other criteria above. Confirm the auto-baseline on the quantification ions or redraw the baselines, as necessary. Quantify each peak following procedures presented in the instrument manufacturer user's manual and Battelle SOP 4-038.

Quantification of analytes identified in samples will be performed by the isotopic dilution method, using the appropriate curve fitting from the ICAL. See Section 7.0 for additional information regarding calculations used for the determination of target analyte concentrations in samples. Upon selection of the appropriate calibration option and the identification of a peak, the MultiQuant™ software calculates the compound amounts from the peak areas, as described in Section 7.0. Review the results against calibration standards and other project samples for reasonableness.

5.4.6 Manual Integrations

Using the MultiQuant™ software, identify target analyte peaks that match retention time and other criteria above. Confirm acceptance of the MultiQuant™ auto-baseline for the peak or redraw the baseline, as necessary. Manual integrations will be used to separate near co-eluted peaks, remove negative peaks, and compensate for other peak shape or baseline anomalies that often occur in environmental samples. Guidance for manual integrations is provided in SOP 4-038.

> *DoD projects*:
> The rationale for manual integrations must be documented in the data package; samples and analytes which required manual integrations must be identified in the case narrative.

5.4.7 Reporting Units

Reporting units are ng/L for water and ng/g for soil, sediments, and tissues unless the QAPP specifies otherwise. Soils and sediments are typically reported on a dry weight basis while tissues are reported on a wet weight basis.

6.0 QUALITY CONTROL

LC Facility operations are documented according to SOP 6-025. Electronic files of all calibrations and sample data are kept in project specific network folders (SOP 6-032). Analysis of quality control samples including Procedural Blank (PB), Laboratory Control Sample (LCS), laboratory Control Sample Duplicate (LCSD), Matrix Spike (MS), Matrix Spike Duplicate (MSD), Duplicate (DUP), and Triplicate (TRP) are specified in the QAPP. The quality control acceptance criteria will follow the criteria outlined in SOP 7-029 unless modified in the QAPP. Key elements of the quality control program include:

1. There must be an initial calibration of the instrument as specified in 5.

2. Each day that analysis is performed, the calibration verification standard should be evaluated to determine if the chromatographic system is operating properly.

3. It is recommended each day that analysis is performed, an instrument blank should be evaluated to determine if the chromatographic system is free of contamination.

4. Peak shape should be evaluated for proper peak shape and symmetry.

5. The instrumental response should be comparable to previous calibrations.

6. The system must be recalibrated at method setup and after major maintenance.

> *DoD projects*:
> The analysis, frequency, and acceptance criteria of quality control samples will be determined in the latest revision of the Quality Systems Manual.

7.0 DATA ANALYSIS AND CALCULATIONS

7.1 Initial Calibration

Correlation Co-efficient

$$r = \left(\sum w \sum wyy_c - \sum wy \sum wy_c\right) / \sqrt{\left(D_y D_{yc}\right)}$$

where:

$$D_y = \sum w \sum wy^2 - \left(\sum wy\right)^2$$

y_c = calculated y-value using the equation below:

$$D_{yc} = \sum w \sum wy_c^2 - \left(\sum wy_c\right)^2$$

Linear Regression Method

- Y = mX + b

  which is equivalent to: $A_A/A_{IS} = [[m \text{ H } (C_A/C_{IS})] + b]$

- $C_A = [(A_A/A_{IS})\ b] \text{ H } (C_{IS}/m)$

The slope and intercept are calculated as:

$$m = \left(\sum w \sum wxy - \sum wx \sum wy\right) / D_x$$

$$b = \left(\sum wx^2 \sum wy - \sum wx \sum wxy\right) / D_x$$

Where:

$$D_x = \sum w \sum wx^2 - \left(\sum wx\right)^2$$

Weighting Type Weight (w)
1 / x   If $|x| < 10^{-5}$, then $w = 10^5$. Otherwise, $w = 1 / |x|$.

7.2 Calibration Verification

Calculate the percent difference (%DIFF) between the calculated amount ("found" amount) and the true amount using the equation below:

$$\%DIFF = \frac{(A_C - A_I)}{A_I} * 100\%$$

Where:
A_I = "true" analyte amount
A_C = "found" analyte amount

7.3 Quantification of Samples

Samples are quantified as detailed in Section 5. The concentration of target analytes is determined using the following equation:

$$x = (y - b) / m$$

8.0 TRAINING

The trainee must read and fully understand the policies and procedures outlined in this SOP and have documented training in Battelle SOPs 4-038 and 6-025. Training for these SOPs should be documented according to procedures outlined in the Quality Assurance Manual. The trainee will then be given a demonstration of all aspects of this SOP.

Analysts may work independently once they have satisfactorily performed the following training:

- Demonstrate ability to set up the instrument and perform routine maintenance
- Analyze an acceptable initial calibration
- Analyze at least four LCS samples concurrently or over a period of days that meet the criteria outlined in SOP 7-029.

When training is completed, the trainee will be issued a Demonstration of Capability (DOC) Certificate (SOP 2-011). The original completed training certificate and all supporting documentation will be stored in the Chemistry files.

Analysts must also demonstrate annual proficiency in the method. SOP 2-011 (Staff Training) outlines the acceptable performance procedures. When annual training is completed, the analyst will be issued a DOC Certificate.

9.0 SAFETY

All LC-MS/MS operators must be experienced with the operation and maintenance of the LC-MS/MS system.

- Protective clothing should be worn when appropriate.
- Proper care must be exercised when using syringes.
- Certain areas of the LC-MS/MS system are heated zones and bodily contact with these zones should be avoided.

- High voltages exist in certain marked areas of the LC-MS/MS system and bodily contact with these areas is to be avoided.
- Care should be taken when using solvents in and around the LC system.

10.0 POLLUTION PREVENTION

Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Staff should make every effort to use the minimum amount of sample and reagent for this analytical procedure. All samples and reagents are contained and disposed of in an appropriate manner (Section 12).

11.0 CORRECTIVE ACTION

Battelle maintains a corrective action program that is detailed in SOP 4-035. The Laboratory Manager must approve all corrective actions initiated within the laboratory. The effectiveness of corrective actions is verified by the Quality Assurance Unit.

12.0 WASTE MANAGEMENT

All waste streams generated within the laboratory are collected and stored in an appropriate container and disposed according to SOP 5-114 or when appropriate, by other approved waste management procedures.

13.0 INTERFERENCES

Method inferences may be caused by contaminants in solvents, reagents, glassware, and other sample processing apparatus that lead to discrete artifacts or elevated baselines in chromatograms. All solvent/reagents must be analyzed initially to demonstrate they are free from interferences (SOP 5-015). Glassware must be scrupulously cleaned following the procedures outlined in SOP 5-216. The use of high purity reagents and solvents helps to minimize these interference problems. Significant effort must be taken to ensure no PTFE or other surface containing PFAS comes in contact with the materials or equipment in the sample pathway from preparation to analysis.

Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending on the nature and diversity of the sample. Specific to PFOS analysis in tissues, the transition 499 → 80 from taurodeoxycholic acid (TDCA) may interfere with quantification. The transition 499 → 107 will be monitored for the presence of TDCA, if present, the quantification of PFOS will be performed using the confirmation transition of 499 → 99.

Cross-contamination can occur whenever high-level and low-level samples are analyzed sequentially. Whenever an unusually concentrated sample is analyzed, the samples following it may need re-analysis if cross-contamination is suspected. The LC system may require maintenance if it has been exposed to high level samples.

14.0 DEFINITIONS

Battelle's methodology terms are consistent with the The NELAC Institute (TNI) Glossary of Terms outlined in the TNI Constitutions, Bylaws and Standards Manual. The TNI Glossary of Terms currently being utilized by Battelle is outlined in Attachment B of Battelle's Quality Assurance Manual. Battelle's method detection terminology is defined in SOP 5-291 and quality control terminology in SOP 7-029.

15.0 METHOD DETECTION LIMITS

Battelle maintains a program for determining and verifying method detection limits (MDL), LOD, LOQ, and reporting limit (RL) values. The policies and procedures are defined in SOP 5-291 and Battelle's Quality Assurance Manual. All MDL, LOD, and LOQ study results are accessible within the laboratory network files. All reporting limits are based on the low standard of the calibration curve, sample dilutions and sample size.

16.0 METHOD PERFORMANCE

Battelle maintains a program for determining method performance. The policies and procedures are outlined in SOP 5-295 and Battelle's Quality Assurance Manual. The Laboratory Manager must approve all new methodologies before use.

17.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA

Battelle maintains a program for assessing data and determining acceptance criteria for quality control measures. These policies and procedures are outlined in SOP 7-029 and in Battelle's Quality Assurance Manual. Battelle also maintains a program for handling out-of-control or unacceptable data. These policies and contingencies are outlined in SOP 4-035, SOP 7-029, and Battelle's Quality Assurance Manual.

18.0 REFERENCES

ASTM. (2014). *D7968: Standard Test Method for Determination of Perfluorinated Compounds in Soil by Liquid Chromatography Tandem Mass Sectrometry (LC/MS/MS).* West Conshohocken: ASTM.

Shoemaker, J. A., Grimmett, P. E., & Boutin, B. K. (2009). *Method 537 Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS).* Cincinnati: EPA.

Simon, R., KC, H., Craig, B., Scott, K., Eric, R., & Christopher, B. (2016). *Quantitation of PFASs in Water Samples Using LC/MS/MS: Large-Volume Direct Injection and Solid Phase Extraction.* Framingham: Sciex.

ATTACHMENTS

Attachment 1	Revision History
Attachment 2	PFAS Target Analyte List
Attachment 3	Acquisition Parameters and Transitions
Attachment 4	Example Chromatograms for Branched Isomers

APPROVALS:

	Name	Date
Author Jonathan Thorn		Digitally signed by Jonathan Thorn Date: 2019.02.14 09:18:04 -05'00'
Technical Reviewer Denise Schumitz	Denise Schumitz	schumitzd@battelle.org 2019.02.19 11:23:36 -05'00'
Quality Systems Manager Zachary Willenberg	Zachary Willenberg	Digitally signed by Zachary Willenberg Date: 2019.02.20 11:22:41 -05'00'
Laboratory Director Jonathan Thorn		Digitally signed by Jonathan Thorn Date: 2019.02.14 09:18:19 -05'00'

ATTACHMENT 1

Revision History

Version	Summary of Changes
02	Removed sample preparation methods from SOP (moved to SOP 5-370). Updated analytical method. This method is not equivalent to the previous analytical method, new Demonstrations of Capability (DOC) will be needed for this version of the SOP. Revision history added as **Attachment 1**.
03	Updated the analyte list and corrected an error in the labeling of the branched isomer examples This method is equivalent to the previous version, a new Demonstration of capability (DOC) will not be needed for this version.
04	Added three target analytes to the analyte list, expanded the list of labeled analogs and internal standards used. Clarified section on post spike samples and Matrix Duplicate samples. This revision requires a new Demonstration of capability (DOC) for the additional analytes.
05	Primary transition for PFHpS updated. The storage of prepared standards updated.
06	Secondary transition for PFHpS updated. Updated internal standard area criteria to use level 5 of the calibration curve. Updated section 5.3 to define calibration points for the CCV and ISC samples.

ATTACHMENT 2

PFAS Target Analyte List

Analyte	**Code**	**CAS No.**
Perfluoro-n-butanoic acid	PFBA	375-22-4
Perfluoro-n-pentanoic acid	PFPeA	2706-90-3
Perfluororhexanoic acid	PFHxA	307-24-4
Perfluoroheptanoic acid	PFHpA	374-85-9
Perfluorooctanoic acid	PFOA	335-67-1
Perfluorononanoic acid	PFNA	375-95-1
Perfluorodecanoic acid	PFDA	335-76-2
Perfluoroundecanoic acid	PFUnA	2058-94-8
Perfluorododecanoic acid	PFDoA	307-55-1
Perfluorotridecanoic acid	PFTrA	72629-94-8
Perfluorotetradecanoic acid	PFTeDA	376-06-7
N-methylperfluoro-1-octanesulfonamidoacetic acid	NMeFOSAA	2355-31-9
N-ethylperfluoro-1-octanesulfonamidoacetic acid	NEtFOSAA	2991-50-6
Perfluoro-1-octanesulfonamide	PFOSA	754-91-6
Perflurorbutanesulfonic acid	PFBS	375-73-5
perfluoro-1-pentanesulfonate	PFPeS	BDO-2114
perfluoro-1-hexanesulfonate	PFHxS	3781-99-6
Perfluoro-1-heptanesulfonate	PFHpS	375-99-6
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluoro-1-nonanesulfonate	PFNS	98789-57-2
Perfluoro-1-decanesulfonate	PFDS	2806-15-7
1H,1H,2H,2H-Perfluorohexane sulfonate	4:2 FTS	NA
1H,1H,2H,2H-Perfluorooctane sulfonate	6:2 FTS	27619-97-2
1H,1H,2H,2H-Perfluorodecane sulfonate	8:2 FTS	39108-34-4
3-perfluoropropyl propanoic acid	3:3 FTCA	356-02-5
3-perfluoropentyl propanoic acid	5:3 FTCA	914637-49-3
3-perfluoroheptyl propanoic acid	7:3 FTCA	812-70-4
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6
4,8-dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid	9Cl-PF3ONS	756426-58-1
Labeled Analogues		
Perfluoro-n-[1,2,3,4-13C4]butanoic acid	$^{13}C_{4}$-PFBA	BDO-2105
Perfluoro-n-[13C5]pentanoic acid	$^{13}C_{5}$-PFPeA	BDO-2216
Perfluoro-n-[1,2,3,4,6-13C5]hexanoic acid	$^{13}C_{5}$-PFHxA	BDO-2217
Perfluoro-n-[1,2,3,4-13C4]hepetanoic acid	$^{13}C_{4}$-PFHpA	BDO-2218
Perfluoro-n-[13C8]octanoic acid	$^{13}C_{8}$-PFOA	BDO-2219

Analyte	**Code**	**CAS No.**
Perfluoro-n-[13C9]nonanoic acid	$^{13}C_9$-PFNA	BDO-2221
Perfluoro-n-[1,2,3,4,5,6-13C6]decanoic acid	$^{13}C_6$-PFDA	BDO-2222
Perfluoro-n-[1,2,3,4,5,6,7-13C7]undecanoic acid	$^{13}C_7$-PFUnA	BDO-2223
Perfluoro-n-[1,2-13C2]dodecanoic acid	$^{13}C_2$-PFDoA	BDO-2112
Perfluoro-n-[1,2-13C2]tetradecanoic acid	$^{13}C_2$-PFTeDA	BDO-2224
N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	d3-MeFOSAA	BDO-2125
N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	d5-EtFOSAA	BDO-2126
Perfluoro-1-[13C8]octanesulfonamide	$^{13}C_8$-FOSA	BDO-2225
perfluoro-1-[2,3,4-13C3]butanesulfonate	$^{13}C_3$-PFBS	BDO-2226
perfluoro-1-[1,2,3-13C3]hexanesulfonate	$^{13}C_3$-PFHxS	BDO-2227
perfluoro-1-[13C8]octanesulfonate	$^{13}C_8$-PFOS	BDO-2228
1H,1H,2H,2H-perfluoro-1-[1,2-13C2]hexanesulfonate	$^{13}C_2$-4:2FTS	BDO-2229
1H,1H,2H,2H-perfluoro-1-[1,2-13C2]octanesulfonate	$^{13}C_2$-6:2FTS	BDO-2230
1H,1H,2H,2H-perfluoro-1-[1,2-13C2]decanesulfonate	$^{13}C_2$-8:2FTS	BDO-2220
Tetrafluoro-2-heptafluoropropoxy-13C3-propanoic acid	$^{13}C_3$-HFPO-DA	BDO-2276
Internal Standards		
Perfluoro-n-[2,3,4-13C3]butanoic Acid	$^{13}C_3$-PFBA	BDO-2231
Perfluoro-n-[1,2-13C2]octanoic acid	$^{13}C_2$-PFOA	BDO-2107
Perfluoro-n-[1,2-13C2]decanoic acid	$^{13}C_2$-PFDA	BDO-2110
Perfluoro-1-]1,2,3,4-13C4]octanesulfonate	$^{13}C_4$-PFOS	BDO-2121
Potential Interferences		
Taurodeoxycholic acid	TDCA	1180-95-6

ATTACHMENT 3

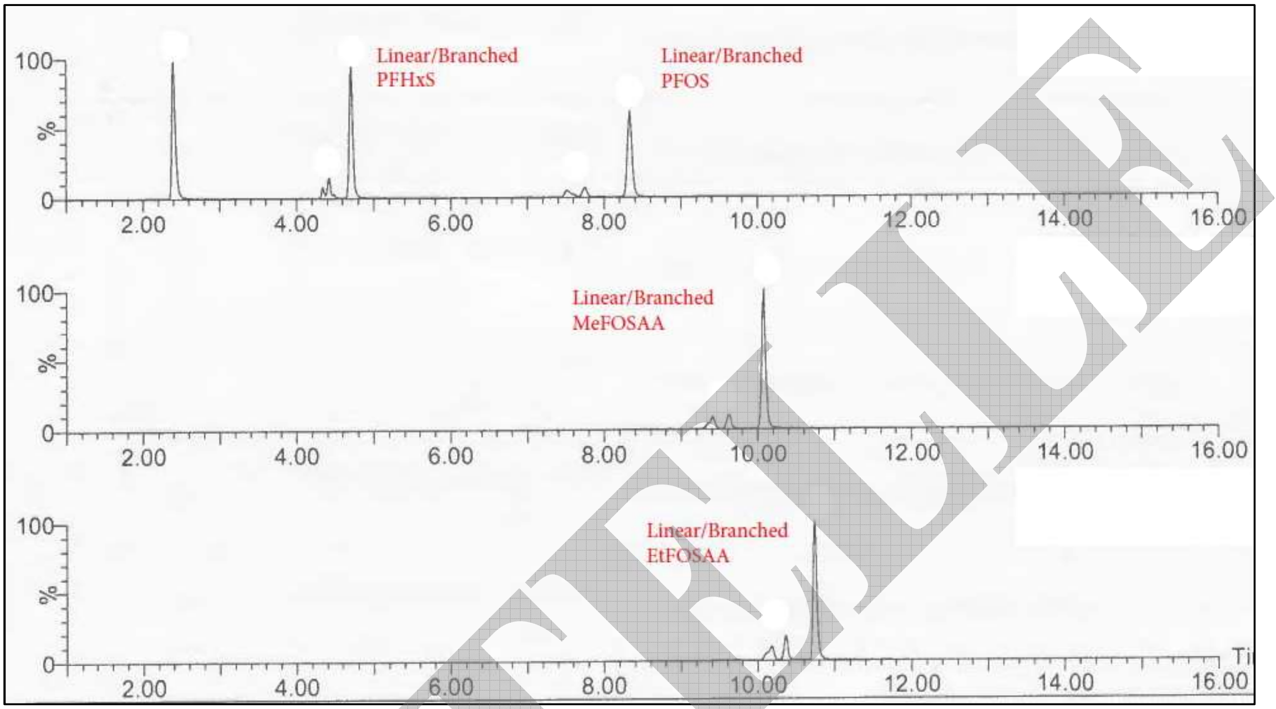
Acquisition Parameters and Transitions

	Primary Transition		Confirmation Transition			
Analyte Code	Q1	Q3	Q1	Q3	**DP**	**CE**
PFBA	213	169	NA	NA	25	12
PFPeA	263	219	NA	NA	20	12
PFHxA	313	269	313	119	25	12
PFHpA	363	319	363	169	25	12
PFOA	413	369	413	169	25	14
PFNA	463	419	463	219	25	14
PFDA	513	469	513	219	25	16
PFUnA	563	519	563	269	25	18
PFDoA	613	569	613	319	25	18
PFTrA	663	619	663	169	25	20
PFTeDA	713	669	713	169	25	22
NMeFOSAA	570	419	570	512	40	36
NEtFOSAA	584	419	584	483	50	36
PFOSA	498	78	498	83	60	85
PFBS	299	80	299	99	35	48
PFPeS	349	99	349	80	35	48
PFHxS	399	80	399	99	60	74
PFHpS	449	80	449	99	65	88
PFOS	499	80	499	99	65	108
PFNS	549	99	549	80	50	120
PFDS	599	80	599	99	85	118
4:2 FTS	327	307	327	80	50	32
6:2 FTS	427	407	427	81	50	32
8:2 FTS	527	507	527	487	50	40
3:3 FTCA	241	177	NA	NA	12	12
5:3 FTCA	341	237	NA	NA	30	20
7:3 FTCA	441	337	NA	NA	50	18
HFPO-DA	285	169	285	118	12	8
ADONA	377	251	377	85	14	12
11Cl-PF3OUdS	631	451	631	83	40	24
9Cl-PF3ONS	531	351	531	83	40	24
$^{13}C_4$-PFBA	217	172	NA	NA	15	10
$^{13}C_5$-PFPeA	268	223	NA	NA	20	15
$^{13}C_5$-PFHxA	318	273	NA	NA	20	15
$^{13}C_4$-PFHpA	367	322	NA	NA	20	15
$^{13}C_8$-PFOA	421	376	NA	NA	20	15
$^{13}C_9$-PFNA	472	427	NA	NA	20	15
$^{13}C_6$-PFDA	519	474	NA	NA	20	15
$^{13}C_7$-PFUnA	570	525	NA	NA	20	15
$^{13}C_2$-PFDoA	615	570	NA	NA	25	18
$^{13}C_2$-PFTeDA	715	670	NA	NA	20	15
d3-MeFOSAA	573	419	NA	NA	40	36

	Primary Transition		Confirmation Transition			
Analyte Code	Q1	Q3	Q1	Q3	**DP**	**CE**
d5-EtFOSAA	589	419	NA	NA	40	36
$^{13}C_8$-FOSA	506	78	NA	NA	65	108
$^{13}C_3$-PFBS	302	99	NA	NA	45	65
$^{13}C_3$-PFHxS	402	99	NA	NA	50	75
$^{13}C_8$-PFOS	507	99	NA	NA	65	108
$^{13}C_2$-4:2FTS	329	81	NA	NA	50	75
$^{13}C_2$-6:2FTS	429	81	NA	NA	50	75
$^{13}C_2$-8:2FTS	529	81	NA	NA	50	75
$^{13}C_3$-HFPO-DA	287	169	NA	NA	10	6
$^{13}C_3$-PFBA	216	172	NA	NA	40	20
$^{13}C_2$-PFOA	415	370	NA	NA	25	14
$^{13}C_2$-PFDA	515	470	NA	NA	25	16
$^{13}C_4$-PFOS	503	99	NA	NA	75	100
TCDA	NA	NA	499	107	TBD	TBD

Attachment 4

Example Chromatograms for Branched Isomers



Battelle
Standard Operating Procedures

for

EXTRACTION OF POLY AND PERFLUOROALKYL SUBSTANCES FROM ENVIRONMENTAL MATRICES

Summary of changes in this version: Updated to include procedure for handling non-potable water samples that are highly turbid or contain suspended solids. This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.

1.0 OBJECTIVE

The objective of this document is to define standard procedures for extracting poly and perfluoroalkyl substances (PFAS) from environmental matrices, including, but not limited to, surface water, ground water, soil, sediment, and tissue. Extraction methods are based on EPA Method 537 (Shoemaker, Grimmett, & Boutin, 2009) and ASTM Method D7968 (ASTM, 2014). All extracts are analyzed via Liquid Chromatography/Tandem Mass Spectrometry (LC-MS/MS) following Battelle SOP 5-369.

Note 1: The mixing and sub-sampling procedures presented in this SOP are appropriate for relatively homogeneous soil and sub-aqueous sediment samples. The mixing and sub-sampling presented in section 3 do not apply to solid samples originating at hazardous waste sites or other sites where potential inherent heterogeneity affects representativeness or comparability. For heterogeneous samples, specific mixing and sub-sampling procedures will be presented in the project- specific Project Plan. Project managers should refer to ASTM D 6323, laboratory Sub-sampling of Media Related to Waste Management Activities for guidance.

2.0 METHOD SUMMARY

PFAS compounds are extracted and purified for water samples, using solid phase extraction (SPE) methods. Soil, sediment, and tissue samples are extracted using a Geno/Grinder® followed by extract cleanup. All samples are fortified with labeled surrogate internal standards (SIS) prior to extraction. All extracts are fortified with an internal standard (IS) after cleanup, just prior to analysis. A flow chart for both aqueous and solid sample extractions is presented in **Attachment 2**.

3.0 PREPARATION

3.1 APPARATUS AND MATERIALS

Apparatus
- Top-loading balance capable of weighing to 0.01 g (SOP No. 3-160)
- Aluminum weighing pans
- Stainless steel spatula (or equivalent)
- Drying oven maintained at 115 ± 15ºC
- Centrifuge
- Spex Geno/Grinder® 2010 (or equivalent)
- Teflon free SPE extraction block (Waters part No. WAT200609, or equivalent)

- SPE manifold vacuum trap (Sigma part No. 57120-U, or equivalent)
- Vacuum pump (Vaccubrand diaphragm pump ME 1, or equivalent)
- Large volume SPE reservoir (Sigma part No. 54258-U, or equivalent)
- High density polyethylene (HDPE) sample bottles, 250 mL (Thermo Fisher part No. 2104-0008, or equivalent), for waters
- HDPE jars (Quality Environmental Containers (QEC) part No. 2214-0008, or equivalent), for solids and tissues
- Falcon 15 mL centrifuge tubes (Thermo Fisher part No. 339650, or equivalent)
- Falcon 50 mL centrifuge tubes (Thermo Fisher part No. 14-432-22, or equivalent)
- 11 mm Polypropylene LC extract vials (Thermo Fisher part No. 22-045618, or equivalent)
- Snap caps (Thermo Fisher part No. 03-345-24G, or equivalent)
- Nitrogen evaporation apparatus, N-Evap or equivalent, with water bath
- Class A volumetrics, various sizes
- Class A graduated cylinders, various sizes
- Calibrated pipettes (SOP 3-181)

3.2 SOLVENTS AND REAGENTS

- Methanol (HPLC grade, or equivalent)
- 7 N NH_3 solution in methanol (Sigma part No. 499145, or equivalent)
- 0.4% NH_3 solution in methanol (W/V) = using the 7 N solution, dilute 3.5 mL to 100 mL in methanol. This solution must be prepared fresh on the day of use.
- Supelclean ENVI-Carb 6 mL / 500 mg SPE cartridge (Supelco part No. 57094-U, or equivalent)
- Oasis Weak Anion Exchange (WAX) 500 mg / 6 mL SPE cartridge (Waters part No. 186004647, or equivalent)
- Millipore water
- Ottawa Sand (Applied Separations part No. 10548, or equivalent)
- Tilapia (locally sourced and verified prior to use)
- Surrogate Internal Standards (SIS) solutions
- Internal Standards (IS) solutions
- Target analyte (LCS/MS) spiking solutions

3.3 LABWARE PREPARATION

All glassware and labware must be cleaned according to laboratory protocols defined in SOP 5-216, glassware is then rinsed with methanol and air dried prior to contact with samples. Glassware pre-cleaned by manufacturer may be used as purchased. Teflon material should be avoided for this method.

3.4 RECORD KEEPING

Samples are assigned unique identification numbers and logged into the Laboratory Information Management System (LIMS) according to laboratory protocols (SOP 6-007). All sample data are managed using the LIMS from sample receipt to data reporting.

Data will be recorded in the sample preparation module in the LIMS (refer to the *LIMS Sample Preparation Training Manual* for examples of reports and instructions on entering data). Information to be recorded includes wet and dry weight information, dates of extraction/processing procedures, initials of laboratory personnel performing the procedures, types and volume of internal standards added to samples, and, if necessary, comments regarding individual samples.

Record information regarding sample integrity that might have bearing on the results; for example, amount of overlying water, sulfurous or oil odors, unusual color, or other unusual attributes. If debris or rocks or stones are removed, document the type and amount.

4.0 PROCEDURES

4.1 GENERAL

Samples are processed and extracted in batches of 20 or fewer authentic field samples. Quality control (QC) samples accompanying each batch may include a procedural blank (PB), laboratory control sample (LCS), matrix spike (MS), reference material (SRM) and/or field sample replicates (DUP and/or TRP). For the PB and LCS samples use Millipore water for aqueous samples, Ottawa Sand for soil and sediment samples, and clean fish tissue (e.g. tilapia) for tissue samples. Record the actual weight in LIMS (based on the target weight listed in the project plans). The moisture for sand is automatically entered as 100% dry weight. (See Section 5.0 for more detail).

Sample processing is performed in a vented area free of contamination. For soil and sediment samples, prior to sub-sampling for percent moisture and extraction, decant over-lying water and remove foreign objects, such as leaves, sticks and rocks. Stir the entire sample in its original container with a spatula for 2 to 3 minutes, until the sample appears uniform. Remove subsamples for analysis and percent moisture only after a uniform consistency and color is observed. In each subsample, use material from the top, middle, and bottom of the homogenized sample in case settling or separation of phases has occurred. Tissue samples will be homogenized using Teflon free homogenization equipment.

4.2 SAMPLE PRE-SCREENING

To avoid potential contamination of the laboratory and instruments, all non-potable water and solid samples will be pre-screened to determine if individual analytes are present in the samples above 10x sample equivalent concentrations of the high level of the calibration for each matrix.

Non-potable water – a small volume of water will be removed from each sample container and pre-screened to determine if concentration levels above 1,000 ng/L are present. All non-potable waters, with the exception of field blanks and equipment blanks will be processed using the following procedure:

- Shake sample bottle well, centrifuge if sample bottle has high levels of particulate matter
- Remove 250 µL of sample
- Add SIS to achieve concentrations of 250 ng/L at a PIV of 1 mL (25 µL of SIS if concentration is 0.005 ng/µL and final volume is 1 mL)
- Add 225 µL of methanol
- Cap, vortex, and transfer to analysis

Solids – all soil and sediment samples will be pre-screened to determine if concentration levels above 1,000 ng/g are present. All solid samples will be processed using the following procedure:

- Mix the solid sample following the procedure in section 4.1.
- Weigh 1 g of well mixed solid into a 50 mL Falcon tube
- Add 5 mL of Methanol
- Extract using Geno/Grinder® (1,200 RPM for 30 minutes)
- Centrifuge for 5 minutes at 2,500 RPM
- Remove 50 µL of extract and place into an Eppendorf tube containing:
    - 25 µL of SIS (0.005 ng/L)

  - 100 µL of Millipore water
  - 325 µL of Methanol
- Cap, vortex, and transfer to analysis

Any samples that have concentrations for individual PFAS compounds above 1,000 ng/L or 1,000 ng/g will need to be processed in a manner to avoid the potential of cross-contaminating the laboratory or the instrument. The client will be consulted if direct injection analysis is required for non-potable water samples.

4.3 AQUEOUS SAMPLE EXTRACTION AND CLEANUP

Water samples should be collected in 250 mL HDPE sample bottles, with the entire sample being extracted. All water samples are extracted using SPE techniques.

In some cases, field samples contain suspended solids that may clog the top filter of the SPE cartridge. Samples should be visually inspected prior to the start of the extraction process. For samples that appear to contain levels of suspended solids that may clog the filter the following steps should be taken in order to minimize the potential for particulate matter interfering with the extraction process and to ensure minimal loss of PFAS compounds to the walls of the sample containers:

- Agitate the sample to ensure that all solids are suspended in the sample
- Decant the entire samples into a clean HDPE bottle
- Centrifuge the sample bottles at approximately 2,500 rpm for 5 minutes
- Decant the overlying water back into the original sample container. This allows for the extraction to include the original sample container from the field, which has had the most contact with the sample since collection
- Keep the solids remaining in the centrifuged bottle with the project samples and return to the sample custodian

Once these steps have been completed, the extraction process can begin.

- Prior to spiking samples, draw a line on each sample container equivalent to the top of the water line (samples should be approximately 250 mL) – this will be used to refill the bottles after extraction to record the sample volumes (sample size may be changed in the Project Plan)
- Fortify samples will the appropriate SIS solutions, per the Project Plan, cap and mix
  - LCS, MS, and MSD samples should be fortified with the appropriate targets
- Condition the OASIS WAX cartridges as follows (***if cartridges go dry during the conditioning step, the process must be restarted***):
  - Rinse cartridges with 2 x 5 mL of methanol (collect to waste)
  - Rinse cartridges with 2 x 5 mL of 0.4% NH_3 in methanol (collect to waste)
  - Rinse cartridges with 2 x 5 mL of Millipore water (collect to waste)
  - Add 1- 2 mL of Millipore water to each cartridge and close the stopcock to stop the flow through the SPE cartridge
- Attach a reservoir to each SPE cartridge using the adaptor
- Load samples onto the cartridges
- Elute at approximately 5 mL/minute (collect to waste)
  - Record the start and stop times in LIMS to verify proper flow rate
- Rinse The sample bottle onto the cartridge with 2 x 7.5 mL washes of Millipore water, ensuring a good rinse of the sample bottle and the reservoir used for extraction (collect to waste)

  - Immediately rinse the sample bottle with 1-mL of methanol, adding the rinsate to the SPE reservoir.
- Once the entire sample has passed through the SPE cartridge, dry columns under vacuum for a minimum of 10 minutes

- Discard waste and replace with clean 15 mL centrifuge tubes
- To ensure that no PFAS compounds have been retained in the original sample container, the following rinses should be added to the original sample bottle prior to eluting the columns
- Under vacuum, elute the SPE cartridge as follows:
    - Elute cartridges with 2 x 5 mL of 0.4% NH_3 in methanol
- Remove the centrifuge tubes from the extraction manifold
- Concentrate the entire extract to dryness under nitrogen in a water bath (temperature set to approximately 35-45 °C)
- Reconstitute extract with 80/20 methanol/water (V/V) and fortify with IS and vortex
    - The volume of methanol used should be equal to the pre-injection volume (PIV) in the Project Plan minus the volume of IS fortified (typical PIV is 1,000 µL)
- Aliquot approximately 300 µL into a polypropylene snap cap vial (no Teflon septa) using a pipettor, the remaining extract can be stored in the 15 mL centrifuge tube, at room temperature.
- Transfer the extract for analysis via LC-MS/MS (SOP 5-369)

4.4 PERCENT MOISTURE DETERMINATION (SOIL / SEDIMENT AND TISSUE SAMPLES)

- Record the weight of an aluminum drying pan
- Place approximately 5 grams of homogenized sample on the drying pan and record the weight
- Place pan in drying oven overnight
- Record the weight of the pan and dried sample

4.5 SOIL / SEDIMENT AND TISSUE EXTRACTION AND CLEANUP

The default extraction solvent is 0.4% NH_3 in methanol, however, other solvents may be substituted if specified in the Project Plan.

4.4.2 Soil/Sediment Sample Extraction

- Accurately weigh 2.0 g (± 0.2 g) of homogenized sample into a 15 mL centrifuge tube (sample size may be changed in the Project Plan)
- Fortify samples will the appropriate SIS solutions, per the Project Plan
    - LCS, MS, and MSD samples should be fortified with the appropriate targets
- Add 5 mL of 0.4% NH_3 in methanol and extract using Geno/Grinder® (1,200 RPM for 15 minutes)
- Centrifuge for 5 minutes at 2,500 RPM
- Decant supernatant into clean 15 mL centrifuge tube
- Add a fresh 5 mL of 0.4% NH_3 in methanol and extract using Geno/Grinder® (1,200 RPM for 15 minutes)
- Centrifuge for 5 minutes at 2,500 RPM
- Decant supernatant combining with the extract from the first extraction and mix the combined extract well (initial volume for split is 10 mL)
- Remove 1 mL for extract cleanup

4.4.3 Tissue Sample Extraction

- Accurately weigh 2.0 g (± 0.2 g) of homogenized sample into a 50 mL centrifuge tube (sample size may be changed in the Project Plan)
- Fortify samples with the appropriate SIS solutions, per the Project Plan

  - LCS, MS, and MSD samples should be fortified with the appropriate targets
- Add 10 mL of 0.4% NH_3 in methanol and extract using Geno/Grinder® (1,200 RPM for 15 minutes)
- Centrifuge for 5 minutes at 2,500 RPM
- Decant supernatant into clean 50 mL centrifuge tube
- Add a fresh 10 mL of 0.4% NH_3 in methanol and extract using Geno/Grinder® (1,200 RPM for 15 minutes)
- Centrifuge for 5 minutes at 2,500 RPM
- Decant supernatant combining with the extract from the first extraction and mix the combined extract well (initial volume for split is 20 mL)
- Remove 2 mL for extract cleanup (starting volume for dilution is 20 mL, dilution factor is 20 mL / 2 mL for a dilution factor of 10)

4.4.4 Extract cleanup

- Place Supelclean ENVI-Carb cartridges on the manifold
- Rinse the Supelclean ENVI-Carb cartridge as follows (***these can go dry between rinses***):
  - Rinse cartridges with 3 x 2 mL of 0.4% NH_3 in methanol
  - Discard waste and replace with clean 15 mL centrifuge tubes
- Load the 1 mL sample from the extraction step above onto the SPE cartridge
- Elute the SPE cartridges as follows:
  - Elute cartridges with 2 x 5 mL of 0.4% NH_3 in methanol
- Remove the centrifuge tubes from the extraction manifold and proceed to final extract processing

4.4.5 Final Extract Processing

- Remove the centrifuge tubes from the extraction manifold, concentrate the entire extract to dryness under nitrogen in a water bath (temperature set to approximately 35-45 °C)
- Reconstitute extract with 80/20 methanol/water (V/V) and fortify with IS and vortex
  - The volume of methanol used should be equal to the PIV in the Project Plan minus the volume of IS fortified (typical PIV is 1,000 µL)
- Aliquot approximately 300 µL into a polypropylene snap cap vial (no Teflon septa) using a pipettor, the remaining extract can be stored in the 15 mL centrifuge tube, at room temperature. Extracts must be analyzed within 28 days of extraction.
- Transfer the extract for analysis via LC-MS/MS (SOP 5-369)

5.0 CALCULATIONS

Calculate percent dry weight with the following equation:

$$\%\, dry\ weight = \frac{aliquot\ dry\ wt^{a}}{aliquot\ wet\ wt^{a}} \times 100$$

[a] corrected for pan weight

Calculate percent moisture with the following equation:

$$\%\, moisture = 100 - \%\, dry\ weight$$

Calculate sample dry weight with the following equation:

*Sample dry weight (g) = % dry wt. * sample wet wt. (g)*

6.0 QUALITY CONTROL

Samples must be extracted in batches of 20 or fewer authentic field samples. QC samples accompanying each batch may include a procedural blank, laboratory control sample, matrix spike, standard reference material and/or field sample replicates.

The QC program for each project is defined in the project plan, which will define the type and amount of internal standards/spiking solutions to be added to the samples, the specific QC samples to be processed, any modifications to the standard QC acceptance criteria, and the corrective action required if QC results do not meet those acceptance criteria.

7.0 TRAINING

The trainee must read and fully understand the policies and procedures outlined in this SOP. The trainee will then be given a demonstration of all aspects of this SOP.

SOP 2-011 defines the training procedures and required documentation for sample preparation and analytical SOPs. These apply to both technicians processing samples and the analysts. The acceptance criteria for the Demonstration of Capability (DOC) are the same as for routine QC samples as defined in SOP 7-029.

When training is completed, the trainee will be issued an IDC Certificate (SOP 2-011). The laboratory Quality Assurance Manual and SOP 2-011 define the locations of training records.

8.0 SAFETY

As part of the above training program, the analyst will be made aware of the particular safety concerns of this procedure, including:

- Use of protective eyewear and clothing
- Proper use of fume hoods
- Location and use of laboratory safety devices; eyewashes, emergency showers, fire extinguishers, fire blankets, and first aid kits, as well as SDS sheets.

References

ASTM. (2014). *D7968: Standard Test Method for Determination of Perfluorinated Compounds in Soil by Liquid Chromatography Tandem Mass Sectrometry (LC/MS/MS).* West Conshohocken: ASTM.

Shoemaker, J. A., Grimmett, P. E., & Boutin, B. K. (2009). *Method 537 Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS).* Cincinnati: EPA.

ATTACHMENTS

Attachment 1	Revision History
Attachment 2	Sample processing flow chart

APPROVALS

Author Jonathan Thorn		Digitally signed by Jonathan Thorn Date: 2019.04.11 12:08:35 -04'00'
Technical Reviewer Denise Schumitz	Denise Schumitz	schumitzd@battelle.org 2019.04.11 12:36:49 -04'00'
Quality Systems Manager Zachary Willenberg	Zachary Willenberg	Digitally signed by Zachary Willenberg Date: 2019.04.16 08:03:33 -04'00'
Laboratory Director Jonathan Thorn		Digitally signed by Jonathan Thorn Date: 2019.04.11 12:08:48 -04'00'
	Name	Date

ATTACHMENT 1

Revision History

Version	Summary of Changes
02	Modified extraction procedures for tissues and updated the SPE cartridge for aqueous samples. This method is equivalent to the previous sample preparation method for water and soil/sediment, new Demonstrations of Capability (DOC) will only be needed for tissue under this version of the SOP. Revision history added as **Attachment 1**.
03	Updated section 4.2 to require recording the start and stop times for loading the samples onto the solid phase extraction cartridges. Updated section 4.4.2 for tissue extraction procedures. Updated section 4.4.3 for elution of cleanup cartridge. This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.
04	Updated initial extraction volume for non-potable water samples. Updated extraction section for solids and tissues (serial extraction). This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.
05	Updated initial extraction volume for non-potable water samples. Updated extraction section for solids and tissues (serial extraction). This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.
06	Updated extraction solvent to be prepared day of use. Reduced blow-down temperatures for final extract concentration. This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.
07	Updated final extract preparation procedures to change final split and pre-injection volume. Added procedure for prescreening samples. Added procedure for direct injection analysis of highly contaminated non-potable water samples. This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.

ATTACHMENT 2

Sample Processing Flow Chart