Naval Facilities Engineering Systems Command Northwest
Silverdale, Washington

Final

Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances Remedial Investigation
Area 6

Naval Air Station Whidbey Island
Oak Harbor, Washington

November 2022

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SAP Worksheet #1—Title and Signature Page

Naval Facilities Engineering Systems Command Northwest
Silverdale, Washington

Final

Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances Remedial Investigation
Area 6

Naval Air Station Whidbey Island
Oak Harbor, Washington

November 2022

Prepared for NAVFAC Northwest
by CH2M HILL, Inc.
Bellevue, Washington
Contract N62470-16-D-9000
CTO N4425521F4202

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

Approval Signatures:

Dana Stonelake
Naval Facilities Engineering Systems Command Atlantic
Quality Assurance Officer

Other Approval Signatures:

CLUBB.KENDRA.R.1374441171
Digitally signed by CLUBB.KENDRA.R.1374441171
Date: 2022.10.24 11:52:23 -07'00'

Kendra Clubb
Naval Facilities Engineering Systems Command Northwest
Remedial Project Manager

CHAN PONGKHAMSING
Digitally signed by CHAN PONGKHAMSING
Date: 2022.10.27 08:21:35 -07'00'

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

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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 Remedial Investigation (RI) specific to releases of per- and polyfluoroalkyl substances (PFAS) at Area 6, Naval Air Station (NAS) Whidbey Island, Ault Field, in Oak Harbor, Washington in Island County. This Uniform Federal Policy-Sampling and Analysis Plan (SAP) describes the investigation activities to be conducted. CH2M prepared this document under the NAVFAC Comprehensive Long-term Environmental Action – Navy 9000 Contract N62470-16-D-9000, Contract Task Order N4425521F4202, for submittal to NAVFAC Northwest, NAVFAC Atlantic, United States Environmental Protection Agency (USEPA), and Washington State Department of Ecology. CH2M prepared this SAP to help ensure that environmental data collected as part of this RI are scientifically sound, of known and documented quality, and suitable for intended uses.

Area 6 is part of NAS Whidbey Island Ault Field, located at the northern end of Whidbey Island along the shoreline of the Strait of Juan de Fuca just north of Oak Harbor, Washington. Two primary waste disposal areas are within Area 6: the landfill, which received Naval wastes between 1969 and the mid-1990s; and a former industrial waste disposal area, which received liquid hazardous waste at a time when regulatory requirements had not been established (between 1969 and the early 1980s).

Investigations for PFAS at Area 6 began in 2017 with the sampling of on-Base groundwater monitoring wells and the groundwater extraction, treatment, and recharge (GETR) system influent and effluent during the Phase 1 Site Inspection (SI) (CH2M, 2020a). The presence of PFAS in monitoring well and GETR samples at concentrations exceeding the Project Action Level (PAL)[1] prompted initiation of a Phase 2 SI and an off-Base drinking water investigation. Phase 2 SI sampling of groundwater monitoring wells (on and off Base) as well as the Phase 1 and 2 investigations of privately owned groundwater wells and drinking water wells near Area 6 was conducted in 2018 and 2019. The results of the sampling conducted between 2017 and 2019 identified the presence of perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorohexanesulfonic acid (PFHxS), and/or perfluorononanoic acid (PFNA) at concentrations exceeding the PALs at ten groundwater monitoring wells, the GETR influent and effluent samples, and two private groundwater wells. In addition, six drinking water wells were identified as having PFOS or PFOS + PFOA concentrations exceeding the 2016 2016 USEPA lifetime drinking water health advisory level of 70 parts per trillion (ppt) through the off-Base drinking water investigation (five drinking water wells) and routine drinking water sampling program (one drinking water well). **Worksheet #10** presents further detail of the previous investigations.

Based on the 2017 through 2019 sampling results, Area 6 will be investigated under this RI. The RI objectives are as follows:

- Define the nature and extent of PFAS in groundwater (on and off Base) above PALs and assess risks to human health receptors.
- Evaluate the extents of the Area 6 aquifers to the north and west/southwest through which PFAS may be migrating.
- Evaluate whether an ongoing source of loading exists to the aquifer system from the vadose zone.
- Define the nature and extent of PFAS above the PALs in surface water within the GETR effluent stream and assess risks to human health and ecological receptors.

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[1] Groundwater data collected during the SI and Phase 1 and 2 investigations described herein are compared to current PALs for this RI specified in **Worksheets #11** and **#15**, which may be inconsistent with the PALs at the time of those investigations.

- Evaluate whether PFAS are present in sediment[2] within the GETR effluent stream, and if present, define the nature and extent of PFAS above the PALs in sediment[2] in the GETR discharge area and assess risks to human health and ecological receptors.
- Refine the understanding of groundwater flow and potential PFAS migration pathways near Area 6 in the shallow, intermediate, and deep aquifers.

It is anticipated that the RI will be accomplished during at least two field investigation phases. If additional data are needed to accomplish the RI objectives, additional phases may be performed and and will be described in an SAP addendum following a modification to this task order, or under future task order's SAP.

Stage 1, On-Base Field Activities:

- Install on-Base well pairs (shallow/intermediate or intermediate/deep) near the former industrial waste disposal area within Area 6 and near the GETR effluent stream north of Ault Field Road.
  - Collect lithologic data from the newly installed groundwater monitoring wells and soil borings to further the understanding of the overall conceptual site model for the site.
  - Conduct surface and subsurface soil sampling, and collect depth-discrete groundwater grab samples at the deeper well in each pair.
- Install a triple completion lysimeter cluster at the former industrial waste disposal.
  - Conduct surface and subsurface soil sampling at the deepest lysimeter boring.
  - Collect vadose zone porewater (VZW) samples from the lysimeters.
- Survey each newly installed groundwater monitoring well and lysimeter location.
- Collect paired surface water and sediment[2] from the GETR effluent discharge stream.
- Collect groundwater samples from 33 existing groundwater monitoring and GETR wells and the newly installed groundwater monitoring wells.
- Perform a synoptic groundwater level survey of newly installed and existing monitoring wells.
- Perform an aquifer test to evaluate aquifer properties and the interconnectivity of the aquifer systems underlying Area 6.

Stage 2, Off-Base Field Activities:

- Install up to eight off-Base groundwater monitoring wells along Ault Field Road (north of Area 6) and to the west/southwest of Area 6.
  - Collect lithologic data from the newly installed groundwater monitoring wells to further understanding of the overall conceptual site model for the site.
  - Collect depth-discrete groundwater grab samples during drilling of up to five off-Base groundwater monitoring wells.
  - Collect groundwater samples and groundwater levels from each new monitoring well.
- Survey each newly installed groundwater monitoring well and lysimeter location.

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[2] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

Groundwater, soil, sediment[2], and surface water samples will be analyzed for PFAS by Vista Analytical using liquid chromatography – tandem mass spectrometry compliant with the Department of Defense (DoD) Quality Systems Manual (QSM) Version 5.3 Table B-15. The 29 PFAS listed in the Unregulated Contaminant Monitoring Rule 5 will be reported as approved by the Environmental Restoration Program Manager. A subset of the subsurface soil samples will be submitted for geotechnical analysis to obtain site-specific solute transport property data.

Synoptic groundwater elevation data, aquifer property data, PFAS concentrations (in all media), and aquifer solute transport property data will be used to update the conceptual site model for groundwater flow and PFAS transport. The data will also be used to support the construction of a groundwater flow and solute transport model of Area 6. The numerical model will be used to quantify groundwater pathways, flow rates, flow velocities, and current and future PFAS migration pathways and mass flux through the soil source areas and aquifer system.

Additional field work stages needed to accomplish the objectives of the RI will be included in a SAP addendum or Field Change Request. Drinking water is being addressed under the routine drinking water sampling program at NAS Whidbey Island (CH2M, 2018b; 2019).

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

- *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (OSWER Directive 9355.3-01)* (USEPA, 1988)
- *Guidance for Quality Assurance Project Plans* (USEPA, 2002)
- *Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP)* (USEPA, 2005)
- *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)
- *Naval Facilities Engineering Command- Sampling and Analysis Plans Update on the Uniform Federal Policy Quality Assurance Project Plans (UFP-QAPP) – Navy Sampling and Analysis Plans (SAP) Tiered Approach.* (Navy, 2011)
- *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/November 2020 Update* (Navy, 2020)

This SAP consists of 37 worksheets specific to the scope of this RI. All tables are embedded within the worksheets. All figures are included at the end of the document. Presentations from the scoping sessions are included in **Appendices A-1** and **A-2**. Ecological screening values are included in **Appendix B**. Field standard operation procedures are included in **Appendix C**. DoD ELAP Accreditation letters are included in **Appendix D**. Laboratory standard operating procedures are included in **Appendix E**.

The PFAS laboratory information cited in this SAP is specific to Vista Analytical. The geotechnical laboratory information cited in this SAP is specific to Core Laboratories. If additional laboratory services are necessary to meet the project objectives, revised SAP worksheets will be submitted to NAVFAC and regulatory agencies (as appropriate) for approval and appended to this SAP.

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SAP Worksheets

Appendices

Tables

Figures

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Acronyms and Abbreviations

°C	degree(s) Celsius
<	less than
≤	less than or equal to
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
>	more than
≥	more than or equal to
%	percent
±	plus or minus
11Cl-PF3OUdS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid
4:2FTS	1H, 1H, 2H, 2H-perfluorohexane sulfonic acid
5.3	Version 5.3
6:2FTS	1H, 1H, 2H, 2H-perfluorooctane sulfonic acid
8:2FTS	1H, 1H, 2H, 2H-perfluorodecane sulfonic acid
9Cl-PF3ONS	9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid
ADONA	4,8-dioxa-3H-perfluorononanoic acid
AFFF	aqueous film-forming foam
AM	Activity Manager
API	American Petroleum Institute
AQM	Activity Quality Manager
ASD	Assistant Secretary of Defense
ASTM	ASTM International
bgs	below ground surface
CA	corrective action
CAS	Chemical Abstract Service
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH2M	CH2M HILL, Inc.
CLEAN	Comprehensive Long-term Environmental Action—Navy
COC	chemical of concern
CSM	conceptual site model
CTI-URS	CTI-URS Environmental Services, LLC
CTO	Contract Task Order
DL	detection limit
DoD	Department of Defense
DQI	data quality indicator
DV	data validation
EDD	electronic data deliverable
EDS	Environmental Data Services, Inc.
EIS	extracted internal standard
ELAP	Environmental Laboratory Accreditation Program

ESV	ecological screening value
EtFOSAA	N-ethyl perfluorooctanesulfonamidoacetic acid
FCR	field change request
FD	field duplicate
FedEx	Federal Express
FTL	Field Team Leader
GETR	groundwater extraction, treatment, and recharge
GW	groundwater
H&S	health and safety
HDPE	high density polyethylene
HFPO-DA	perfluoro-2-methyl-3-oxahexanoic acid
HQ	hazard quotient
HSM	Health and Safety Manager
HSP	Health and Safety Plan
HSU	hydrostratigraphic unit
ICAL	initial calibration
ICV	initial calibration verification
ID	identification
IDW	investigation-derived waste
ISC	instrument sensitivity check
LC-MS/MS	liquid chromatography – tandem mass spectrometer
LCS	laboratory control sample
LCL	lower control limit
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MD	matrix duplicate
MeFOSAA	N-methyl perfluorooctanesulfonamidoacetic acid
mL	milliliter(s)
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NAS	Naval Air Station
NAVD 88	North American Vertical Datum of 1988
NAVFAC	Naval Facilities Engineering Systems Command
Navy	Department of the Navy
NEtFOSA	N-ethyl perfluorooctanesulfonamide
NEtFOSAA	n-ethylperfluoro-1-octancesulfonamidoacetic acid
NFDHA	nonafluoro-3,6-dioxaheptanoic acid
NMeFOSA	N-methyl perfluorooctanesulfonamide
NMeFOSAA	n-methylperfluoro-1-octanesulfonamidoacetic acid
ng/L	nanogram(s) per liter
NTR	Navy Technical Representative

PA	preliminary assessment
PAL	project action limit
PC	Project Chemist
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonic acid
PFDA	perfluorodecanoic acid
PFDoA	perfluorododecanoic acid
PFEESA	perfluoro(2-ethoxyethane)sulfonic acid
PFHpA	perfluoroheptanoic acid
PFHpS	perfluoroheptanesulfonic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFMBA	perfluoro-4-methoxybutonoic acid
PFMPA	perfluoro-3-methoxypropanoic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic acid
PFPeA	perfluoropentanoic acid
PFPeS	perfluoropentansulfonic acid
PFTeDA	perfluorotetradecanoic acid
PFTrDA	perfluorotridecanoic acid
PFUnA	perfluoroundecanoic acid
PID	photoionization detector
PM	Project Manager
POC	point of contact
ppm	part(s) per million
ppt	part(s) per trillion
PQL	project quantitation limit
PQO	project quality objective
PVC	polyvinyl chloride
QA	quality assurance
QAO	Quality Assurance Officer
QC	quality control
QSM	Quality Systems Manual
RI	Remedial Investigation
ROD	Record of Decision
RPD	relative percent difference
RPM	Remedial Project Manager
RSL	regional screening level
RT	retention time
SAP	Sampling and Analysis Plan
Sealaska	Sealaska Environmental Services, LLC
SI	Site Inspection
SL	screening level

SME	Subject Matter Expert
SOP	standard operating procedure
SPE	Solid Phase Extraction
SSHO	Site Safety and Health Officer
STC	Senior Technical Consultant
SW	surface water
TAT	turnaround time
TBD	to be determined
TCE	trichloroethene
TM	Task Manager
UCL	upper control limit
UCMR5	Unregulated Contaminant Monitoring Rule 5
URS	URS Consultants, Inc. or URS Group, Inc.
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound
VZW	vadose zone porewater

SAP Worksheet #2—Sampling and Analysis Plan Identifying Information

Site Name/Number:	Area 6, Ault Field, Oak Harbor, Naval Air Station (NAS) Whidbey Island
Operable Unit:	Not applicable (N/A)
Contractor Name:	CH2M HILL, Inc. (CH2M)
Contract Number:	N62470-16-D-9000, Contract Task Order 4202
Contract Title:	Comprehensive Long-term Environmental Action – Navy (CLEAN) Program 9000
Work Assignment:	Remedial Investigation (RI) specific to releases of per- and polyfluoroalkyl substances (PFAS) to the environment for Naval Facilities Engineering Systems Command (NAVFAC) Northwest at Area 6, Ault Field in Oak Harbor, Washington

1. **This Sampling and Analysis Plan (SAP) was prepared in accordance with the following guidance documents:**
   - *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (OSWER Directive 9355.3-01)* (USEPA, 1988)
   - *Superfund Amendments and Reauthorization Act* (USEPA, 1986)
   - *Guidance for Quality Assurance Project Plans* (USEPA, 2002)
   - *Uniform Federal Policy for Quality Assurance Project Plans: Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs - Part 1: UFP-QAPP Manual* (USEPA, 2005)
   - *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)
   - *Naval Facilities Engineering Command- Sampling and Analysis Plans Update on the Uniform Federal Policy Quality Assurance Project Plans (UFP-QAPP) – Navy Sampling and Analysis Plans (SAP) Tiered Approach.* (Navy, 2011)
   - *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/November 2020 Update* (Navy, 2020)
   - *Department of the Navy Environmental Restoration Program Manual* (Navy, 2018)
2. **Identify regulatory Program:**
   - Comprehensive Environmental Response, Compensation and Liability Act of 1980; and Superfund Amendments and Reauthorization Act (USEPA, 1986).
3. **This document is a project-specific SAP.**
4. **List dates of scoping sessions that were held:**

Scoping Session	Date
Project Scoping Session with NAVFAC Northwest, United States Environmental Protection Agency (USEPA), Washington Department of Ecology, and Washington Department of Health	November 17, 2021
Project Scoping Session with NAVFAC Northwest and NAVFAC Atlantic	December 17, 2021

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

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

Document	Date
Sampling and Analysis Plan Site Inspection of Per- and Polyfluoroalkyl Substances and Additional Characterization of 1,4-Dioxane, and Vinyl Chloride in Groundwater and Drinking Water for Remedial Design Refinement, Area 6, Ault Field, Naval Air Station Whidbey Island, Oak Harbor, Washington (CH2M, 2017)	November 2017
Sampling and Analysis Plan Addendum Site Inspection of Per- and Polyfluoroalkyl Substances and Additional Characterization of 1,4-Dioxane, and Vinyl Chloride in Groundwater and Drinking Water for Remedial Design Refinement, Area 6, Ault Field, Naval Air Station Whidbey Island, Oak Harbor, Washington (CH2M, 2018b)	July 2018
Sampling and Analysis Plan Addendum 2 Site Inspection of Per- and Polyfluoroalkyl Substances and Additional Characterization of 1,4-Dioxane, and Vinyl Chloride in Groundwater and Drinking Water for Remedial Design Refinement, Area 6, Ault Field, Naval Air Station Whidbey Island, Oak Harbor, Washington (CH2M, 2018c)	August 2018

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

Organization Partners/Stakeholders	Connection
NAVFAC Northwest – Kendra Clubb	RPM
NAVFAC Atlantic	Quality Assurance Officer (QAO)
USEPA Region 10 – Chan Pongkhamsing	Technical Representative/Base Stakeholder
Washington State Department of Ecology – Michael Shaljian	Technical Representative/Base Stakeholder

7. **Lead organization:**

   – Department of the Navy (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	Email Address or Mailing Address
Kendra Clubb	RPM/Task Order Contracting Officer's Representative	NAVFAC Northwest	(509) 999-6843	kendra.r.clubb.civ@us.navy.mil
Charlie Escola	Navy Technical Representative (NTR)	NAVFAC Northwest	(503) 201-5020	charles.r.escola.civ@us.navy.mil
Steve Skeehan	NTR	NAVFAC Northwest	(253) 279-0212	steve.skeehan@navy.mil
Dana Stonelake	NAVFAC QAO	NAVFAC Atlantic	(757) 322-4942	dana.m.stonelake.civ@us.navy.mil
Chan Pongkhamsing	Project Manager (PM)	USEPA Region 10	(206) 553-1806	pongkhamsing.chan@epa.gov
Michael Shaljian	Toxics Cleanup, Hydrogeologist	Washington State Department of Ecology	(360) 489-2753	mish461@ecy.wa.gov
Jennifer Madsen	Activity Manager (AM), PM	CH2M	(360) 888-0281	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
Heather Perry	Project Task Manager (TM)	CH2M	(530) 355-1622	heather.perry@jacobs.com
Janna Staszak	Program SAP Quality Reviewer	CH2M	(757) 671-6256	janna.staszak@jacobs.com
Anita Dodson	CLEAN Program Chemist/SAP Reviewer	CH2M	(757) 671-6218	anita.dodson@jacobs.com
Tiffany Hill	Project Chemist (PC)	CH2M	(541) 768-3109	tiffany.hill@jacobs.com
Nancy Weaver	Data Validator PM	Environmental Data Services, Inc. (EDS)	(757) 564-0090	nweaver@end-data.com
To be determined (TBD)[a]	Field Team Leader (FTL)	CH2M	TBD[a]	TBD[a]
TBD[a]	Site Safety and Health Officer (SSHO)	CH2M	TBD[a]	TBD[a]

SAP Worksheet #3—Distribution List (continued)

Name of SAP Recipients	Title/Role	Organization	Telephone Number	Email Address or Mailing Address
Karen Volpendesta	Laboratory PM	Vista Analytical	(916) 673-1520	kvolpendesta@vista-analytical.com
Brett Elliot	Laboratory PM	Core Laboratories – Geotechnical Laboratory	(713) 328-2503	brett.elliot@corelab.com

[a] Cells will be populated with information after personnel are selected, prior to fieldwork.

SAP Worksheet #4—Project Personnel Sign-off Sheet

Certification that project personnel have read the text will be obtained by one of the following methods as applicable:

- In the case of regulatory agency personnel with oversight authority, approval letters or emails will constitute verification that applicable sections of the SAP have been reviewed. Copies of regulatory agency approval letters/emails will be retained in the project files as project records (Worksheet #29).
- Emails will be sent to the listed Navy, CH2M, and subcontractor project personnel who will be requested to verify by email that they have read the applicable SAP sections and the date on which they were reviewed. Copies of the verification email will be included in the project files (Worksheet #29).
- A copy of the signed Worksheet #4 will be retained in the project files and is identified as a project record in Worksheet #29.
- Key personnel will be instructed to read the SAP portions indicated in this worksheet prior to attending an internal site-specific kickoff meeting for field activities. The CH2M PM will track when the reviews have been completed, obtain signatures, and ensure that the completed sign-off sheet is included in the central project file.

Name	Organization/Title/Role	Telephone Number	Signature/ Email Receipt	SAP Section Reviewed	Date SAP Read
Jennifer Madsen	CH2M/AM, PM	(360) 888-0281			
Peter Lawson	CH2M/STC	(530) 229-3383			
Paul Townley	CH2M/AQM	(425) 233-5302			
Laura Cook	CH2M/SME	(757) 671-6214			
Heather Perry	CH2M/TM	(530) 355-1622			
Anita Dodson	CH2M/CLEAN Program Chemist/SAP Reviewer	(757) 671-6218			
Tiffany Hill	CH2M/PC	(541) 768-3109			
TBD[a]	CH2M/FTL	TBD[a]			
TBD[a]	CH2M/SSHO	TBD[a]			
Karen Volpendesta	Vista Analytical/Laboratory PM	(916) 673-1520			
Brett Elliot	Core Laboratories – Geotechnical Laboratory PM	(713) 328-2503			
Nancy Weaver	EDS/Data Validator PM	(757) 564-0090			

Notes:

[a] Cells will be populated with information after personnel are selected, prior to fieldwork.

The sampling personnel will read the appropriate sections of this document before performing activities related to this SAP. The completed sign-off worksheet will be maintained in the CH2M project file.

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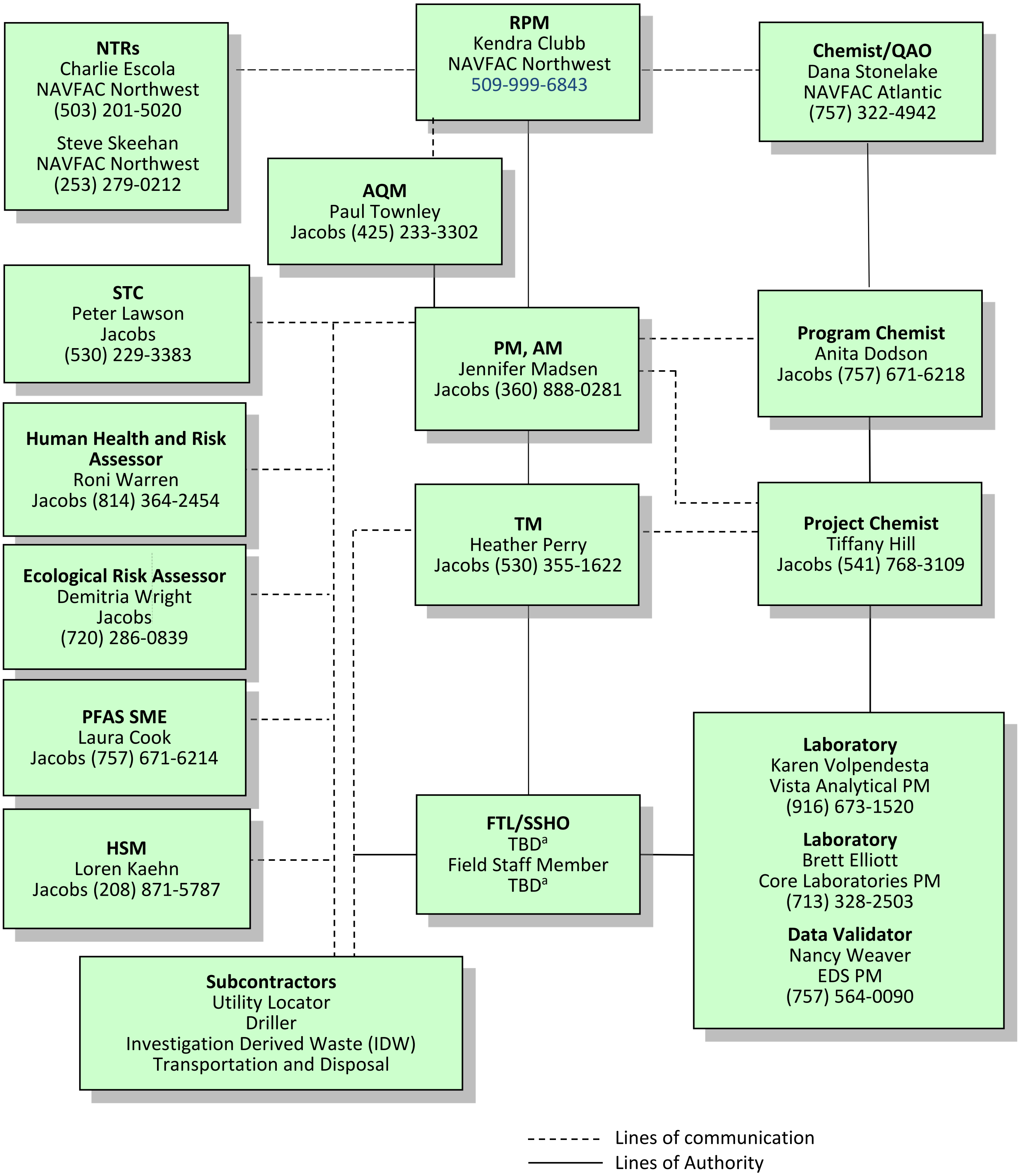
SAP Worksheet #5—Project Organizational Chart



[a] Information will be populated with information after personnel are selected, prior to fieldwork.

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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Entity	Name	Email Address Phone Number	Procedure (timing, pathway to and from, and similar)
Authorization for CH2M to initiate fieldwork	Navy RPM	Kendra Clubb	kendra.r.clubb.civ@us.navy.mil (509) 999-6843	The CH2M AM/PM communicates either verbally or by email the earliest schedule possible for fieldwork to commence.
Communication with Navy (lead agency)	NAVFAC Northwest NTR	Charlie Escola	charles.r.escola.civ@us.navy.mil (503) 201-5020	Point of contact (POC) for NAVFAC Northwest for the contractor during fieldwork; oversees fieldwork, provides Base-specific information, provides coordination with NAS Whidbey Island, and can delegate communication to other internal POCs.
Communication with Navy (lead agency)	NAVFAC Northwest NTR	Steve Skeehan	steve.skeehan@navy.mil (253) 279-0212	Primary POC for NAVFAC Northwest for the contractor during fieldwork; oversees fieldwork, provides Base-specific information, provides coordination with NAS Whidbey Island, and can delegate communication to other internal POCs.
Communication with Navy (lead agency)	NAVFAC Northwest RPM	Kendra Clubb	kendra.r.clubb.civ@us.navy.mil (509) 999-6843	Primary POC for NAVFAC Northwest; can delegate communication to other internal or external POCs. CH2M PM will notify the NTR, RPM, and NAVFAC Atlantic QAO by email or telephone call within 24 hours for changes affecting the scope or implementation of the SAP.
Communication with Navy (lead agency)	NAVFAC Atlantic QAO	Dana Stonelake	dana.m.stonelake.civ@us.navy.mil (757) 322-4942	Primary POC for NAVFAC Atlantic.
CH2M POC with Navy RPM: Communication regarding overall project status and implementation and primary POC with RPMs and project team	CH2M AM/PM	Jennifer Madsen	jennifer.madsen@jacobs.com (360) 888-0281	Materials and information about the project are forwarded to the Navy RPM by the AM. The AM 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, and RPM via email and will communicate in-field changes to the team by email or phone within 24 hours. All data results will be communicated to appropriate team members following data receipt and review.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Email Address Phone Number	Procedure (timing, pathway to and from, and similar)
Communication regarding items specific to Area 6 tasks and primary POC for field team	CH2M TM	Heather Perry	heather.perry@jacobs.com (530) 355-1622	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 and RPM to prepare an FCR to be submitted via email to the NTR and RPM 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) 949-0870	Contact STC regarding questions/issues encountered in the field, input on data interpretation, as needed. The STC will have 24 hours to respond to technical field questions, via phone or email, as necessary. Additionally, the STC will review the data as necessary prior to discussions with NAVFAC Northwest and reporting review.
Quality issues	CH2M AQM	Paul Townley	paul.townley@jacobs.com (206) 295-6904	Contact AQM via email or phone regarding quality issues during project implementation. The AQM will report to the AM, RPM, and NTR.
Technical communications for project implementation, and data interpretation	CH2M SME	Laura Cook	laura.cook@jacobs.com (757) 671-6214	Contact SME regarding questions/issues encountered in the field, input on data interpretation, as needed. SME will have 24 hours to respond to technical field questions, via phone or email, as necessary. Additionally, SME will review the data as necessary prior to Base and NAVFAC Northwest discussions and reporting review.
SAP amendments	Navy CLEAN Program Chemist	Anita Dodson	anita.dodson@jacobs.com (757) 284-9208	Changes to the project that would prompt a SAP change that would require Navy QAO approval include the following: 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 Department of Defense (DoD) Quality Systems Manual (QSM) version, inclusion of a new laboratory into the SAP for any reason, or updates to the conceptual site model (CSM) that prompt new data quality objectives. Updated laboratory limit of quantitation (LOQ), limit of detection (LOD), and detection limit (DL) values will not prompt a SAP update for Navy QAO approval unless those updates negatively affect the ability to meet project action limits (PALs).

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Email Address Phone Number	Procedure (timing, pathway to and from, and similar)
SAP amendment approvals	Navy QAO	Dana Stonelake	dana.m.stonelake.civ@us.navy.mil (757) 322-4942	Issues final approval of SAP amendments to Program Chemist via signed approval form (portable document format is acceptable) with concurrence from the Navy RPM.
Health and safety (H&S)	CH2M Health and Safety Manager (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 AM will contact the HSM as needed regarding questions/issues encountered in the field.
H&S	CH2M SSHO	TBD[a]	TBD[a]	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 AM as soon as possible.
Stop Work Order	CH2M AM	Jennifer Madsen	jennifer.madsen@jacobs.com (360) 888-0281	Any field member can immediately stop work if an unsafe condition that is immediately threatening to human health is observed. Navy QAO, or representative, has authority to stop work if quality-related compliance issues are identified, or if noncompliance with field quality control (QC) protocols occurs, as specified in this SAP. The field staff members, FTL, or SSHO should notify the NTR, RPM, and the CH2M AM immediately via phone. Ultimately, the FTL and AM can stop work for a period of time. NAVFAC Northwest can stop work at any time.
	CH2M TM	Heather Perry	heather.perry@jacobs.com (530) 355-1622	
	CH2M FTL/ SSHO	TBD[a]	TBD[a]	
	CH2M Field Team Members	TBD[a]	TBD[a]	
	Navy QAO	Data Stonelake	dana.m.stonelake.civ@us.navy.mil (757) 322-4942	
SAP changes prior to field work	CH2M TM	Heather Perry	heather.perry@jacobs.com (530) 355-1622	TM notifies FTL by phone and email of changes at least 2 days prior to field implementation.
SAP changes in field	CH2M FTL	TBD[a]	TBD[a]	Documentation of deviations from the SAP will be made by the FTL in the field notes, and the AM and TM will be notified immediately via phone or email. Deviations will be made only with approval from the AM and approval of FCR by RPM.
Field progress reports	CH2M FTL	TBD[a]	TBD[a]	Documentation of field activities in field notes; provide daily progress reports to AM and TM by phone or email.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Email Address Phone Number	Procedure (timing, pathway to and from, and similar)
Field Corrective Actions (CAs)	AM/PM, TM, and FTL	Jennifer Madsen	jennifer.madsen@jacobs.com (360) 888-0281	Field issues requiring CA will be determined by the FTL and/or TM, AM on an as-needed basis. The AM will ensure SAP requirements are met by field staff members for the duration of the project. The FTL will notify the AM via phone of any need for CA within 4 hours. The AM will notify the NTR and RPM of any field issues that would negatively affect schedule or the ability to meet project data quality objectives.
		Heather Perry	heather.perry@jacobs.com (530) 355-1622	
		TBD[a]	TBD[a]	
Analytical deviations from the SAP, sample receipt variances, or reporting analytical data quality issues	PFAS Laboratory PM Geotechnical Laboratory PM	Karen Volpendesta Brett Elliot	kvolpendesta@vista-analytical.com (916) 673-1520 brett.elliot@corelab.com (713) 328-2503	All quality assurance (QA)/quality control (QC) issues with project field samples will be reported by phone or email within 2 days to the PC by the laboratory. Sample receipt variances will be communicated by the laboratory to the PC within 24 hours.
Analytical CAs	Navy CLEAN Program Chemist	Anita Dodson	anita.dodson@jacobs.com (757) 284-9208	Any CAs for field and analytical issues will be determined by the Program Chemist and reported to the AM within 4 hours. The AM will ensure SAP requirements are met by field staff members 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 AM. The PC will inform the Navy CLEAN Program Chemist, who will notify the Navy QAO and RPM of any laboratory issues that would prevent the project from meeting project quality objectives (PQOs) or would cause significant delay in the project schedule.
Analytical data validation issues	Data Validator	Nancy Weaver	nweaver@env-data.com (757) 564-0090	The Data Validator reviews and qualifies analytical data as necessary. The Data Validator notifies PC within 2 business days and documents issues in the data validation report. The data along with a validation narrative are returned to the PC within 7 calendar days.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Email Address Phone Number	Procedure (timing, pathway to and from, and similar)
Notification of nonusable analytical data	Navy CLEAN Program Chemist	Anita Dodson	anita.dodson@jacobs.com (757) 284-9208	If the laboratory or the project team identifies problems that affect the usability of the data (that is, the data are rejected or the data quality objectives [DQOs] are not met), the CH2M Program Chemist or PC will notify the PM and Navy QAO within 24 hours. The PM will notify the Navy RPM within 24 hours.
Report submittal to regulatory agencies	NAVFAC Northwest RPM	Kendra Clubb	kendra.r.clubb.civ@us.navy.mil (509) 999-6843	Navy RPM receives report from CH2M and submits to USEPA and Washington State Department of Ecology.
Response to regulatory comments	NAVFAC Northwest RPM	Kendra Clubb	kendra.r.clubb.civ@us.navy.mil (509) 999-6843	Navy RPM receives regulatory comments on submitted SAP and field activity report and coordinates responses with CH2M, as necessary.

[a] Cells will be populated with information after personnel are selected, prior to fieldwork.

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SAP Worksheet #7—Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Kendra Clubb	RPM	NAVFAC Northwest	Oversees entire project for Navy; reviews and approves SAP and changes to SAP; provides Base-specific information and coordinates with NAS Whidbey Island.
Charlie Escola	NTR	NAVFAC Northwest	Oversees fieldwork; provides Base-specific information, and coordination with NAS Whidbey Island.
Steve Skeehan	NTR	NAVFAC Northwest	Oversees fieldwork; provides Base-specific information, and coordination with NAS Whidbey Island.
Dana Stonelake	NAVFAC QAO/Chemist	NAVFAC Atlantic	Provides QA oversight and reviews SAPs.
Jennifer Madsen	AM/PM	CH2M	Oversees and manages project activities.
Heather Perry	Project TM	CH2M	Oversees and manages all tasks associated with Area 6
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.
Janna Staszak	SAP Reviewer	CH2M	Reviews and approves the SAP and changes or revisions to the SAP.
Anita Dodson	CLEAN 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.
Nancy Weaver	Data Validator PM	EDS	Validate laboratory data from an analytical standpoint prior to data use.
TBD[a]	FTL	CH2M	Coordinates all field activities and sampling.
TBD[a]	Field staff member	CH2M	Conducts field activities.

SAP Worksheet #7—Personnel Responsibilities Table (continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
Karen Volpendesta Brett Elliot	Laboratory PM	Vista Analytical Core Laboratories	Manages samples tracking and maintains good communication with PC.
Teresa Morrison	Laboratory QAO	Vista Analytical	Responsible for audits, CA, and checks of QA performance within the laboratory.

[a] Cells will be populated with information after personnel are selected, prior to fieldwork.

SAP Worksheet #8—Special Personnel Training Requirements Table

Specialized training beyond standard H&S training is not required for this project.

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

Project Name: Area 6 Remedial Investigation **Projected Date(s) of Sampling:** August 2022 through November 2022 and February 2023 through April 2023 **AM:** Jennifer Madsen/CH2M HILL, Inc. (CH2M)	**Site Name:** Area 6, Ault Field, NAS Whidbey Island **Site Location:** Oak Harbor, Washington

Date of Session: Wednesday, November 17, 2021

Scoping Session Purpose: To obtain consensus on overall objectives of the per-and polyfluoroalkyl substances (PFAS) RI at Area 6 and agree to the investigation scope

Name	Title/Project Role	Affiliation	Phone Number	Email Address
Kendra Clubb	Remedial Project Manager (RPM)	NAVFAC Northwest	(509) 999-6843	kendra.r.clubb.civ@us.navy.mil
Mike Shaljian	Hydrogeologist	Washington State Department of Ecology	(360) 489-2753	mish461@ecy.wa.gov
Ted Repasky	Superfund Hydrogeologist	USEPA Region 10	TBD	repasky.ted@epa.gov
Chan Pongkhamsing	Superfund Remedial Project Manager	USEPA Region 10	(206) 553-1806	pongkhamsing.chan@epa.gov
Steve Hulsman	SME, Hydrogeologist	Washington State Department of Health	TBD	steve.hulsman@dlh.wa.gov
Jennifer Madsen	AM/PM	CH2M	(360) 888-0281	jennifer.madsen@jacobs.com
Heather Perry	TM	CH2M	(530) 229-3276	heather.perry@jacobs.com
Peter Lawson	STC/Hydrogeologist	CH2M	(530) 229-3383	peter.lawson@jacobs.com
Brittany Prentice	SAP Author	CH2M	(253) 335-1661	brittany.prentice@jacobs.com

Comments

The RI objectives and activities for Area 6 are based on the Ault Field Preliminary Assessment (PA), which identified Area 6 as a potential release area (CH2M, 2018a) and the 2017 to 2019 on- and off-Base PFAS sampling results at and near Area 6 (CH2M, 2020a).

Discussion Points

Goals for the RI field investigation discussed during the scoping call are as follows:

- Define the nature and extent (laterally and vertically) of site-related groundwater concentrations (in excess of PFAS project action limits [PALs]) and assess risks to human health and ecological receptors. PFAS will be evaluated within the applicable DoD, Navy, and/or USEPA policy, guidance, or directives using the state-of-the-science toxicological information available and current at the time the RI Report is prepared. Prior to conducting an ecological risk screening, ESVs will be reviewed based on current science and relevancy to site-specific receptors (for example, relevant ecological receptors present). ESVs selected for the screening will be presented in a technical memorandum or other documented form for regulatory review and acceptance.
- Define the nature and extent of site-related soil concentrations (in excess of PFAS PALs) and assess risks to human health and ecological receptors.

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

- Define the nature and extent of site-related surface water and sediment[3] concentrations (in excess of PFAS PALs) and assess risks to human health and ecological receptors.
- Refine the understanding of the groundwater flow direction and potential PFAS migration pathways at and near Area 6.
- Identify potential vadose zone source areas that may represent an ongoing source of PFAS to the underlying aquifer system.
- Evaluate the lateral and vertical extents of the Area 6 aquifers to the north and west/southwest through which PFAS may be migrating.
- Obtain data to estimate aquifer properties and to evaluate degree of hydraulic connection between the site aquifers.

The team discussed the focus of the RI, which is on areas where data do not exist or are insufficient to confirm nature and extent of PFAS. The scope of the RI field effort includes installation of on-Base monitoring wells near the former industrial waste disposal area to delineate the lateral and vertical extent of PFAS in groundwater at and downgradient of this source area, installation of on-Base monitoring wells north of Ault Field Road to delineate the lateral and vertical extent of PFAS being redistributed by the groundwater extraction, treatment, and recharge (GETR) effluent stream, installation of off-Base groundwater monitoring wells to delineate the lateral extent of PFAS between on-Base source areas and the residential drinking water wells to the southwest, installation of lysimeters in the former industrial waste disposal area to determine if an ongoing vadose zone source area is present, and groundwater, surface water and sediment[3] sampling to provide data with which to evaluate whether unacceptable human health or ecological risks are present. The on-Base field effort will occur first, followed by off-Base monitoring well installation and sampling to allow time for property owner access agreements.

Appendix A-1 provides the scoping presentation, which was shared with stakeholders during this session.

Consensus Decisions

The team agreed with the RI approach with regard to sampling at Area 6. All stakeholders agreed on the general scope of work of the RI.

Action Item

Generate the project SAP, Environmental Protection Plan-Waste Management Plan, and Accident Prevention Plan – Site Safety and Health Plan.

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[3] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

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

Project Name: Area 6 RI **Projected Date(s) of Sampling:** August 2022 through November 2022 and February 2023 through April 2023 **AM:** Jennifer Madsen/CH2M			**Site Name:** Area 6, Ault Field, NAS Whidbey Island **Site Location:** Oak Harbor, Washington	
Date of Session: Friday, December 17, 2021 **Scoping Session Purpose:** To obtain consensus on the scope and approach for the PFAS RI at Area 6				
Name	**Title/Project Role**	**Affiliation**	**Phone Number**	**Email Address**
Kendra Clubb	RPM	NAVFAC Northwest	(509) 999-6843	kendra.r.clubb.civ@us.navy.mil
Katie Tippin	SME	NAVFAC Atlantic	(757) 831-1113	kathryn.z.tippin.civ@us.navy.mil
Jennifer Corack	SME	NAVFAC Atlantic	(757) 322-4335	jennifer.m.corack.civ@us.navy.mil
Laura Himes	Area 6 Superfund RPM	NAVFAC Northwest	(360) 396-0031	laura.m.himes.civ@us.navy.mil
Jennifer Madsen	AM/PM	CH2M	(360) 888-0281	jennifer.madsen@jacobs.com
Heather Perry	TM	CH2M	(530) 229-3276	heather.perry@jacobs.com
Peter Lawson	STC/Hydrogeologist	CH2M	(530) 229-3383	peter.lawson@jacobs.com
Laura Cook	SME/Hydrogeologist	CH2M	(757) 671-6214	laura.cook@jacobs.com
Brittany Prentice	SAP Author	CH2M	(253) 335-1661	brittany.prentice@jacobs.com

Comments

This scoping presentation addressed content requirements of **Worksheets #9**, **#10**, **#11**, **#14**, and **#17**.

Discussion Points

The team reviewed the Area 6 investigation history, RI objectives and scope, RI data analysis decision tree, and PALs.

The scope of the RI field effort includes installation of on-Base monitoring wells near the former industrial waste disposal area to delineate the lateral and vertical extent of PFAS in groundwater at and downgradient of this source area, installation of on-Base monitoring wells north of Ault Field Road to delineate the lateral and vertical extent of PFAS being redistributed by the GETR effluent stream, installation of off-Base groundwater monitoring wells to delineate the lateral extent of PFAS between on-Base source areas and the residential drinking water wells to the southwest, installation of lysimeters in the former industrial waste disposal area to determine if an ongoing vadose zone source area is present, and groundwater, surface water and sediment[4] sampling to provide data with which to evaluate whether unacceptable human health or ecological risks are present. The on-Base field effort will occur first, followed by off-Base monitoring well installation and sampling to allow time for property owner access agreements.

Appendix A-2 provides the scoping presentation, which was shared with Naval Facilities Engineering Systems Command Atlantic (LANT) SMEs during this session.

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[4] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

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

Consensus Decisions

The team agreed with the approach and information proposed to be included in **Worksheets #9, #10, #11, #14**, and **#17**.

The team agreed to remove ecological language from the groundwater portion of the RI investigation (there is no direct discharge of groundwater to surface water bodies within the Area 6 boundary) and revise the RI data analysis decision tree (**Figure 11-1**) to reflect this change to the ecological risk assessment language.

The team agreed to remove discussion of potential interim removal actions from the SAP; the action levels that would drive an interim removal action are TBD (based on the outcome of the risk assessment).

The team agreed that the Area 6 RI SAP would include verbiage indicating that environmental screening values (ESVs) for ecological risk assessment would be issued in a technical memorandum for stakeholder review and concurrence at the time of the risk assessment.

The team agreed that the SAP will include verbiage that sampling and analysis of drinking water is not a part of the RI investigation.

The team agreed to add language to provide flexibility if additional wells or sampling are needed to meet the RI objectives.

The team agreed to forgo inclusion of analytical method 1633 from the Area 6 RI SAP; at the time of this meeting it is uncertain whether labs will have Environmental Laboratory Accreditation Program (ELAP) letters at the time of the RI investigation.

The team agreed to forgo inclusion of the biosolids staging, handling, and land application areas (a potential source area) as part of this investigation; there is not a confirmed release at this time. Information regarding the biosolids potential source area will be documented in a PA addendum and will be investigated subsequently, if necessary.

A summary of consensus decisions made during this scoping meeting will be provided to stakeholders as this session occurred after stakeholders had been briefed on the proposed scope of the Area 6 RI field investigation.

Action Item

Generate **Worksheets #9**, **#10**, **#11**, **#14**, and **#17** for NAVFAC Atlantic SME review in advance of the full SAP.

SAP Worksheet #10—Conceptual Site Model

Site Description

Area 6 is a 260-acre tract in the southeastern corner of Ault Field and is located on Whidbey Island near Oak Harbor, Washington. Ault Field is one of three NAS Whidbey Island installations (**Figure 10-1**). Area 6 has historically been used as a waste disposal site and is currently used as a composting facility. Area 6 is bordered by Ault Field Road to the north, State Highway 20 to the east, and the Oak Harbor landfill on the south and southwest (**Figure 10-2**). Privately owned forested or logged land, and a commercial sand and gravel quarry operation, are located immediately west of Area 6. Various businesses, such as auto repair shops, an auto salvage yard, storage facilities, the Auld Holland Inn, and a mobile home park, are west and south of Area 6. Private residences are to the east, west, and south of Area 6.

Site History

Currently, Area 6 is mostly vacant; however, the following facilities and infrastructure are located within Area 6: a compost facility, an approximate 40-acre engineered and capped landfill, a stormwater detention basin, groundwater monitoring and extraction wells, two GETR treatment plants, and the GETR discharge area (**Figure 10-2**).

Approximately 60 acres of Area 6 were historically used for waste staging and disposal activities between 1969 and 1996. The following are two primary areas within Area 6 where wastes are known to have been disposed (**Figure 10-3**):

- The former industrial waste disposal area: This feature consisted of an acid disposal pit and an oily sludge pit (Foster Wheeler, 2002). The acid disposal pit received approximately 300,000 to 700,000 gallons of acids, caustics, and solvents between the 1970s and 1980s. The oily sludge pit received approximately 100,000 to 600,000 gallons of liquid sludge between 1969 and the mid-1970s.
- The landfill: This feature included 23 cut-and-fill trenches with native materials in between; the landfill received Department of the Navy (Navy) waste from 1969 through the mid-1990s (Foster Wheeler, 1997; Navy, 1993; URS-AECOM, 2018). The landfill received sanitary solid and industrial wastes (which may have contained hazardous constituents) from 1969 to 1983, Navy waste through 1992, yard waste and construction debris during 1993, and soil and sediments classified as nonhazardous (from other remedial actions) in 1995 and 1996 (Foster Wheeler, 1997; Navy, 1993). No known disposal of regulated wastes has occurred since 1983 (Navy, 1993).

Area 6 is currently a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-designated site due to the presence of volatile organic compounds (VOCs) and 1,4-dioxane in environmental media. The 1993 Record of Decision (ROD) identified trichloroethene (TCE); 1,1,1-trichloroethane; 1,1-dichloroethane; 1,1-dichloroethene; cis-1,2-dichloroethene; and vinyl chloride as chemicals of concern (COCs) in groundwater (Navy, Ecology, and USEPA, 1993). The conclusions of the associated risk assessment were that concentrations of COCs in soils, sediments, and surface water posed unacceptable ecological risks and that future migration of COCs in groundwater posed the greatest potential risk to human health. Remedial Actions implemented following the 1993 ROD focused on minimizing the leaching of chemicals from the vadose zone to the groundwater system and capture/treatment of contaminated groundwater. Remedial Actions implemented subsequent to the ROD included:

- Construction and operation of the western GETR system to capture and treat VOCs in groundwater via air stripping is ongoing since 1995 (Navy, 2019).

SAP Worksheet #10—Conceptual Site Model (continued)

- Construction of a landfill cap in 1996 to minimize infiltration through landfill wastes to the water table (Foster Wheeler, 1997).

An interim soil removal action was performed at the former industrial waste disposal area in 2001 to remove vadose zone mass containing VOCs; however, confirmation samples indicate that elevated concentrations of TCE in soil remain in place post-excavation (Foster Wheeler, 2002).

An in-situ treatability study, consisting of one round of in-situ chemical oxidation injections, was performed at the former industrial waste disposal area in 2014.

1,4-Dioxane was identified in groundwater at Area 6 in 2005 (SES-Tech, 2008). Subsequent characterization identified that the extent of 1,4-dioxane in groundwater extended off Base to the south of Area 6. A ROD Amendment was issued in 2019 to modify the treatment technology for Area 6 groundwater from air stripping to advanced oxidation process (Navy, 2019). A southern GETR was constructed to address the off-Base groundwater plumes and has been operating since October 2021. Design of upgrades for the western GETR plant is ongoing. Currently, neither the western nor southern GETR treatment plants include a PFAS treatment train; however, space is available in the southern plant to add this component in the future if necessary. As such, PFAS captured by the GETR systems are being redistributed in Area 6 via the GETR effluent discharge stream. As will be discussed in the following section, perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), and perfluorobutane sulfonic acid (PFBS) concentrations in GETR samples are below the PALs for this RI.

In summary, Area 6 is a 260-acre area in the southeastern portion of Ault Field. Approximately 60 acres in the western portion of the site were historically used for waste storage and disposal. In addition, the current GETR systems do not incorporate PFAS treatment; therefore, PFAS are being redistributed in the environment via the GETR effluent stream. As such, the multiple potential release areas comprise Area 6.

Previous PFAS Investigations

PFAS sampling at Area 6 was initiated in anticipation that advanced oxidation process would be selected for treatment of groundwater in the ROD Amendment (Navy, 2019). The final ROD Amendment was issued in 2019; however, it became clear during earlier planning stages that advance oxidation process would be the likely treatment option selected to address 1,4-dioxane at the site. Oxidation processes may transform PFAS precursor compounds into PFAS with current toxicity values; therefore, if PFAS were present in Area 6, there was a potential for the selected remedy to increase concentrations of PFAS with toxicity values.

Area 6 has received a wide variety of waste including soil from locations on Ault Field where PFAS releases are known to have occurred (for example, the Clover Valley Fire School and Runway Ditches). As a result, an initial Site Inspection (SI) for PFAS were determined to be necessary.

Phase 1 Site Inspection

The Phase SI at Area 6 was conducted in 2017 and involved the collection of samples from 13 on-Base groundwater monitoring wells and GETR influent and effluent to evaluate whether PFAS were present in groundwater at Area 6 (CH2M, 2020a). PFAS were detected in samples collected from on-Base groundwater monitoring wells and the influent and effluent at the western GETR treatment plant (**Figure 10-3**). Because VOCs in groundwater are limited to the shallow aquifer system at Area 6 (which is discussed further in **Table 10-1**), PFAS sampling focused on 11 shallow aquifer monitoring wells and two of the three intermediate aquifer monitoring wells present at the Site. Deep aquifer monitoring wells were not sampled as part of the SI.

SAP Worksheet #10—Conceptual Site Model (continued)

PFOA was detected in 8 of the 13 wells sampled, the GETR influent, and the GETR effluent and exceeded the PAL[5] of 6 parts per trillion (ppt) in samples from 6 wells and the GETR influent and effluent samples (**Figure 10-3**). PFOS was detected in 2 of the 13 wells sampled and was not detected in GETR influent and effluent samples. The PFOS results exceeded the PAL of 4 ppt at one of the monitoring wells (6-S-26). PFBS was detected at 8 of the 13 monitoring wells sampled, the GETR influent, and the GETR effluent samples, none of which exceeded the PAL of 600 ppt. Perfluorohexanesulfonic acid (PFHxS) was detected at 8 of the 13 monitoring wells sampled and the GETR influent and effluent samples. PFHxS exceeded the PAL of 39 ppt in three of the monitoring wells and the GETR influent and effluent samples. Perfluorononanoic acid (PFNA) was detected in 3 of the 13 wells sampled and was not detected in GETR influent and effluent samples. PFNA exceeded the PAL of 5.9 ppt at one monitoring well. Perfluoro-2-methyl-3-oxahexanoic acid (HFPO-DA) was not included in the PFAS analytical suite at the time of the Phase 1 SI.

Phase 2 Site Inspection

Because the presence of PFAS in groundwater at Area 6 was confirmed by the Phase 1 SI, the Phase 2 SI was implemented in 2018. The Phase 2 SI included collection of samples for PFAS analysis from 17 additional on- and off-Base groundwater monitoring wells. Of the groundwater monitoring wells sampled, PFOA was detected at 4 of the 17 groundwater monitoring wells sampled, all of which exceeded the PAL of 6 ppt (**Figure 10-4**). PFOS was detected at 3 of the 17 groundwater monitoring wells sampled, none of which exceeded the PAL of 4 ppt. PFBS was detected at 7 of the 17 groundwater monitoring wells sampled, none of which exceeded the PAL of 600 ppt. PFHxS was detected at 8 of the 17 groundwater monitoring wells sampled, none of which exceeded the PAL of 39 ppt. PFNA was detected at 1 of the 17 groundwater monitoring wells sampled and did not exceed the PAL of 5.9 ppt. HFPO-DA was not included in the PFAS analytical suite at the time of the Phase 2 SI.

Phase 1 and 2 Off-Base Investigations

Because the presence of PFAS in groundwater at Area 6 was confirmed by the Phase 1 and 2 SI, the Phase 1 off-Base groundwater and drinking water investigation was implemented. Phase 1 and Phase 2 off-Base residential drinking water sampling occurred between 2018 and 2019 (CH2M, 2020a). The investigation included collection of samples for PFAS analysis from 22 off-Base private drinking water and groundwater wells. Of the 22 private off-Base wells sampled, 12 wells were single-resident drinking water wells, 6 were community drinking water wells, and 4 were private groundwater (irrigation, nonpotable, or inactive) wells.

Off-Base Private Groundwater Well Results

PFOA was detected at three of the four off-Base private groundwater (irrigation, nonpotable, or inactive) wells sampled, one of which exceeded the PAL of 6 ppt. PFOS was detected at two of the four off-Base private groundwater wells sampled, one of which exceeded the PAL of 4 ppt (**Figure 10-5**). PFBS was detected in three of the four private groundwater wells sampled, none of which exceeded the PAL of 600 ppt. PFHxS was detected in three of the four private groundwater wells sampled, two of which exceeded the PAL of 39 ppt. PFNA was not detected in the private groundwater wells sampled.

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[5] Groundwater data collected during the SI and Phase 1 and 2 investigations described herein are compared to current PALs for this RI specified in **Worksheets #11** and **#15**, which may be inconsistent with the PALs at the time of those investigations.

SAP Worksheet #10—Conceptual Site Model (continued)

Off-Base Drinking Water Well Results

PFOA was detected at 7 of the 18 off-Base drinking water wells sampled, none of which exceeded the 2016 USEPA lifetime drinking water health advisory level of 70 ppt (**Figure 10-5**). PFOS was detected at 7 of the 18 off-Base drinking water wells sampled, 3 of which exceeded the 2016 USEPA lifetime drinking water health advisory level of 70 ppt for PFOS (**Figure 10-5**). PFOA + PFOS were detected in 7 of the 18 off-Base drinking water wells sampled, 5 of which exceeded the 2016 USEPA lifetime drinking water health advisory level of 70 ppt for PFOA + PFOS (**Figure 10-5**). Residents of these parcels are being provided bottled water until they can be connected to the City of Oak Harbor water supply, which was the remedy selected in the Engineering Evaluation/Cost Analysis for long-term solutions (CH2M, 2020b). In addition, these drinking water wells, as well as drinking water wells on adjacent parcels, were incorporated into the routine drinking water sampling program at NAS Whidbey Island (CH2M, 2018b; 2019). Through this routine sampling, a nineteenth drinking water well, located within the Phase 2 sampling area, was sampled and was identified as exceeding the 2016 USEPA lifetime drinking water health advisory level (**Figure 10-5**). This drinking water well represented the sixth location with an exceedance of the 2016 USEPA lifetime drinking water health advisory level.

The results of the Area 6 PFAS SI identified the presence of PFAS in groundwater and drinking water at and surrounding Area 6, primarily in the shallow aquifer. The shallow aquifer is an unconfined groundwater unit found in the Vashon Advance Outwash, and to which the former industrial waste disposal area discharged directly. Two of three intermediate aquifer wells on Base were sampled, PFAS were detected in one of the two sampled intermediate aquifer wells present on Base at Area 6, and the deep aquifer was not investigated during the SI.

Off Base, PFAS detections included concentrations of PFOA and/or PFOS above the PALs in six private, shallow aquifer drinking water wells southwest of Area 6. These wells are downgradient of Area 6 based on the southerly direction of shallow aquifer groundwater, as described in detail in **Table 10-1**, and indicate a potential link to PFAS releases at Area 6. However, the overall lateral and vertical extent of PFAS associated with Area 6 is uncertain.

Area 6 site conditions, release areas, chemicals of potential concern, migration pathways, human health receptors and exposure scenarios, and ecological receptors and exposure scenarios are presented in **Table 10-1**. **Figure 10-2** illustrates the location, layout, site characteristics, and features of Area 6. **Figures 10-3** through **10-5** present PFAS groundwater and drinking water sampling results from the previous PFAS investigations (CH2M, 2020a).

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Area 6 Conceptual Site Model

Site Name	Area 6, Ault Field, NAS Whidbey Island, Oak Harbor, Washington (**Figures 10-1** and **10-2**)	
Site Conditions	**Topography and Geology**	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. Ground surface within the Area 6 boundary is variable, ranging from a low of approximately 100 feet above the North American Vertical Datum of 1988 (NAVD 88) in the northwestern corner of the site to a high of approximately 225 feet NAVD 88 on the southern portion of the capped landfill. The surface soil near Ault Field (which includes Area 6) primarily consists of artificial fill, post-glacial deposits, glaciomarine drift, and glacial deposits. Artificial fill, consisting of coarse- or fine-grained material, underlies the runway areas. Post-glacial deposits, consisting of peaty sand and silt, are generally found in the low-lying marshy areas (Navy, 1994). Four glacial units have been identified at Area 6 and include, from youngest to oldest: the Vashon Recessional Outwash (thin and discontinuous layer of sand and gravel with some silt only present in the eastern part of Area 6 at the ground surface) (CTI-URS, 2018), which is interpreted as being predominantly unsaturated in Area 6 based on published cross-sections (URS-AECOM, 2018); Vashon Till (laterally extensive layer of silty, fine sand with some gravel, containing localized layers of clay or silt typically present at the ground surface); Vashon Advance Outwash (laterally extensive coarse, gravelly sand that gradually becomes finer-grained with depth with local layers of silty sand, silt, or clay); and Whidbey Formation Units 1 through 4 (alternating finer-grained and coarser-grained materials). **Figure 10-6** presents a north-south cross-section through Area 6 illustrating the relative thicknesses and vertical locations of the units. More detailed descriptions of the units can be found in the Area 6 southern GETR design document (CTI-URS, 2018).
		The U.S. Geological Survey has identified up to five major hydrostratigraphic units (HSUs) or aquifers above bedrock in Island County, where NAS Whidbey Island is located, (Jones, 1985; Sapik et al., 1988). The existing aquifer units are composed of sand or sand and gravel, while the adjacent confining layers are composed of till, glaciomarine drift, or nonglacial clay and silt. Perched, saturated zones may exist locally above noncontinuous areas of till or other clay-rich units. The following three (of the five upper aquifers) have been identified at Area 6 (**Figure 10-6**): • The shallow aquifer is an unconfined groundwater unit found in the Vashon Advance Outwash beneath Area 6. The former industrial waste disposal pits (Site 55) discharged directly into this unit. • The intermediate aquifer is a moderately continuous groundwater body found in the sandy unit that corresponds to the Whidbey Formation Unit 2. Near Area 6, this aquifer is confined below the silt and clay of Whidbey Formation Unit 1, which acts as an aquitard. • The deep aquifer is also a nearly continuous confined groundwater body found near Area 6. This aquifer is confined below the silt and clay of Whidbey Formation Unit 3 (which acts as an aquitard) and occupies a thick sand layer in Whidbey Formation Unit 4.
	Hydrogeology	The vadose zone within Area 6 varies in thickness, generally increasing in thickness from north to south (**Figure 10-6**). Adjacent to the former industrial waste disposal area, the vadose zone is approximately 75 feet thick and comprised of Vashon Advanced Outwash; below the landfill, the vadose zone is over 100 feet thick, also in the Vashon Advanced Outwash. Based on potentiometric maps presented in the Annual 2019-2020 Groundwater Long-Term Monitoring Report (Sealaska, 2020), the groundwater flow direction in the Vashon Advance Outwash (shallow aquifer) underlying Area 6 is predominantly to the south (**Figure 10-7**). A potential local southwesterly component of groundwater flow is in the northwestern corner of Area 6. The 1993 RI identified a potential groundwater divide north of Area 6, which separates the southerly groundwater flow directions observed at Area 6 from the northerly groundwater flow directions present in eastern Ault Field proper (Navy, 1993). The location of this groundwater divide is uncertain. Groundwater flow direction in the Whidbey Formation Unit 2 (intermediate aquifer) is predominantly to the southeast; however, measurements from a subset of Area 6 monitoring wells (6-I-01, 6-I-03, and 6-I-08) suggest a local component of groundwater flow to the northeast (Navy, 1993).

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Area 6 Conceptual Site Model

<table>
<tr><td rowspan="1">Site Conditions
(con't)</td><td>Hydrogeology (continued)</td><td colspan="2">Groundwater elevation data from wells completed in the Whidbey Formation Unit 4 (deep aquifer) suggest groundwater flow directions ranging from southeast to southwest (Navy, 1993). Downward vertical hydraulic gradients exist at the site, with differences in groundwater elevations between the shallow and intermediate aquifer ranging from 5 to 20 feet and approximately 50 feet between the shallow and deep aquifer (CTI-URS, 2018) (Figure 10-6). The majority of monitoring infrastructure at Area 6 is completed within the shallow aquifer (that is, wells with an “S” in the location names on the figures included in this worksheet).
There are limited, readily available information regarding the subsurface characteristics of the off-Base area surrounding Area 6. Regionally, Whidbey Island consists of a thick sequence of glacial and interglacial deposits overlying lower permeability bedrock. The relatively continuous lithologic/HSUs likely extend off Base.</td></tr>
<tr><td>Surface Water</td><td colspan="3">Currently, effluent from the western and southern GETR systems is discharged to land surface on the southern side of the Area 6 composting facility (Figure 10-2). The effluent flows to the north, following a natural surface water drainage (adjacent to wells 6-S-26 and 6-S-07) and through a culvert north of Ault Field Road. The GETR effluent stream is ponded by a weir north of Ault Field Road, creating a wetland near piezometers P-1 through P-4. Surface water spilling over the weir continues to flow north into Ault Field proper. A drainage ditch parallels Ault Field Road on the north side. GETR effluent may flow eastward in this ditch.</td></tr>
<tr><td>Release Areas</td><td colspan="3">It is unknown whether aqueous film-forming foam (AFFF) was directly disposed of at Area 6; the historical site use as a disposal area suggests that disposal of AFFF from other airfield operations is feasible. Examples of potential PFAS-containing materials disposed at the landfill include sediment excavated from NAS Whidbey Island runway ditch system added to the landfill in 1995 before construction of the cap (Foster Wheeler, 1997) and wastes excavated as part of remedial actions at other NAS Whidbey Island sites (such as the Clover Valley Fire School) (Sealaska, 2015).</td></tr>
<tr><td>Chemicals of Potential Concern</td><td colspan="2">• PFOA
• PFOS
• PFBS
• Perfluorobutanoic acid (PFBA)
• Perfluoropentanoic acid (PFPeA)
• N-ethyl perfluorooctanesulfonamidoacetic acid (EtFOSAA)
• N-methyl perfluorooctanesulfonamidoacetic acid (MeFOSAA)
• Perfluorodecanoic acid (PFDA)
• Perfluorododecanoic acid (PFDoA)
• Perfluoroheptanoic acid (PFHpA)
• PFHxS
• Perfluorohexanoic acid (PFHxA)
• PFNA
• Perfluorotetradecanoic acid (PFTeDA)
• Perfluorotridecanoic acid (PFTrDA)
• Perfluoroundecanoic acid (PFUnA)
• Perfluoropentansulfonic acid (PFPeS)</td><td>• Perfluoroheptanesulfonic acid (PFHpS)
• 1<i>H,</i> 1<i>H</i>, 2<i>H</i>, 2<i>H</i>-Perfluorohexane sulfonic acid (4:2FTS)
• 1<i>H,</i> 1<i>H</i>, 2<i>H</i>, 2<i>H</i>-Perfluorooctane sulfonic acid (6:2FTS)
• 1<i>H,</i> 1<i>H</i>, 2<i>H</i>, 2<i>H</i>-Perfluorodecane sulfonic acid (8:2FTS)
• 4,8-dioxa-3H-perfluorononanoic acid (ADONA)
• Perfluoro-3-methoxypropanoic acid (PFMPA)
• Perfluoro-4-methoxybutonoic acid (PFMBA)
• Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)
• 9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)
• 11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)
• Perfluoro-2-methyl-3-oxahexanoic acid (HFPO-DA)
• Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)</td></tr>
</table>

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Area 6 Conceptual Site Model

Migration Pathways	**Figure 10-8** presents an overview of the conceptual model for potential PFAS migration and transport pathways at Area 6. The potential and known migration pathways at Area 6 are as follows: • Leaching of PFAS in waste materials and subsurface soil (currently and/or historically present) within the vadose zone to groundwater • Transport via horizontal advection with groundwater flow. However, due to the uncertainty of the location of the groundwater divide north of Ault Field Road, groundwater migration pathways in this area are not currently understood • Capture of groundwater containing PFAS by western GETR pumping wells • Transport of PFAS in surface water via treated GETR effluent discharge to land surface • Transport of PFAS via surface water • Partitioning from surface water to sediment in the GETR effluent discharge area, surface stream, and wetland area • Reinfiltration of PFAS-containing surface water in the GETR effluent discharge area, surface stream, and wetland area to the aquifer
Human Health Receptors and Exposure Scenarios	Soil[a] • Workers, visitors, trespassers, and recreators at and around Area 6 could potentially 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. Construction or other ground-disturbing activities, including landscaping, could result in the potential generation of and exposure to dust. PFAS toxicity values currently are unavailable to evaluate inhalation exposures. Groundwater[a] • Groundwater at Area 6 is not used as a drinking water source, and land use controls are in place for the Area 6 boundary to preclude future residential development; therefore, there is no current exposure pathway for groundwater to workers or potential future on-Base residents through drinking water. • Depth to groundwater over most of Area 6 is greater than 70 feet below ground surface (bgs); however, shallow groundwater (less than 20 feet bgs) is present in the northwest portion of the site. Construction workers may be exposed to PFAS through dermal contact during excavation activities in this portion of the site. • Current and future off-Base residents could be exposed to PFAS in groundwater downgradient of Area 6 that is used as a drinking water source. Sampling and analysis of drinking water near Area 6 is part of the biannual PFAS residential drinking water well sampling program. As such, sampling of private drinking water wells is not included in the scope of this RI. Surface Water and associated Sediment[b] • Workers, visitors, trespassers, residents, and recreators could be exposed to PFAS through incidental ingestion of and dermal contact with the GETR effluent surface water and streambed sediment.[b] Biota PFAS have been detected in groundwater in drinking and irrigation wells southwest of Area 6. If impacted groundwater is used to irrigate crops in areas surrounding Area 6 used for agriculture, human receptors (such as off Base or downgradient of the site) could be exposed to PFAS present in vegetables, fruits, and grains; game (such as deer); livestock; poultry; fish; eggs; and dairy products if these food sources contain PFAS.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Area 6 Conceptual Site Model

Ecological Receptors and Exposure Scenarios	Soil • Lower trophic level terrestrial ecological receptors (such as terrestrial plants and soil invertebrates) could be exposed to PFAS released to surface soils through root uptake, direct contact, and/or direct ingestion. Because there is evidence that PFAS bioaccumulate in terrestrial food items (such as plants), upper trophic level receptors (such as birds and mammals) may be exposed to these substances via the food web, as well as through incidental ingestion of soil and direct ingestion of drinking water (if PFAS are released to a fresh water source). Groundwater • Area 6 groundwater does not directly discharge to surface water features within the Area 6 boundary or off-Base surface water features in the primary direction of shallow aquifer groundwater flow to the south; therefore, ecological receptors do not have direct exposure to Area 6 groundwater. • If it is determined that the GETR wetland north of Ault Field Road is hydraulically connected to groundwater and that groundwater in the wetland area flows to the north, this groundwater transport pathway to downgradient freshwater streams will be considered in a revised CSM and subsequent risk evaluations. Surface Water and Streambed Sediment[b] Effluent (containing PFAS) from the western GETR treatment plant is directly discharged to the land surface north of the capped landfill and flows north via a surface stream to a wetland area north of Ault Field Road. Lower trophic level ecological receptors (such as plants, benthic or terrestrial invertebrates, reptiles, and amphibians) could be exposed to PFAS released in surface water and/or sediment[b] through root uptake, direct contact, and/or direct ingestion. Because there is evidence that PFAS bioaccumulate in food items, upper trophic level receptors (such as birds and mammals) may be exposed to these compounds via the food web, as well as through incidental ingestion of sediment[b] and, if the pathway is complete, offsite drainages' sediment and direct ingestion of fresh surface water.

[a] Land use controls are in place to prevent future residential development of Area 6. Therefore, residents are not current or likely future receptors for environmental media being evaluated under this SAP; however, the human health risk assessment will include future residents to evaluate an unrestricted land use scenario.

[b] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

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

Problem Statement and Objectives

The objectives, environmental questions, investigation approach, and PQOs are presented in **Table 11-1**. **Figure 11-1** shows the decision logic associated with **Table 11-1**. Sample locations are shown on **Figures 11-2**, **11-3**, and **11-4**. The investigation approach presented in **Table 11-1** applies to Stages 1 and 2 of the RI. The Stage 1 investigation includes the on-Base field effort. Because of the lead-time associated with procuring access agreements for off-Base wells, this portion of the field investigation is included as a separate effort (Stage 2). Any additional field work stages needed to accomplish the objectives of the RI will be included in a SAP addendum or FCR.

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

Problem Definition/Objective	Environmental Question	General Investigation Approach	Project Quality Objective
PFOA, PFOS, PFHxS, and PFNA have been detected at on- and off-Base groundwater monitoring wells located at and near Area 6 at concentrations above the PALs during the 2017 and 2018 sampling events (**Figures 10-3** and **10-4**); however, the extent of PFAS exceeding the PALs in groundwater is uncertain. In 2018 and 2019, PFOA and PFOS were detected at six residential drinking water wells at concentrations exceeding the drinking water PALs southwest of Area 6. **Objective 1** of the RI field effort is to define the nature and extent of PFAS in groundwater (on and off Base) above PALs and assess risks to human health receptors.[a] Limited lithologic data are available outside of Area 6 to evaluate how the layered aquifer system at the site fits into the regional setting. **Objective 2** of the RI field effort is to evaluate the extents of the Area 6 aquifers to the north and west/southwest through which PFAS may be migrating.	What are the horizontal and vertical extents of PFAS exceeding the PALs in the groundwater and are PFAS present at concentrations which pose unacceptable risk to human health receptors?[a] Are PFAS transported by the GETR surface water stream reinfiltrating to the underlying aquifer system north of Ault Field Road? If present, what is the extent of PFAS exceeding PALs. If present, are concentrations indicative of unacceptable risks to human health?[a] Do the shallow, intermediate, and deep aquifers identified at Area 6, through which PFAS may be migrating, extend to areas north of Ault Field Road and off Base west/southwest of the Area 6 boundary?	**Stage 1.** Advance up to eight new soil borings at four paired locations on Base near the former industrial waste disposal area within Area 6 and near the GETR effluent stream north of Ault Field Road and collect lithologic data during drilling. Collect up to three depth-discrete groundwater grab samples between the water table and approximately 250 feet bgs during drilling of the deeper of each of the paired locations. The analytical results from the groundwater grab samples will be evaluated and used to determine screen placement for the monitoring wells. The samples and rationale are outlined in **Worksheet #17.** Install four monitoring wells (one shallow aquifer well, two intermediate aquifer wells, and one deep aquifer well) near the former industrial waste disposal area within Area 6 and install four monitoring wells near the GETR effluent stream north of Ault Field Road (two shallow aquifer and two intermediate aquifer wells) (**Figure 11-3**). Sample newly installed groundwater monitoring wells, 25 existing monitoring wells (19 shallow aquifer, 3 intermediate aquifer, and 3 deep aquifer), and 8 shallow aquifer pumping wells from the western GETR system. Samples will be analyzed for PFAS by Vista Analytical using LC-MS/MS compliant with DoD QSM 5.3 Table B-15. **Stage 2.** Install up to eight new monitoring wells off Base (up to 250 feet bgs on the north side of Ault Field Road, 150 feet bgs to the west and southwest of Area 6) and collect lithologic data during drilling. Collect up to three depth-discrete groundwater grab samples during drilling of up to five off-Base locations. The analytical results from the groundwater grab samples will be evaluated and used to determine screen placement for the monitoring wells. The samples and rationale are outlined in **Worksheet #17.** It is anticipated that there will be seven shallow aquifer wells and one intermediate aquifer well. Groundwater samples will be collected from newly installed off-Base groundwater monitoring wells, and samples will be analyzed for the 29 PFAS listed in the UCMR5. The samples and rationale are outlined in **Worksheet #17**. Lithologic information collected during the RI field investigation will be integrated with existing lithologic data to generate cross-sections. If additional wells and/or samples are needed, additional RI field investigation phases may occur under a separate SAP addendum or FCR.	If PFAS are detected in grab groundwater samples, the depth and concentrations from the sample will be used to inform well screen placement. If PFAS are not detected, well screen intervals will be selected for consistency with the existing monitoring wells. The cross-sections generated will support the evaluation of whether the aquifers at Area 6 are laterally extensive or whether they "pinch out" to the north of Ault Field Road and/or off-Base west/southwest of the Area 6 boundary. The groundwater data collected from monitoring wells will be evaluated in accordance with **Figure 11-1**.
It is unknown whether PFAS are present in the vadose zone near the former industrial waste disposal area and whether this area represents an ongoing source of PFAS mass loading to the underlying aquifer system. **Objective 3** of the RI field investigation is to evaluate whether there is an ongoing source of loading to the aquifer system from the vadose zone.	Does mass in the vadose zone represent an ongoing source of PFAS loading to the underlying aquifer system?	A triple completion lysimeter cluster will be installed near 6-S-44 in the former industrial waste disposal areas. VZW samples will be collected and analyzed for PFAS. Soil samples will be collected during the drilling of boreholes at up to five locations. Soil samples will be collected at three depths: surface, water table, and one depth within the shallow aquifer at a lithologic interface.	If PFAS are detected in soil or VZW samples, a one-dimensional vadose zone leaching model may be used to evaluate potential mass loading to the aquifer (concentration and timing). If PFAS are not detected in soil or VZW samples, it will be concluded that vadose zone source areas are not present near the sample locations.

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

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

Problem Definition/Objective	Environmental Question	General Investigation Approach	Project Quality Objective
PFOA and PFBS were detected in GETR influent and effluent (discharge) samples collected at the western treatment plant in 2017; however, it is unknown if surface water downgradient of the GETR effluent has been impacted, and if so, to what extent. **Objective 4** of the RI field effort is to define the nature and extent of PFAS above the PALs in surface water within the GETR effluent stream and assess risks to human health and ecological receptors.	What is the extent of PFAS exceeding PALs in surface water within the GETR effluent stream and downgradient surface water? Are concentrations indicative of unacceptable risks to human health or ecological receptors?	Surface water samples will be collected from up to five locations within the GETR effluent stream. Samples will be collected at the effluent discharge location, one location between the effluent discharge location and the Area 6 boundary, one location in the wetland north of Ault Field Road, one location in the effluent discharge stream north of the wetland, and one location in the ditch east of the wetland and north of Ault Field Road.	The surface water data will be evaluated in accordance with **Figure 11-1**.
PFOA and PFBS were detected in GETR influent and effluent samples collected at the western treatment plant in 2017**;** however, it is uncertain whether PFAS present in the GETR effluent stream have partitioned to sediment[b]. **Objective 5** of the RI field effort is to evaluate whether PFAS are present in sediment[b] within the GETR effluent stream and, if present, to define the nature and extent of PFAS above the PALs in sediment[b] in the GETR discharge area and assess risks to human health and ecological receptors.	Are PFAS present in sediment[b] within the GETR effluent stream and downgradient sediment? If PFAS are present in sediment[b], what is the extent of PFAS exceeding PALs in sediment[b] within the GETR effluent stream? Are concentrations indicative of unacceptable risks to human health or ecological receptors?	Sediment[b] samples will be collected from up to five locations within the GETR effluent stream. Samples will be collected at the effluent discharge location, one location between the effluent discharge location and the Area 6 boundary, one location in the wetland north of Ault Field Road, one location in the effluent discharge stream north of the wetland, and one location in the ditch east of the wetland and north of Ault Field Road.	If PFAS are not detected in sediment[b] samples, it will be concluded that PFAS in the GETR effluent have not partitioned to sediment[b] and no further action will be taken. If PFAS are detected in sediment[b] samples, the data will be evaluated in accordance with **Figure 11-1**.
PFAS have been detected at residential drinking water wells at concentrations exceeding the PALs southwest of Area 6. There is uncertainty in the location of the groundwater divide north of Ault Field Road; therefore, there are currently insufficient data to evaluate potential PFAS migration pathways from Area 6 to off-Base receptors. **Objective 6** of the RI field effort is to refine the understanding of groundwater flow and potential PFAS migration pathways near Area 6 in the shallow, intermediate, and deep aquifers.	Where does the groundwater divide occur, and what effect does this have on the groundwater flow directions and potential PFAS migration pathways from Area 6 to potential off-Base receptors in the shallow, intermediate, and deep aquifers?	A synoptic groundwater level survey will be conducted to evaluate the groundwater divide location and overall flow directions in the aquifer systems underlying Area 6.[c] The synoptic groundwater level survey will include new and existing groundwater monitoring wells in the shallow, intermediate, and deep aquifer systems. An aquifer test will be performed to evaluate aquifer properties and the interconnectivity of the aquifer systems underlying Area 6. Up to 10 geotechnical samples will be collected to obtain site-specific solute transport property data. A three-dimensional groundwater flow and solute transport model will be constructed to support evaluation of PFAS migration. If additional drinking water sampling will need to occur, it will be addressed under a separate SAP investigation.	Synoptic groundwater elevation data, aquifer property data, PFAS concentrations (in all media), and aquifer solute transport property data will be used to update the CSM for groundwater flow and PFAS transport. These data will also be used to support construction of a groundwater flow and solute transport model of Area 6. The numerical model will be used to quantify groundwater pathways, flow rates, flow velocities, and both current and future PFAS migration pathways and mass flux through the soil source areas and aquifer system.

[a] If it is determined that the GETR wetland north of Ault Field Road is hydraulically connected to groundwater and that groundwater in the wetland area flows to the north, this groundwater transport pathway to downgradient freshwater streams will be considered in a revised CSM and subsequent risk evaluations.

[b] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

[c] Shallow aquifer groundwater elevation data will be used to refine the understanding of the location of the groundwater divide that separates the southerly groundwater flow direction observed at Area 6 from the northerly groundwater flow direction present in southeastern Ault Field. This information will be used to refine the Area 6 CSM. If present, the location and magnitude of the groundwater divide may change seasonally and with precipitation/groundwater recharge events. The data collected during the current field effort will be used to determine the presence/absence of this divide immediately north of Ault Field Road. Additional groundwater level surveys may be conducted during future field efforts to further refine the CSM.

5.3 = Version 5.3

DoD = Department of Defense

LC-MS/MS = liquid chromatograph – tandem mass spectrometry

UCMR5 = Unregulated Contaminant Monitoring Rule 5

VZW = vadose zone porewater

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

What are the PALs?

The PALs for collected data are presented in **Worksheet #15** and described as follows.

Human Health

- **Groundwater, Surface Water, VZW:** Groundwater, surface water, and VZW data will be compared to tap water PALs from the USEPA regional screening level (RSL) table (USEPA, 2022) based on a hazard quotient (HQ) of 0.1 for PFOA (6 ppt), PFOS (4 ppt), PFBS (600 ppt), PFHxS (39 ppt), PFNA (5.9 ppt), and HFPO-DA (6 ppt) and as approved by the Assistant Secretary of Defense July 6, 2022 memorandum, "*Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program*" (ASD, 2022). Surface water data are compared to the tapwater RSLs because there are currently no screening levels for surface water that is not being used as a drinking water supply or used for fishing. In addition, the use of a 10x RSL approach for surface water is USEPA-region specific and is not accepted by USEPA Region 10, where this work is being conducted. PFAS results for constituents without a PAL will be provided in an appendix to the RI report for comparison to appropriate screening values if they are available in the future.
- **Soil and Sediment:** Surface and subsurface soil data and sediment data will be compared to residential soil PALs from the USEPA RSL table (USEPA, 2022) based on an HQ of 0.1 for PFOA (19 micrograms per kilogram [µg/kg]), PFOS (13 µg/kg), PFBS (1,900 µg/kg), PFHxS (130 µg/kg), PFNA (19 µg/kg), and HFPO-DA (23 ppt) (ASD, 2022). Sediment data will be compared to the residential soil RSLs because the use of a 10x RSL approach for sediment is USEPA-region specific and is not accepted by USEPA Region 10, where this work is being conducted. PFAS results for constituents without a PAL will be provided in an appendix to the RI report for comparison to appropriate screening values if they are available in the future.

  Soil data will also be evaluated for leaching potential based on a multiple lines of evidence approach, including the assessment of groundwater concentrations, consideration of soil type and PFAS distribution in the vadose zone, solute transport modeling, and state-of-the-science research on PFAS leaching.

  While preliminary screening against soil-to-groundwater screening levels (SLs) will be used as a part of the multiple lines of evidence approach to assess leaching potential, soil-to-groundwater SLs are not considered PALs for this project and are not considered clean up goals or intended for use in remedial action or risk assessment decision making.

Ecological

Groundwater, Surface Water, VZW, Soil, and Sediment:

The Navy currently recommends that initial nature and extent data for PFAS be gathered for an environmental medium prior to performing the initial steps (Steps 1 and 2 comprising an SL ecological risk assessment and Step 3A refinement) of the ecological risk assessment process. The analytical data collected as part of this phase of the RI will be evaluated to determine complete exposure pathways and evaluate the potential for unacceptable risk to be present for ecological receptors. Initial ESVs, based on available documents in the literature, are included in **Appendix B** to ensure that data collected during the RI are suitable to meet the needs to complete a future ecological risk assessment; however, the final ESVs used for the initiation of an SL ecological risk assessment completed during the overall RI will be reviewed and updated based on the state of the science at the time of the evaluation and presented to regulatory partners.

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

For What Will the Data be Used?

Data will be used to address the environmental questions and PQOs listed in **Table 11-1**.

The following uncertainties will be considered in data use:

- Scientific research and regulatory guidelines related to PFAS are rapidly evolving. As such, the information provided in this SAP presents the state of the science at the time of issuance of the SAP. The Navy will reevaluate changing science and regulations at the time of reporting to ensure data evaluation and risk assessments presented in the report reflect any changes to toxicology information, regulatory standards, and DoD and Navy policy and guidance. Changes to the proposed data evaluation and risk assessment approaches will be discussed with stakeholders prior to issuance of the report.
- Part of the sampling approach includes sampling of existing monitoring wells. While procedures for the installation of new wells include requirements for avoidance of PFAS-containing materials, there is no way to confirm whether these materials might have been used during construction of existing wells. Based on the sampling of numerous background wells at other facilities, impacts from past well construction are believed to be minimal; however, well construction will be considered if data indicate impacts are likely (for example, a group of wells installed concurrently have similar concentrations regardless of location relative to the likely release areas).

What Types of Data are Needed?

Table 11-1 and **Worksheets #17** and **#18** contain detailed information on the types of data needed for this project. The field methodology is included in **Worksheet #14**. 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. Laboratory detection limits will be suitable to detect PFOA, PFOS, PFBS, PFHxS, PFNA, and HFPO-DA at or below the PALs in accordance with **Worksheet #15**. 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 DoD QSM (DoD, 2019a) as applicable and laboratory in-house limits where the QSM does not apply.

Where, When, and How Should the Data be Collected and Generated?

Sample locations are shown on **Figures 11-2, 11-3**, and **11-4**. Field activities 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 standard operating procedures (SOPs) presented in **Worksheet #21**.

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

Matrix: Groundwater

Analytical Group: PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15

QC Sample[a]	Analytical Group	Frequency	DQIs	MPC
MS/MSD	PFAS	One per 20 samples	Accuracy/Precision	**Worksheet #28**
Equipment Rinsate Blank		One per day of field sampling for decontaminated equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
FD		One per 10 samples	Precision	If the native and duplicate results are ≥ 2x the LOQ, relative percent difference (RPD) ≤ 30%. If the native and duplicate result is < 2x the LOQ, use professional judgement.
Field Blank[b]		One per sample location	Bias/Contamination	No analytes detected > 1/2 LOQ or > 1/10 sample concentration, whichever is greater
Cooler Temperature Indicator		One per cooler	Accuracy/ Representativeness	Temperature ≤ 10 °C, not frozen

[a] Field QA/QC will be collected separately for each matrix, with the exception of field blanks.

[b] The preservative Trizma is only required for drinking water samples. Since the field samples are not from drinking water sources, the laboratory supplied PFAS-free water for the PFAS field blank, as well as sample containers, do not contain Trizma.

°C = degrees Celsius
< = less than
≤ = less than or equal to
> = more than
% = percent
DQI = data quality indicator
FD = field duplicate
MS = matrix spike
MSD = matrix spike duplicate

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

Matrix: Vadose Zone Porewater
Analytical Group: PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15

QC Sample[a]	Analytical Group	Frequency	DQIs	MPC
MS/MSD	PFAS	One per 20 samples	Accuracy/Precision	**Worksheet #28**
Equipment Rinsate Blank		One per day of field sampling for decontaminated equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
FD		One per 10 samples	Precision	If the native and duplicate results are ≥ 2x the LOQ, relative percent difference (RPD) ≤ 30%. If the native and duplicate result is < 2x the LOQ, use professional judgement.
Field Blank[b]		One per sample location	Bias/Contamination	No analytes detected > 1/2 LOQ or > 1/10 sample concentration, whichever is greater
Cooler Temperature Indicator		One per cooler	Accuracy/ Representativeness	Temperature ≤ 10 °C, not frozen

[a] Field QA/QC will be collected separately for each matrix, with the exception of field blanks.

[b] The preservative Trizma is only required for drinking water samples. Since the field samples are not from drinking water sources, the laboratory supplied PFAS-free water for the PFAS field blank, as well as sample containers, do not contain Trizma.

SAP Worksheet #12-3—Measurement Performance Criteria Table – Field Quality Control Samples

Matrix: Surface Water
Analytical Group: PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15

QC Sample[a]	Analytical Group	Frequency	DQIs	MPC
MS/MSD	PFAS	One per 20 samples	Accuracy/Precision	**Worksheet #28**
Equipment Rinsate Blank		One per day of field sampling for decontaminated equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
FD		One per 10 samples	Precision	If the native and duplicate results are ≥ 2x the LOQ, relative percent difference (RPD) ≤ 30%. If the native and duplicate result is < 2x the LOQ, use professional judgement.
Field Blank[b]		One per sample location	Bias/Contamination	No analytes detected > 1/2 LOQ or > 1/10 sample concentration, whichever is greater
Cooler Temperature Indicator		One per cooler	Accuracy/ Representativeness	Temperature ≤ 10 °C, not frozen

[a] Field QA/QC will be collected separately for each matrix, with the exception of field blanks.

[b] The preservative Trizma is only required for drinking water samples. Since the field samples are not from drinking water sources, the laboratory supplied PFAS-free water for the PFAS field blank, as well as sample containers, do not contain Trizma.

SAP Worksheet #12-4—Measurement Performance Criteria Table – Field Quality Control Samples

Matrix: Soil

Analytical Group: PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15

QC Sample[a]	Analytical Group	Frequency	DQIs	MPC
MS/MSD	PFAS	One per 20 samples	Accuracy/Precision	**Worksheet #28**
Equipment Rinsate Blank		One per day of field sampling for decontaminated equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
Field Blank[b]		One per site	Bias/Contamination	No target analytes detected > 1/2 LOQ, or greater than 1/10 sample concentration, whichever is greater
FD		One per 10 samples	Precision	If the native and duplicate results are ≥ 2x the LOQ, relative percent difference (RPD) ≤ 50%. If the native and duplicate result is < 2x the LOQ, use professional judgement.
Cooler Temperature Indicator		One per cooler	Accuracy/ Representativeness	Temperature ≤ 10°C, not frozen

[a] Field QA/QC will be collected separately for each matrix, with the exception of field blanks.

[b] The preservative Trizma is only required for drinking water samples. Since the field samples are not from drinking water sources, the laboratory supplied PFAS-free water for the PFAS field blank, as well as sample containers, do not contain Trizma.

SAP Worksheet #12-5—Measurement Performance Criteria Table – Field Quality Control Samples

Matrix: Sediment[a]
Analytical Group: PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15

QC Sample[b]	Analytical Group	Frequency	DQIs	MPC
MS/MSD	PFAS	One per 20 samples	Accuracy/Precision	**Worksheet #28**
Equipment Rinsate Blank		One per day of field sampling for decontaminated equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ
Field Blank[c]		One per site	Bias/Contamination	No target analytes detected > 1/2 LOQ, or greater than 1/10 sample concentration, whichever is greater
FD		One per 10 samples	Precision	If the native and duplicate results are ≥ 2x the LOQ, relative percent difference (RPD) ≤ 50%. If the native and duplicate result is < 2x the LOQ, use professional judgement.
Cooler Temperature Indicator		One per cooler	Accuracy/ Representativeness	Temperature ≤ 10°C, not frozen

[a] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

[b] Field QA/QC will be collected separately for each matrix, with the exception of field blanks.

[c] The preservative Trizma is only required for drinking water samples. The field samples are not from drinking water sources; therefore, the laboratory supplied PFAS-free water for the PFAS field blank, as well as sample containers, do not contain Trizma.

SAP Worksheet #12-6—Measurement Performance Criteria Table – Field Quality Control Samples

Matrix: Soil

Analytical Group: Geotechnical Parameters

QC Sample	Analytical Group	Frequency	DQIs	MPC
N/A	Geotechnical Parameters	N/A	N/A	**Worksheet #28**

SAP Worksheet #13—Secondary Data Criteria and Limitations Table

Secondary Data	Data Source (originating organization, report title and date)	Data Generator(s) (originating organization, data types, data generation/ collection dates)	How Data Will Be Used	Limitations on Data Use
Groundwater elevation and analytical data from groundwater monitoring wells within and surrounding Ault Field Area 6 and drinking water wells off Base near Area 6	CH2M. 2020a. Evaluation of Per- and Polyfluoroalkyl Substances, 1,4-Dioxane, and Vinyl Chloride in Groundwater and Drinking Water, Ault Field, Area 6 Naval Air Station Whidbey Island, Oak Harbor, Washington. September.	CH2M. Groundwater and drinking water PFAS data. 2017 through 2019.	Data will be used to assist the placement of groundwater monitoring wells included in this investigation and for the human health risk assessment.[a]	None
Details regarding potential source areas of PFAS on-Base at Ault Field	CH2M. 2018a. Preliminary Assessment for Per- and Polyfluoroalkyl Substances (PFAS), Ault Field, Naval Air Station Whidbey Island Oak Harbor and Coupeville, Washington. November.	CH2M. Geology, historical information through 2018.	Data will be used to assist the placement of soil borings included in this investigation.	None
Historical groundwater elevation data, groundwater pumping data, and lithologic data at Area 6	Sealaska Environmental Services, LLC (Sealaska). 2020. Annual 2019-2020 Groundwater Long-Term Monitoring Report for Operable Unit 1 Area 6 and Operable Unit 5 Area 31. November. CTI-URS Environmental Services, LLC (CTI-URS). 2019. 90 Percent Basis of Design Report for Southern and Western GETR System Remedial Designs Area 6. October.	Sealaska and CTI-URS. These reports summarize the site history, geology, hydrogeology, and historical data collected at Area 6. Historical information through 2020.	Facilitate selection of on- and off-Base sampling location by providing insight on groundwater flow directions and the vertical/spatial distribution of groundwater contamination.	None
Hydrostratigraphy	Sapik et. al. 1988. Ground-Water Resources and Simulation of Flow in Aquifers Containing Freshwater and Seawater, Island County, Washington. Jones, M.A. 1985. Occurrence of Ground Water and Potential for Seawater Intrusion, Island County, Washington.	United States Geological Survey (USGS). Summarizes the hydrostratigraphy of the Island County aquifer systems, including structure contour and isopach maps.	Information will be used to assist in construction of the Area 6 groundwater flow and solute transport model.	None

SAP Worksheet #13—Secondary Data Criteria and Limitations Table (continued)

Secondary Data	Data Source (originating organization, report title and date)	Data Generator(s) (originating organization, data types, data generation/ collection dates)	How Data Will Be Used	Limitations on Data Use
Existing numerical models of Area 6	URS Group, Inc. (URS). 2018. Naval Air Station Whidbey Island (Area 6) Groundwater Flow and Transport Model Development and Results, Revision 1. October. Simonds. 2002. Simulation of Ground-Water Flow and Potential Contaminant Transport at Area 6 Landfill, Naval Air Station Whidbey Island, Island County, Washington.	URS and USGS. Description of the construction and calibration of previous groundwater flow and solute transport models of Area 6.	Information will be used to assist in construction of the Area 6 groundwater flow and PFAS solute transport model.	None

[a] If it is determined that the GETR wetland north of Ault Field Road is hydraulically connected to groundwater and that groundwater in the wetland area flows to the north, this groundwater transport pathway to downgradient freshwater streams will be considered in a revised CSM and subsequent ecological risk evaluations.

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 C**.

Premobilization Tasks

- Work plan development and approval (SAP, Accident Prevention Plan – Site Safety and Health Plan, and Waste Management Plan – Environmental Protection Plan)
- National Historic Preservation Act Section 106 Consultation with the State Historic Preservation Officer and/or the Advisory Council on Historic Preservation to identify possible conflicts between historic preservation objectives and the proposed activities in the clearance area shown on **Figures 11-2**, **11-3**, and **11-4**
- Subcontractor procurement
  - Analytical laboratory
  - Data validator
  - Utility locator
  - Surveyor
  - Driller
  - Vegetation clearance contractor
  - Investigation-derived waste (IDW) transportation and disposal contractor
- Fieldwork scheduling
- Well reconnaissance
- Coordination with NAS Whidbey Island for site access and IDW staging at Ault Field Area 6

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 stage of work, CH2M and its subcontractors will have field meetings to discuss the work items and worker responsibilities, and to familiarize workers with the Accident Prevention Plan – Site Safety and Health Plan.

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 utilities near the proposed monitoring well locations and lysimeter locations. Any proposed intrusive sample location within 5 feet of marked utilities 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 TM, CH2M STC, and NAVFAC Northwest RPM to establish a new well location.

Soil Borings

Soil borings will be advanced by a Washington-licensed driller using sonic drilling techniques in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix C**. The drilling subcontractor will be responsible for procuring the necessary well permits. Each drilling location will be hand cleared to a depth of 5 feet bgs using noninvasive methods prior to drilling to ensure that undetected buried utilities are not present. Materials containing PFAS will not be used during drilling.

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

Soil borings will be advanced during Stages 1 and 2 as follows:

- Stage 1: Eight soil borings will be advanced on-Base at Area 6 to a maximum depth of 250 feet bgs and will have groundwater monitoring wells installed. Up to three soil samples (one surface [0 to 6 inches bgs] and two subsurface [at the top of the capillary fringe in the unsaturated soil and at another lithologic interface encountered during drilling]) will be collected from the deeper boring in each planned well pair and one lysimeter boring (discussed below) and up to three grab groundwater samples will be collected for PFAS analysis during drilling of the deeper boring in each monitoring well pair. Soil samples will be analyzed with a standard turnaround time (TAT), while grab groundwater samples will be analyzed with a 72-hour TAT. One 10-inch diameter soil boring will be advanced to accommodate installation of a 4-inch diameter monitoring well that will be used as an aquifer testing pumping well.

  One soil boring will be advanced in the former industrial waste disposal area for the installation of a triple completion lysimeter. The soil boring will be 10 inches in diameter and will be advanced to the water table (estimated to be approximately 85 feet bgs). Up to three soil samples will be collected during the drilling of the lysimeter soil boring (as discussed herein).

  Archaeological monitoring will be performed during the first day of drilling all borings included in the RI field investigation.

- Stage 2: Up to eight soil borings will be advanced off Base near Area 6 to a maximum depth of 150 feet bgs. One soil boring (6-I-13) will be drilled to a maximum depth of up to 250 feet bgs for the collection of deeper lithologic information and up to three grab groundwater samples will be collected during the drilling at up to five Stage 2 locations. Grab groundwater samples will be submitted for PFAS analysis with a 72-hour TAT.

  Archaeological monitoring will be performed during the first day of drilling all borings included in the RI field investigation.

Soil Logging

Continuous soil cores will be collected for lithologic classification and screened for VOCs using a photoionization detector. Soil cores will be closely examined for signs of saturation and the presence of fine-grained beds that could indicate the presence of perched groundwater or confining conditions. Lithology observed in the soil cores will be classified according to the Unified Soil Classification System, and then logged in accordance with applicable SOPs included in **Appendix C**.

Monitoring Well Installation

Groundwater monitoring wells will be installed and developed in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix C**.

Groundwater monitoring wells will be installed and developed during Stages 1 and 2 as follows:

- Stage 1: Eight new on-Base groundwater monitoring wells will be installed at Area 6 at areas where data gaps exist (**Figure 11-3**).
- Stage 2: Up to eight new off-Base groundwater monitoring wells will be installed at areas where data gaps exist (**Figure 11-4**).

Monitoring well construction will occur following the advancement of the soil borings. The installation depths of the wells will be determined based on field observations of lithology. Monitoring wells will generally be constructed with a 2-inch diameter Schedule 40 polyvinyl chloride (PVC) riser connected to a 10- or 20-foot, factory-slotted 0.020-inch PVC screen with a bottom cap. The aquifer testing pumping well will be installed with

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

4-inch diameter Schedule 40 PVC. A sand filter pack (12/20 washed silica) will be placed in the annular space around the screen from the bottom of the boring to a minimum height of 2 feet above the top of the screen. A bentonite seal, at least 2 feet thick, will be placed above the top of the sand pack. After the bentonite has been hydrated, a cement-bentonite grout will be placed in the remaining annular space. Construction materials will be free of fluorine. Polymer-coated bentonite formulations will not be used; they have been shown to contain PFAS. Monitoring wells will be completed with either aboveground steel stovepipe or flush-mount completions that include a metal vault and concrete pad. Bollards will be installed at wells with aboveground completions. A locking watertight cap will be placed on the top of the PVC casing. The monitoring wells will be labeled on the stovepipe or flush-mount vaults' exterior with a metal stamp and will include well identification and pertinent well construction information. Each newly constructed monitoring well will be allowed to sit for at least 24 hours before being developed.

Monitoring Well Development

After construction, each newly installed monitoring well will be developed using a combination of bailing, surging, and pumping throughout the screen in accordance with the applicable SOPs included in **Appendix C**. During development, field water quality parameters, including potential of Hydrogen (pH), temperature, conductivity, and turbidity, will be measured with a water quality meter. Development will continue until turbidity readings are below 10 nephelometric turbidity units and water is free of visible sediment, measurements for three consecutive water quality parameter readings stabilize, a minimum of 10 well casing volumes have been purged, or until 4 hours of total development time (including the surge and bail period) has been reached, whichever occurs first.

Lysimeter Installation

A triple completion porous stainless steel suction lysimeter well cluster (6-LYS-01 through 6-LYS-03) will be installed at the former industrial waste disposal area during the Stage 1 RI field investigation. Lysimeter installation activities will be consistent with the SOP listed in **Worksheet #21** and provided in **Appendix C**. It is anticipated that the deepest lysimeter in the cluster will be approximately 85 feet bgs; however, final depths will be determined based on field conditions.

Surveying

New monitoring wells and lysimeters will be horizontally and vertically surveyed by a Washington-licensed surveyor. In addition, a limited number of existing monitoring wells may be resurveyed if the available coordinate and/or elevation data are deemed unreliable. The surveyor will provide easting and northing horizontal coordinates referenced to Washington State Plane North Zone based on the North American Datum of 1983. Horizontal coordinates will be provided to the nearest 0.01 foot. The surveyor will provide vertical elevations (top of PVC casing and ground surface) in units of feet referenced to NAVD 88. Vertical coordinates will be provided to the nearest 0.001 foot.

Sampling Tasks

In general, field notes will be taken in accordance with the SOP *Preparing Field Log Books* (**Worksheet #21** and **Appendix C**).

Soil Sampling

Soil sampling will be completed in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix C**. Up to three soil samples will be collected from the deeper boring in each planned well pair and one lysimeter boring during the Stage 1 field investigation (a total of 15 soil samples, excluding QA/QC samples). Soil samples from the selected locations (6-D-06, 6-I-10, 6-I-11, 6-I-12, and 6-LYS-03) will be sent for laboratory analysis of PFAS with a standard TAT.

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

Up to 10 soil samples will be collected during the Stage 1 field investigation using "least disturbed" techniques included in the *Geotechnical Soil Sampling Procedures* SOP listed in **Worksheet #21** and provided in **Appendix C**. Samples will be collected such that they represent the range of lithologic materials through which PFAS may be migrating in each of the aquifers underlying the site (such as sand, silty sand, silt, clay, and similar) Geotechnical soil samples will be submitted for laboratory analysis of geotechnical parameters (such as total and air-filled porosity, dry bulk density, grain density, fraction organic carbon, and grain size analysis).

Vertical Profile Sampling

Depth-discrete groundwater vertical profile sampling will be completed during the Stage 1 and Stage 2 field efforts, with up to three groundwater samples collected from 6-D-06, 6-I-10, 6-I-11, 6-I-12 during the Stage 1 RI field effort and from up to five locations during the Stage 2 RI field effort. Depth-discrete groundwater vertical profile sampling during the RI will be in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix C**.

Groundwater grab samples will be sent for laboratory analysis of PFAS with a 72-hour TAT; groundwater profiling results will be used to determine target well settings for the paired wells.

Lysimeter Sampling

VZW samples will be collected from 6-LYS-01 through 6-LYS-03 during the Stage 1 RI field investigation. Analysis of soil samples from the lysimeter boring will provide data relating to the total PFAS concentration in the vadose zone, including PFAS in VZW, PFAS adsorbed to soil particles, and PFAS air-water interfacial adsorption. Analysis of VZW samples will provide the fraction of the total PFAS present in aqueous phase, which may be more readily leached to the water table. Comparison of the two datasets will provide information regarding whether the various phases are in equilibrium. These data will be used as input to the 1-dimensional leaching model to evaluate loading to the water table. Lysimeter sampling will be conducted in accordance with the SOP listed in **Worksheet #21** and provided in **Appendix C**. Additional lysimeter sampling events may be conducted under future field efforts.

Monitoring Well, GETR Pumping Well, and Private Groundwater Well Sampling

Groundwater sampling will be completed at all new monitoring well locations as well as select existing groundwater monitoring wells in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix C**. Samples will be submitted for laboratory analysis of PFAS with a standard TAT. Monitoring well sampling will occur during Phases 1 and 2 as follows:

- Stage 1: Groundwater samples will be collected from up to 25 existing and 8 newly installed groundwater monitoring wells on Base. Up to eight western GETR pumping wells will be sampled during routine semi-annual long-term groundwater monitoring at Area 6. Samples will be coordinated with and collected by the GETR contractor (for example, the GETR contractor would fill the PFAS sample bottleware) in accordance with their standard procedures (Sealaska, 2020). During the Phase 2 SI field activities, samples were not collected from one inactive, private groundwater well (that is, not a residential drinking water well) due to logistical, budgetary, and schedule constraints (CH2M, 2020a). Sampling of this off-Base well will be performed during the Stage 1 RI field investigation in accordance with the *Final Sampling and Analysis Plan Site Inspection of Per- and Polyfluoroalkyl Substances and Additional Characterization of 1,4-Dioxane, and Vinyl Chloride in Groundwater and Drinking Water for Remedial Design Refinement* (CH2M, 2017) and *Final Sampling and Analysis Plan Addendum Site Inspection of Per- and Polyfluoroalkyl Substances and Additional Characterization of 1,4-Dioxane, and Vinyl Chloride in Groundwater and Drinking Water for Remedial Design Refinement* (CH2M, 2018c).

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

- Stage 2: Groundwater samples will be collected from the up to eight newly installed groundwater monitoring wells off Base.

Surface Water Sampling

Surface water samples will be collected from up to five locations during the Stage 1 field effort in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix C**. Surface water samples will be submitted for laboratory analysis of PFAS with a standard TAT.

Sediment[6] Sampling

Sediment[6] samples will be collected from up to five locations during the Stage 1 field effort in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix C**. Sediment[6] samples will be submitted for laboratory analysis of PFAS with a standard TAT.

Aquifer Testing

One single well aquifer test will be conducted at an on-Base monitoring wells during the Stage 1 RI field investigation in accordance with the SOP listed in **Worksheet #21** and provided in **Appendix C**. The aquifer pumping and observation network will be selected based on field conditions at the onset of the Stage 1 drilling program. Up to 10 observation wells will be instrumented with data logging pressure transducers during the aquifer test.

Synoptic Water Level Survey

Manual groundwater levels will be measured at all new and existing groundwater monitoring wells during the RI field investigation in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix C.**

Decontamination

Drilling equipment used during well installation and reusable sampling equipment will be decontaminated immediately after each use in accordance with applicable SOPs referenced in **Worksheet #21** and provided in **Appendix C**. Sensitive instrumentation, such as equipment used to collect water quality parameters, will be decontaminated in accordance with the equipment manufacturers’ guidelines.

Investigation-derived Waste Handling

IDW will be managed in accordance with the Interim PFAS Site Guidance for NAVFAC RPMs, November 2020 Update (Navy, 2020) and in accordance with SOPs listed in **Worksheet #21** and provided in **Appendix C**. Aqueous IDW with concentrations exceeding 70 nanogram(s) per liter (ng/L) (combined PFOA and PFOS) will be treated to levels less than 70 ng/L prior to disposal, if necessary, based on the offsite disposal methodology. Incineration will not be conducted. All efforts will be made to segregate source area IDW from that generated in downgradient areas where concentrations are likely to be lower to minimize the volume of aqueous IDW requiring treatment.

Analyses and Testing Tasks

The PFAS analytical laboratory will process and prepare soil samples for analysis. Soil samples will be analyzed for PFAS by Vista Analytical using LC-MS/MS compliant with DoD QSM 5.3 Table B-15 in accordance with **Worksheets #18** and **#19**.

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[6] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

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

Geotechnical samples will be sent to Core Laboratories for analysis of geotechnical parameters (such as total porosity, dry bulk density, fraction organic carbon, and grain size analysis). Groundwater samples (including vertical provide samples), VZW samples, and surface water samples will be analyzed for PFAS by Vista Analytical using LC-MS/MS compliant with DoD QSM 5.3 Table B-15, in accordance with **Worksheets #18** and **#19**. Sediment[6] samples will be analyzed for PFAS by Vista Analytical using LC-MS/MS compliant with DoD QSM 5.3 Table B-15 in accordance with **Worksheets #18** and **#19**.

Modeling

Data collected during the RI will be used to update the CSM and develop a local-scale groundwater flow and solute transport model. Initial model structure, parameterization, and boundary conditions will be extracted from the regional, baseline model (in development). Data collected during the RI investigation will be used to refine the local-scale model to accommodate local-scale conditions, such as more refined parameterization, model layering, grid resolution, GETR pumping data, and PFAS solute transport boundary conditions. The local-scale groundwater flow model will be calibrated to steady-state hydraulic conditions. HYDRUS software, or similar, will be used to conceptualize PFAS transport from the soil source areas to shallow groundwater. The solute mass flux values obtained from HYDRUS will then be used as flux boundary conditions for the solute transport model. The model will be used to evaluate up to three future scenarios (such as changes to pumping rates or distributions).

Quality Control Tasks

Implement SOPs for field and laboratory activities being performed.

Field QC samples are described on **Worksheet #20**.

Secondary Data

Refer to **Worksheet #13**.

Data Validation, Review, and Management Tasks

Refer to **Worksheets #34** through **#36** for discussion of data management procedures.

Documentation and Reporting

Daily reports will be submitted to the NAVFAC Northwest RPM.

A summary of field activities and a data evaluation will be documented in an RI report, and then submitted to the NAVFAC Northwest RPM and stakeholder agencies for review and approval.

Assessment and Audit Tasks

Refer to **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 the course of field operations may be demobilized before the final project completion date. The following will occur before demobilization:

- Chain-of-custody records will be reviewed to verify that all samples were collected as planned and submitted for appropriate analyses.
- The site will be restored to an appropriate level and will be verified by the CH2M FTL and Navy Representative.

Equipment will be inspected, packaged, and shipped to the appropriate location.

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

Matrix: Groundwater/Vadose Zone Porewater
Analytical Group: PFAS – PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15

Analyte	CAS Number	PALs		Laboratory Limits (ng/L)			LCS and MS/MSD Recovery Limits and RPD[a] (%)		
		Tapwater RSLs (ng/L)	PAL Reference	LOQs (ng/L)	LODs (ng/L)	DLs (ng/L)	LCL	UCL	RPD
Perfluorooctanoic acid (PFOA)	335-67-1	6	ASD, 2022	8	4	2	49	141	30
Perfluorooctane Sulfonic acid (PFOS)	1763-23-1	4	ASD, 2022	8	4	2	40	144	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	600	ASD, 2022	8	4	2	56	134	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	8	4	2	51	137	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	8	4	2	48	136	30
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	39	ASD, 2022	8	4	2	52	128	30
Perfluorononanoic acid (PFNA)	375-95-1	5.9	ASD, 2022	8	4	2	58	122	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	8	4	2	59	135	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	8	4	2	64	134	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	8	4	2	75	131	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	8	4	2	42	148	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	--	8	4	2	42	158	30
N-Ethyl Perfluorooctanesulfonamidoacetic acid (EtFOSAA)	2991-50-6	--	--	8	4	2	51	131	30
N-Methyl Perfluorooctanesulfonamidoacetic acid (MeFOSAA)	2355-31-9	--	--	8	4	2	50	146	30
Perfluoro-2-methyl-3-oxahexanoic acid (HFPO-DA)	13252-13-6	6	ASD, 2022	8	4	2	65	135	30
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	8	4	2	65	135	30
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	--	--	8	4	2	65	135	30

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

Analyte	**CAS Number**	**PALs**		**Laboratory Limits (ng/L)**			**LCS and MS/MSD Recovery Limits and RPD[a] (%)**		
		Tapwater RSLs (ng/L)	**PAL Reference**	**LOQs (ng/L)**	**LODs (ng/L)**	**DLs (ng/L)**	**LCL**	**UCL**	**RPD**
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	8	4	2	**65**	**135**	30
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	--	--	8	4	2	63	143	30
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	--	--	8	4	2	64	140	30
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	--	--	8	4	2	67	138	30
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	--	--	8	4	2	**65**	**135**	30
Perfluorobutanoic acid (PFBA)	375-22-4	--	--	8	4	2	73	129	30
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	--	--	8	4	2	**65**	**135**	30
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	--	--	8	4	2	69	134	30
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	--	--	8	4	2	**65**	**135**	30
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	--	--	8	4	2	**65**	**135**	30
Perfluoropentanoic acid (PFPeA)	2706-90-3	--	--	8	4	2	72	129	30
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	--	--	8	4	2	71	127	30

Notes:

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

[a] Accuracy and precision are per DoD QSM 5.3 (DoD, 2019a). For analytes not found in DoD QSM 5.3, laboratory in-house limits will be used. Analytes using in-house laboratory limits are bolded.

CAS = Chemical Abstract Service
LCL = lower control limit
LCS = laboratory control sample
UCL = upper control limit

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

Matrix: Surface Water
Analytical Group: PFAS – PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15

Analyte	CAS Number	PALs		Laboratory Limits (ng/L)			LCS and MS/MSD Recovery Limits and RPD[a] (%)		
		Tapwater RSLs (ng/L)	PAL Reference	LOQs (ng/L)	LODs (ng/L)	DLs (ng/L)	LCL	UCL	RPD
Perfluorooctanoic acid (PFOA)	335-67-1	6	ASD, 2022	8	4	2	49	141	30
Perfluorooctane Sulfonic acid (PFOS)	1763-23-1	4	ASD, 2022	8	4	2	40	144	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	600	ASD, 2022	8	4	2	56	134	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	8	4	2	51	137	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	8	4	2	48	136	30
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	39	ASD, 2022	8	4	2	52	128	30
Perfluorononanoic acid (PFNA)	375-95-1	5.9	ASD, 2022	8	4	2	58	122	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	8	4	2	59	135	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	8	4	2	64	134	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	8	4	2	75	131	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	8	4	2	42	148	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	--	8	4	2	42	158	30
N-Ethyl Perfluorooctanesulfonamidoacetic acid (EtFOSAA)	2991-50-6	--	--	8	4	2	51	131	30
N-Methyl Perfluorooctanesulfonamidoacetic acid (MeFOSAA)	2355-31-9	--	--	8	4	2	50	146	30
Perfluoro-2-methyl-3-oxahexanoic acid (HFPO-DA)	13252-13-6	6	ASD, 2022	8	4	2	65	135	30
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	8	4	2	65	135	30

SAP Worksheet #15-2—Reference Limits and Evaluation Tables (continued)

Analyte	**CAS Number**	**PALs**		**Laboratory Limits (ng/L)**			**LCS and MS/MSD Recovery Limits and RPD[a] (%)**		
		Tapwater RSLs (ng/L)	**PAL Reference**	**LOQs (ng/L)**	**LODs (ng/L)**	**DLs (ng/L)**	**LCL**	**UCL**	**RPD**
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	--	--	8	4	2	**65**	**135**	30
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	8	4	2	**65**	**135**	30
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	--	--	8	4	2	63	143	30
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	--	--	8	4	2	64	140	30
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	--	--	8	4	2	67	138	30
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	--	--	8	4	2	**65**	**135**	30
Perfluorobutanoic acid (PFBA)	375-22-4	--	--	8	4	2	73	129	30
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	--	--	8	4	2	**65**	**135**	30
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	--	--	8	4	2	69	134	30
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	--	--	8	4	2	**65**	**135**	30
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	--	--	8	4	2	**65**	**135**	30
Perfluoropentanoic acid (PFPeA)	2706-90-3	--	--	8	4	2	72	129	30
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	--	--	8	4	2	71	127	30

Notes:

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

[a] Accuracy and precision are per DoD QSM 5.3 (DoD, 2019a). For analytes not found in DoD QSM 5.3, laboratory in-house limits will be used. Analytes using in-house laboratory limits are bolded.

SAP Worksheet #15-3—Reference Limits and Evaluation Table

Matrix: Sediment[a]

Analytical Group: PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15

Analyte	CAS Number	PALs		Laboratory Limits (µg/L)[b]			LCS and MS/MSD Recovery Limits and RPD (%)[c]		
		Residential Soil RSLs (µg/kg)	PAL Reference	LOQs (µg/kg)	LODs (µg/kg)	DLs (µg/kg)	LCL	UCL	RPD
Perfluorooctane Sulfonic acid (PFOS)	1763-23-1	13	ASD, 2022	2	1	0.5	50	130	30
Perfluorooctanoic acid (PFOA)	335-67-1	19	ASD, 2022	2	1	0.5	56	136	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1,900	ASD, 2022	2	1	0.5	57	145	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	2	1	0.5	45	135	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	2	1	0.5	60	128	30
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	130	ASD, 2022	2	1	0.5	52	132	30
Perfluorononanoic acid (PFNA)	375-95-1	19	ASD, 2022	2	1	0.5	54	130	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	2	1	0.5	55	141	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	2	1	0.5	57	137	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	2	1	0.5	62	134	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	2	1	0.5	51	127	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	--	2	1	0.5	34	162	30
N-Ethyl Perfluorooctanesulfonamidoacetic acid (EtFOSAA)	2991-50-6	--	--	2	1	0.5	54	124	30
N-Methyl Perfluorooctanesulfonamidoacetic acid (MeFOSAA)	2355-31-9	--	--	2	1	0.5	52	146	30
Perfluoro-2-methyl-3-oxahexanoic acid (HFPO-DA)	13252-13-6	23	ASD, 2022	2	1	0.5	65	135	30
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	2	1	0.5	65	135	30
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	--	--	2	1	0.5	65	135	30

SAP Worksheet #15-3—Reference Limits and Evaluation Table (continued)

Analyte	CAS Number	PALs		Laboratory Limits (µg/L)[b]			LCS and MS/MSD Recovery Limits and RPD (%)[c]		
		Residential Soil RSLs (µg/kg)	PAL Reference	LOQs (µg/kg)	LODs (µg/kg)	DLs (µg/kg)	LCL	UCL	RPD
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	2	1	0.5	**65**	**135**	30
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	--	--	2	1	0.5	62	145	30
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	--	--	2	1	0.5	64	140	30
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	--	--	2	1	0.5	65	137	30
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	--	--	2	1	0.5	**65**	**135**	30
Perfluorobutanoic acid (PFBA)	375-22-4	--	--	2	1	0.5	71	135	30
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	--	--	2	1	0.5	**65**	**135**	30
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	--	--	2	1	0.5	70	132	30
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	--	--	2	1	0.5	**65**	**135**	30
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	--	--	2	1	0.5	**65**	**135**	30
Perfluoropentanoic acid (PFPeA)	2706-90-3	--	--	2	1	0.5	69	132	30
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	--	--	2	1	0.5	73	123	30

Notes:

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 Atlantic QAO in advance of sample testing.

[a] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

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

[c] Accuracy and precision limits are per DoD QSM 5.3 (DoD, 2019a). For analytes not found in DoD QSM 5.3, laboratory in-house limits will be used. Analytes using in-house laboratory limits are bolded.

µg/L = micrograms per liter

SAP Worksheet #15-4—Reference Limits and Evaluation Table

Matrix: Soil

Analytical Group: PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15

Analyte	CAS Number	PALs		Laboratory Limits (µg/L)[a]			LCS and MS/MSD Recovery Limits and RPD (%)[b]		
		Residential Soil RSLs (µg/kg)	PAL Reference	LOQs (µg/kg)	LODs (µg/kg)	DLs (µg/kg)	LCL	UCL	RPD
Perfluorooctane Sulfonic acid (PFOS)	1763-23-1	13	ASD, 2022	2	1	0.5	50	130	30
Perfluorooctanoic acid (PFOA)	335-67-1	19	ASD, 2022	2	1	0.5	56	136	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1,900	ASD, 2022	2	1	0.5	57	145	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	2	1	0.5	45	135	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	2	1	0.5	60	128	30
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	130	ASD, 2022	2	1	0.5	52	132	30
Perfluorononanoic acid (PFNA)	375-95-1	19	ASD, 2022	2	1	0.5	54	130	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	2	1	0.5	55	141	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	2	1	0.5	57	137	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	2	1	0.5	62	134	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	2	1	0.5	51	127	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	--	2	1	0.5	34	162	30
N-Ethyl Perfluorooctanesulfonamidoacetic acid (EtFOSAA)	2991-50-6	--	--	2	1	0.5	54	124	30
N-Methyl Perfluorooctanesulfonamidoacetic acid (MeFOSAA)	2355-31-9	--	--	2	1	0.5	52	146	30
Perfluoro-2-methyl-3-oxahexanoic acid (HFPO-DA)	13252-13-6	23	ASD, 2022	2	1	0.5	65	135	30
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	2	1	0.5	65	135	30
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	--	--	2	1	0.5	65	135	30

SAP Worksheet #15-4—Reference Limits and Evaluation Table (continued)

Analyte	CAS Number	PALs		Laboratory Limits (µg/L)[a]			LCS and MS/MSD Recovery Limits and RPD (%)[b]		
		Residential Soil RSLs (µg/kg)	PAL Reference	LOQs (µg/kg)	LODs (µg/kg)	DLs (µg/kg)	LCL	UCL	RPD
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	2	1	0.5	**65**	**135**	30
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	--	--	2	1	0.5	62	145	30
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	--	--	2	1	0.5	64	140	30
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	--	--	2	1	0.5	65	137	30
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	--	--	2	1	0.5	**65**	**135**	30
Perfluorobutanoic acid (PFBA)	375-22-4	--	--	2	1	0.5	71	135	30
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	--	--	2	1	0.5	**65**	**135**	30
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	--	--	2	1	0.5	70	132	30
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	--	--	2	1	0.5	**65**	**135**	30
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	--	--	2	1	0.5	**65**	**135**	30
Perfluoropentanoic acid (PFPeA)	2706-90-3	--	--	2	1	0.5	69	132	30
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	--	--	2	1	0.5	73	123	30

Notes:

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

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

[b] Accuracy and precision limits are per DoD QSM 5.3 (DoD, 2019a). For analytes not found in DoD QSM 5.3, laboratory in-house limits will be used. Analytes using in-house laboratory limits are bolded.

SAP Worksheet #15-5—Reference Limits and Evaluation Table

Matrix: Soil
Analytical Group: Geotechnical Parameters

Analyte[a]	**Method**[b]	**CAS Number**[c]	**Units**
Gravel (%)	ASTM D422	GRAVEL	%
Sand (%)	ASTM D422	14808-60-7	%
Coarse Sand (%)	ASTM D422	COARSE SAND	%
Very Coarse Sand (%)	ASTM D422	VERY COARSE SAND	%
Medium Sand (%)	ASTM D422	MEDIUM SAND	%
Fine Sand (%)	ASTM D422	FINE SAND	%
Very Fine Sand (%)	ASTM D422	VERY FINE SAND	%
Silt (%)	ASTM D422	SILT	%
Clay (%)	ASTM D422	CLAY	%
Dry Bulk Density	ASTM D2937	DENSITY	grams per cubic meter
Total Porosity	API RP40	TBD	%
Fractional Organic Carbon	Walkley Black	%FOC	%

[a] There are no action limits, laboratory reporting limits, or LCS recovery limits for grain size analytes.

[b] Geotechnical parameters are not DoD-certified. Data will be used to assess soil characteristics and are considered screening-level data.

[c] In some instances, a contractor-specific identifier is used.

API = American Petroleum Institute
ASTM = ASTM International

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SAP Worksheet #16—Project Schedule/Timeline Table

Activities	Organization	Dates		Deliverable
		Anticipated Date(s) of Initiation	**Anticipated Date of Completion**	
Draft SAP Preparation	CH2M	September 2021	May 2022	Draft SAP
SAP Review	NAVFAC	May 2022	July 2022	Comments
QAO Review	NAVFAC	July 2022	August 2022	Comments
Stakeholder Review	USEPA Region 10 Washington State Department Ecology	August 2022	September 2022	Comments
Final SAP	CH2M	October 2022	November 2022	Final SAP
Subcontractor Procurement	CH2M	TBD	TBD	
On-Base Monitoring Well Installation and Survey	CH2M, Subcontractor	December 2022	August 2023	
On-Base Groundwater Sampling	CH2M	December 2022	August 2023	
On-Base Surface Water and Sediment[a] Sampling	CH2M	December 2022	August 2023	
Off-Base Monitoring Well Installation and Survey	CH2M, Subcontractor	August 2023	September 2023	
Off-Base Groundwater Sampling	CH2M	August 2023	September 2023	
Laboratory Analysis	Subcontractor	Varied TATs are detailed on **Worksheet #30**.		Analytical data
Data Management	CH2M	TBD	TBD	
DV	Subcontractor	TBD	TBD	
Groundwater Flow and Solute Transport Model Development	CH2M	September 2023	January 2024	Calibrated Groundwater Flow and PFAS Transport Model
Draft RI Preparation	CH2M	January 2024	April 2024	Draft RI
RI Review	NAVFAC	April 2024	May 2024	Comments

SAP Worksheet #16—Project Schedule/Timeline Table (continued)

Activities	Organization	Dates		Deliverable
		Anticipated Date(s) of Initiation	Anticipated Date of Completion	
Stakeholder Review	USEPA Region 10	June 2024	July 2024	Comments
	Washington State Department Ecology			
Final SAP	CH2M	July 2024	August 2024	Final SAP

[a] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

SAP Worksheet #17—Sampling Design and Rationale

The investigation objectives described in this worksheet are listed in **Worksheet #11**. Media to be investigated for this SAP are groundwater from existing and newly installed groundwater monitoring wells, soil from newly installed groundwater monitoring well soil borings, VZW from newly installed lysimeters, and surface water and sediment[a] sampling from the ditches at or near Area 6. The sampling strategy and rationale are detailed in **Table 17-1**.

Table 17-1. Sampling Strategy and Rationale

Well Name/ Station ID[b]	Matrix	Depth of Samples (feet bgs)[c]	Analysis[d]	Laboratory Method	Number of Initial Samples[c]	Sampling Strategy	Rationale
Existing Groundwater Monitoring Wells and GETR Pumping Wells (Figure 11-2)							
6-D-01	GW	241 to 251	PFAS	LC-MS/MS compliant with DoD QSM 5.3, Table B-15	33	GW will be collected from 33 existing GW monitoring wells and GETR pumping wells for field water quality parameters and laboratory analysis of PFAS. Groundwater samples will be submitted for PFAS analysis with a standard TAT.	Samples and GW elevations from deep aquifer wells will be used obtain deep aquifer PFAS data to delineate the vertical extent of PFAS in GW south of the landfill (6-D-01), at the eastern boundary of Area 6 (6-D-03), and near the former industrial waste disposal area (6-D-05), and refine the understanding of GW flow and potential PFAS migration pathways in the deep aquifer near Area 6, to meet RI Objectives 1 and 6 (**Worksheet #11**). Sampling of deep aquifer wells was not included in the SI. These locations represent all existing deep aquifer wells at Area 6 (**Figure 11-2**).
6-D-03		190 to 200					
6-D-05		193 to 203					
6-I-01		163 to 177					Samples and GW elevations from intermediate aquifer wells will be used to obtain intermediate aquifer PFAS data to delineate the vertical extent of PFAS in GW near the former industrial waste disposal area (6-I-01), at the western boundary of Area 6 (6-I-03 and 6-I-08), and refine the understanding of GW flow and potential PFAS migration pathways in the intermediate aquifer near Area 6, to meet RI Objectives 1 and 6 (**Worksheet #11**). These locations represent all existing intermediate wells at Area 6 (**Figure 11-2**).
6-I-03		166 to 176					
6-I-08		147 to 157					
6-S-04		129.5 to 139.5					Samples and GW elevations from shallow aquifer wells have been selected to provide horizontal (lateral) delineation along the western and southern Area 6 boundaries adjacent to the landfill and refine the understanding of GW flow in the shallow aquifer (**Figure 11-2**). Data collected will meet RI Objectives 1 and 6 (**Worksheet #11**).
6-S-13		145 to 155					
6-S-19		143.5 to 153.5					
6-S-25		115 to 125					
6-S-29		144 to 164					
MW-09		132 to 152					
6-S-07		28.5 to 38.5					Samples and GW elevations from shallow aquifer wells have been selected to provide horizontal (lateral) delineation of PFAS along the northern Area 6 boundary, evaluate the extent of the shallow aquifer GW flow, and the location of the groundwater divide in the shallow aquifer. Data collected will meet Objectives 1, 2, and 6 **(Worksheet #11).**
6-S-26		63.5 to 73.5					
6-S-14		145 to 155					Sample and GW elevations from this shallow aquifer well have been selected to provide horizontal (lateral) delineation of PFAS near the landfill and refine the understanding of GW flow in the shallow aquifer (**Figure 11-2**). Data collected will meet Objectives 1 and 6 **(Worksheet #11).**
6-S-12		134.5 to 144.5					Samples and GW elevations from these shallow aquifer wells have been selected to provide horizontal (lateral) delineation of PFAS west of Area 6 (off Base) and refine the understanding of GW flow in the shallow aquifer (**Figure 11-2**). Data collected will meet Objectives 1 and 6 **(Worksheet #11).**
6-S-18		59.5 to 69.5					
6-S-24		105 to 115					
6-S-22		110 to 120					Samples and GW elevations from shallow aquifer wells have been selected to provide horizontal (lateral) delineation of PFAS near the former industrial waste disposal area and refine the understanding of GW flow in the shallow aquifer (**Figure 11-2**). Data collected will meet Objectives 1 and 6 **(Worksheet #11).**
6-S-30		72 to 82					
6-S-31		112 to 122					
6-S-44		86 to 96					

SAP Worksheet #17—Sampling Design and Rationale

Table 17-1. Sampling Strategy and Rationale

Well Name/ Station ID[b]	Matrix	Depth of Samples (feet bgs)[c]	Analysis[d]	Laboratory Method	Number of Initial Samples[c]	Sampling Strategy	Rationale
6-S-47	GW	85 to 95	PFAS	LC-MS/MS compliant with DoD QSM 5.3, Table B-15 or the most recent	33	GW will be collected from 33 existing GW monitoring wells and GETR pumping wells for field water quality parameters and laboratory analysis of PFAS. Groundwater samples will be submitted for PFAS analysis with a standard TAT.	Samples and GW elevations from shallow aquifer wells have been selected to provide horizontal (lateral) delineation of PFAS near the former industrial waste disposal area and refine the understanding of GW flow in the shallow aquifer (**Figure 11-2)**. Data collected will meet Objectives 1 and 6 **(Worksheet #11).**
6-S-48		95 to 105					
MW-07		118.4 to 148.4					Sample and GW elevations from this shallow aquifer well have been selected to provide horizontal (lateral) delineation of PFAS along the western boundary of Area 6 and refine the understanding of GW flow in the shallow aquifer (**Figure 11-2)**. Data collected will meet Objectives 1 and 6 **(Worksheet #11).**
PW-1		87.5 to 117.5					Samples from GETR pumping wells will be used to evaluate the concentration of PFAS potentially being captured by the western GETR system and to delineate the lateral extent of PFAS in the shallow aquifer along the western and southern boundaries of Area 6 (**Figure 11-2**). Data collected will meet RI Objective 1 (**Worksheet #11**).
PW-3		108 to 148					
PW-4		128 to 163					
PW-5		120 to 155					
PW-6		116.5 to 156.5					
PW-7		133 to 163					
PW-8		146 to 166					
PW-9		130 to 150					
Newly Installed On-Base Groundwater Monitoring Well Samples and Depth-discrete Grab Groundwater Samples (Figure 11-3)							
6-I-09	GW	Middle of well screen; well screen settings TBD	PFAS	LC-MS/MS compliant with DoD QSM 5.3, Table B-15	1	GW samples will be collected for field water quality parameter and laboratory analysis of PFAS from each newly installed monitoring well. Vertical profile grab GW samples will be collected during the drilling of the deepest boring at each well pair. Monitoring well samples will be submitted for PFAS analysis with a standard TAT. Vertical profile samples will be submitted for PFAS analysis with a 72-hour TAT.	Elevated PFAS concentrations were detected in the shallow aquifer (Well 6-S-44) in the former industrial waste disposal area during the SI. Samples, GW elevations, and lithologic data from these wells (at the former industrial waste disposal area) will be used to vertically delineate the extent of PFAS in GW beneath this source area, evaluate the extent of the aquifers beneath Area 6, and refine the understanding of GW flow and potential PFAS migration pathways in the intermediate and deep aquifers(**Figure 11-3**). Data collected will meet RI Objectives 1, 2, and 6 (**Worksheet #11**). Depth-discrete grab GW samples will be collected during drilling of 6-D-06 to delineate the vertical distribution of PFAS (RI Objective 1) and provide data to inform well screen placement.
6-D-06					1		
6-D-06_XX-XX		Depths of vertical profile samples will be determined based on field observations			3		
6-D-06_XX-XX							
6-D-06_XX-XX							
6-S-60		Middle of well screen; well screen settings TBD			1		Elevated PFAS concentrations were detected in the shallow aquifer in the former industrial waste disposal area during the SI. Samples, GW elevations, and lithologic data from these locations will be used to inform lateral and vertical delineation of the extent of PFAS in GW downgradient of the former industrial waste disposal area, evaluate the extent of the aquifers beneath Area 6, and refine the understanding of GW flow and potential PFAS migration pathways from Area 6 to off-Base receptors in the shallow and intermediate aquifers (**Figure 11-3**). Data collected will meet RI Objectives 1, 2, and 6 (**Worksheet #11**). Depth-discrete grab GW samples will be collected during drilling of 6-I-10 to delineate the vertical distribution of PFAS (RI Objective 1) and provide data to inform well screen placement.
6-I-10					1		
6-I-10_XX-XX		Depths of vertical profile samples will be determined based on field observations			3		
6-I-10_XX-XX							
6-I-10_XX-XX							

SAP Worksheet #17—Sampling Design and Rationale

Table 17-1. Sampling Strategy and Rationale

Well Name/ Station ID[b]	Matrix	Depth of Samples (feet bgs)[c]	Analysis[d]	Laboratory Method	Number of Initial Samples[c]	Sampling Strategy	Rationale
6-S-61	GW	Middle of well screen; well screen settings TBD	PFAS	LC-MS/MS compliant with DoD QSM 5.3, Table B-15	1	GW samples will be collected for field water quality parameter and laboratory analysis of PFAS from each newly installed monitoring well. Vertical profile grab GW samples will be collected during the drilling of the deepest boring at each well pair. Monitoring well samples will be submitted for PFAS analysis with a standard TAT. Vertical profile samples will be submitted for PFAS analysis with a 72-hour TAT.	Samples, GW elevations, and lithologic data from these wells will be used to delineate the lateral and vertical extent of PFAS in GW north of the GETR effluent wetland area, evaluate the extent of the aquifers beneath Area 6, and refine the understanding of GW flow directions north of Area 6 (**Figure 11-3**). Data collected will meet RI Objectives 1 and 6 (**Worksheet #11**). Lithologic data from these locations will be used to inform the lateral and vertical continuity of the Area 6 hydrostratigraphy and the extent of the shallow and intermediate aquifers through which PFAS may be migrating. Data collected will meet RI Objective 2 (**Worksheet #11**). Depth-discrete grab GW samples will be collected during drilling of 6-I-11 to delineate the vertical distribution of PFAS (RI **Objective 1**) and provide data to inform well screen placement.
6-I-11					1		
6-I-11_XX-XX		Depths of vertical profile samples will be determined based on field observations			3		
6-I-11_XX-XX							
6-I-11_XX-XX							
6-S-62		Middle of well screen; well screen settings TBD			1		Samples, GW elevations, and lithologic data from these wells will be used to delineate the lateral and vertical extent of PFAS in GW east of the GETR effluent wetland, evaluate the extent of the aquifers beneath Area 6, and refine the understanding of GW flow directions north of Area 6 and at the GW divide (**Figure 11-3**). Data collected will meet RI Objectives 1 and 6 (**Worksheet #11**). Lithologic data from these locations will be used to inform the lateral and vertical continuity of the Area 6 hydrostratigraphy and the extent of the shallow and intermediate aquifers through which PFAS may be migrating. Data collected will meet RI Objective 2 **(Worksheet #11**). Depth-discrete grab GW samples will be collected during drilling of 6-I-12 to delineate the vertical distribution of PFAS (RI **Objective 1**) and provide data to inform well screen placement.
6-I-12					1		
6-I-12_XX-XX		Depths of vertical profile samples will be determined based on field observations			3		
6-I-12_XX-XX							
6-I-12_XX-XX							
6-D-06	Soil	TBD (between the ground surface and water table)			15	Up to three soil samples will be collected from each location at the surface (0 to 6 inches bgs), at the top of the capillary fringe in the unsaturated soil, and at another lithologic interface below the water table determined during drilling. Soil samples will be submitted for laboratory analysis of PFAS with a standard TAT.	Soil samples will be collected from the deepest boring at each well pair location and lysimeter location to evaluate whether there is an ongoing source of PFAS loading to the aquifer system from the vadose zone at Area 6 and to characterize the lateral and vertical distribution of PFAS in the vadose zone (**Figure 11-3**). Data collected will meet RI Objective 3 (**Worksheet #11**).
6-I-10							
6-I-11							
6-I-12							
WI-A6-LYS03							
TBD		TBD	Geotechnical Parameters	ASTM D422 ASTM D2937 API RP40 Walkley Black	10	Up to ten soil samples will be collected during the drilling of new on-Base monitoring wells. Samples will be collected to be representative of the range of lithologies through which PFAS may be migrating. Soil samples will be submitted for laboratory analysis of geotechnical parameters with a standard TAT.	Soil samples will be collected during the drilling of new on-Base groundwater monitoring wells. Samples will be selected to represent the range of different lithologies through which PFAS may be migrating laterally and vertically (that is, sand, gravel, silt, clay, silty sand, and similar). Geotechnical parameters will be used to parameterize the solute transport model and will meet RI Objective 6 (**Worksheet #11**)

SAP Worksheet #17—Sampling Design and Rationale

Table 17-1. Sampling Strategy and Rationale

Well Name/ Station ID[b]	Matrix	Depth of Samples (feet bgs)[c]	Analysis[d]	Laboratory Method	Number of Initial Samples[c]	Sampling Strategy	Rationale
Vadose Zone Porewater Samples (Figure 11-3)							
WI-A6-LYS01	VZW	Lysimeter Porous Cap Depths TBD	PFAS	LC-MS/MS compliant with DoD QSM 5.3, Table B-15	3	One VZW sample will be collected from each lysimeter and submitted for laboratory analysis of PFAS with a standard TAT.	VZW samples from lysimeters located within the former industrial waste disposal area (**Figure 11-3**) will provide data to evaluate whether or not vadose zone mass in release area represents an ongoing source of PFAS loading to the shallow aquifer and to characterize the lateral and vertical distribution of PFAS in the vadose zone. Analysis of soil samples from the lysimeter boring (described herein) will provide data relating to the total PFAS concentration in the vadose zone, including PFAS in VZW, PFAS adsorbed to soil particles, and PFAS air-water interfacial adsportion. Analysis of VZW samples will provide the fraction of the total PFAS present in aqueous phase, which may be more readily leached to the water table. Comparison of the two datasets will provide information regarding whether the various phases are in equilibrium. These data will be used as input to the 1-dimensional leaching model to evaluate loading to the water table. Data collected will meet RI Objective 3 (**Worksheet #11**).
WI-A6-LYS02							
WI-A6-LYS03							
Surface Water and Sediment Samples (Figure 11-3)							
WI-A6-SWSD01	SW	Surface	PFAS	LC-MS/MS compliant with DoD QSM 5.3, Table B-15	5	Surface water samples will be collected from an estimated five locations along drainage running north of Area 6 (**Figure 11-4**).	PFAS were detected in western GETR plant influent and effluent samples during the SI; however, it is unknown if surface water downgradient of the GETR effluent has been impacted, and if so, the lateral extent of PFAS in surface water and the potential for PFAS to partition from surface water to sediment[a]. Surface water and sediment[a] samples collected from the GETR effluent stream (**Figure 11-3**) will be used to delineate the lateral extent of PFAS in surface water above PALs and to determine whether PFAS in surface water are partitioning to sediment[a]. Data collected will meet RI Objectives 4 and 5 (**Worksheet #11**).
WI-A6-SWSD02							
WI-A6-SWSD03							
WI-A6-SWSD04							
WI-A6-SWSD05							
WI-A6-SWSD01	Sediment (or surface soil, as applicable)	0 to 6 inches bgs			5	Sediment samples will be collected from an estimated five locations along drainage running north of Area 6 (**Figure 11-4**).	
WI-A6-SWSD02							
WI-A6-SWSD03							
WI-A6-SWSD04							
WI-A6-SWSD05							
Newly Installed Off-Base Groundwater Monitoring Wells (Figure 11-4)							
6-S-63	GW	Middle of well screen; well screen settings TBD	PFAS	LC-MS/MS compliant with DoD QSM 5.3, Table B-15	1	GW samples will be collected for laboratory analysis of PFAS from each newly installed monitoring well. Monitoring well samples will be submitted for PFAS analysis with a standard TAT.	Samples, GW elevations, and lithologic data from these wells located south of the GETR effluent wetland (**Figure 11-3**) will be used to delineate the lateral and vertical extent of PFAS in GW and refine the understanding of GW flow directions north of Area 6. Data collected will meet RI Objectives 1 and 6 (**Worksheet #11**). Lithologic data from these locations will be used to inform the lateral and vertical continuity of the Area 6 hydrostratigraphy and the extent of the shallow and intermediate aquifers through which PFAS may be migrating. Data collected will meet RI Objective 2 (**Worksheet #11**).
6-I-13					1		
TBD					1	GW samples will be collected for laboratory analysis of PFAS from each newly installed monitoring well. Vertical profile grab GW samples will be collected during the drilling of the deepest boring at the well pair along Ault Field Road. Monitoring well samples will be submitted for PFAS analysis with a standard TAT.	Samples, GW elevations, and lithologic data from these wells will be used to delineate the lateral extent of PFAS in GW between Area 6 and the impacted drinking water wells southwest of Area 6 and refine the understanding of GW flow directions west and southwest of Area 6. Data collected will meet RI Objectives 1 and 6 (**Worksheet #11**) (**Figure 11-4**). Lithologic data from these locations will be used to inform the lateral and vertical continuity of the Area 6 hydrostratigraphy and the extent of the shallow and intermediate aquifers through which PFAS may be migrating. Data collected will meet RI Objective 2 (**Worksheet #11**).
TBD					1		
TBD					1		
TBD					1		
TBD					1		
TBD					1		

SAP Worksheet #17—Sampling Design and Rationale

Table 17-1. Sampling Strategy and Rationale

Well Name/ Station ID[b]	Matrix	Depth of Samples (feet bgs)[c]	Analysis[d]	Laboratory Method	Number of Initial Samples[c]	Sampling Strategy	Rationale
TBD		Depths of vertical profile samples will be determined based on field observations			3	Up to three vertical profile grab GW samples will be collected during the drilling of up to five off-Base groundwater monitoring wells Vertical profile samples will be submitted for PFAS analysis with a 72-hour TAT.	Depth-discrete grab GW samples will be collected during drilling of up to five off-Base groundwater monitoring wells to delineate the vertical distribution of PFAS (RI Objective 1) and provide data to inform well screen placement.
TBD					3		
TBD					3		
TBD					3		
TBD					3		

[a] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.
[b] Station identification is applicable to lysimeter, surface water, and sediment locations.
[c] Additional field work stages needed to accomplish the objectives of the RI will be included in a SAP addendum or FCR.
[d] The PFAS laboratory is Vista Analytical. The geotechnical laboratory is Core Laboratories.

GW = groundwater
ID = identification
SW = surface water
TBD = to be determined

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SAP Worksheet #18—Location-Specific Sampling Methods/Standard Operating Procedure Requirements Table

Well Name	Sample ID	Matrix	Depth[a] (feet bgs)	Analytical Group	Number of Samples[a] (Identify FDs)	Sampling SOP Reference
Existing Groundwater Monitoring Wells and GETR Pumping Wells						
6-D-01	WI-A6-6-D-01-MMYY	Groundwater	241 to 251	PFAS (LC-MS/MS compliant with DoD QSM 5.3, Table B 15[b])	1	**Worksheet #21**
6-D-03	WI-A6-6-D-03-MMYY		190 to 200		1	
6-D-05	WI-A6-6-D-05-MMYY		193 to 203		1	
6-I-01	WI-A6-6-I-01-MMYY		163 to 177		1	
6-I-03	WI-A6-6-I-03-MMYY		166 to 176		1	
6-I-08	WI-A6-6-I-08-MMYY		147 to 157		1	
6-S-04	WI-A6-6-S-04-MMYY		129.5-139.5		2 (FD)	
	WI-A6-6-S-04P-MMYY					
6-S-07	WI-A6-6-S-07-MMYY		28.5 to 38.5		1	
6-S-13	WI-A6-6-S-13-MMYY		145 to 155		3 (MS/MSD)	
	WI-A6-6-S-13-MMYY-MS					
	WI-A6-6-S-13-MMYY-MSD					
6-S-12	WI-A6-6-S-12-MMYY		134.5 to 144.5		1	
6-S-14	WI-A6-6-S-14-MMYY		145 to 155		1	
6-S-18	WI-A6-6-S-18-MMYY		59.5 to 69.5		2 (FD)	
	WI-A6-6-S-18P-MMYY					
6-S-19	WI-A6-6-S-19-MMYY		143.5 to 153.5		1	
6-S-22	WI-A6-6-S-22-MMYY		110 to 120		1	
6-S-24	WI-A6-6-S-24-MMYY		105 to 115		1	
6-S-25	WI-A6-6-S-25-MMYY		115 to 125		1	
6-S-26	WI-A6-6-S-26-MMYY		63.5 to 73.5		1	
6-S-29	WI-A6-6-S-29-MMYY		144 to 164		1	
6-S-30	WI-A6-6-S-30-MMYY		72 to 82		1	
6-S-31	WI-A6-6-S-31-MMYY		112 to 122		2 (FD)	
	WI-A6-6-S-31P-MMYY					

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

Well Name	**Sample ID**	**Matrix**	**Depth[a] (feet bgs)**	**Analytical Group**	**Number of Samples[a] (Identify FDs)**	**Sampling SOP Reference**
6-S-44	WI-A6-6-S-44-MMYY	Groundwater	86 to 96	PFAS (LC-MS/MS compliant with DoD QSM 5.3, Table B 15[b])	1	**Worksheet #21**
6-S-47	WI-A6-6-S-47-MMYY		TBD		1	
6-S-48	WI-A6-6-S-48-MMYY		TBD		1	
MW-07	WI-A6-MW-07-MMYY		118.4 to 148.4		1	
MW-09	WI-A6-MW-09-MMYY		132 to 152		1	
PW-1	WI-A6-PW-1-MMYY		87.5 to 117.5		3 (MS/MSD)	
	WI-A6-PW-1-MMYY-MS					
	WI-A6-PW-1-MMYY-MSD					
PW-3	WI-A6-PW-3-MMYY		108 to 148		1	
PW-4	WI-A6-PW-4-MMYY		128 to 163		1	
PW-5	WI-A6-PW-5-MMYY		120 to 155		1	
PW-6	WI-A6-PW-6-MMYY		116.5 to 156.5		2 (FD)	
	WI-A6-PW-6P-MMYY					
PW-7	WI-A6-PW-7-MMYY		133 to 163		1	
PW-8	WI-A6-PW-8-MMYY		146 to 166		1	
PW-9	WI-A6-PW-9-MMYY		130 to 150		1	

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

Well Name	Sample ID	Matrix	Depth[a] (feet bgs)	Analytical Group	Number of Samples[a] (Identify FDs)	Sampling SOP Reference
Newly Installed On-Base Groundwater Monitoring Well Samples and Depth-discrete Grab Groundwater Samples						
6-I-09	WI-A6-6-I-09-MMYY	Groundwater	Groundwater samples will be collected from the middle of the well screen.	PFAS (LC-MS/MS compliant in accordance with DoD QSM 5.3, Table B-15[b])	1	**Worksheet #21**
6-D-06	WI-A6-6-D-06-MMYY				3 (MS/MSD)	
	WI-A6- 6-D-06-MMYY-MS					
	WI-A6- 6-D-06-MMYY-MSD					
	WI-A6- 6-D-06-XXYY				1	
	WI-A6- 6-D-06-XXYY				1	
	WI-A6- 6-D-06-XXYY				1	
	WI-A6-SS06D-000H	Surface Soil	Soil samples will be collected from the surface (0 to 6 inches bgs) and two subsurface (at the top of the capillary fringe in the unsaturated soil and at another lithologic interface encountered during drilling)		2 (FD)	
	WI-A6-SS06DP-000H					
	WI-A6-SB06D-XXYY	Subsurface Soil			1	
	WI-A6-SB06D-XXYY				1	
6-S-60	WI-A6-6-S-60-MMYY	Groundwater	Groundwater samples will be collected from the middle of the well screen.		1	
6-I-10	WI-A6-6-I-10-MMYY				1	
	WI-A6-6-I-10-XXYY				1	
	WI-A6-6-I-10-XXYY				2 (FD)	
	WI-A6-6-I-10P-XXYY					
	WI-A6-6-I-10 -XXYY				1	
	WI-A6-SS10I-000H	Surface Soil	Soil samples will be collected from the surface (0 to 6 inches bgs) and two subsurface (at the top of the capillary fringe in the unsaturated soil and at another lithologic interface encountered during drilling)		1	
	WI-A6-SB10I-XXYY	Subsurface Soil			3 (MS/MSD)	
	WI-A6-SB10I-XXYY-MS					
	WI-A6-SB10I-XXYY-MSD					
	WI-A6-SB10I-XXYY				1	

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

Well Name	**Sample ID**	**Matrix**	**Depth[a] (feet bgs)**	**Analytical Group**	**Number of Samples[a] (Identify FDs)**	**Sampling SOP Reference**
6-S-61	WI-A6-6-S-61-MMYY	Groundwater	Groundwater samples will be collected from the middle of the well screen.	PFAS (LC-MS/MS compliant in accordance with DoD QSM 5.3, Table B-15[b])	1	**Worksheet #21**
6-I-11	WI-A6-6-I-11-MMYY				1	
	WI-A6-6-I-11-XXYY				1	
	WI-A6-6-I-11-XXYY				1	
	WI-A6-6-I-11-XXYY				1	
	WI-A6-SS11I-000H	Surface Soil	Soil samples will be collected from the surface (0 to 6 inches bgs) and two subsurface (at the top of the capillary fringe in the unsaturated soil and at another lithologic interface encountered during drilling)		1	
	WI-A6-SB11I-XXYY	Subsurface Soil			1	
	WI-A6-SB11I-XXYY				2 (FD)	
	WI-A6-SB11IP-XXYY					
6-S-62	WI-A6-6-S-62-MMYY	Groundwater	Groundwater samples will be collected from the middle of the well screen.		2 (FD)	
	WI-A6-6-S-62P-MMYY					
6-I-12	WI-A6-6-I-12-MMYY				1	
	WI-A6-6-I-12-XXYY				1	
	WI-A6-6-I-12-XXYY				1	
	WI-A6-6-I-12-XXYY				1	
	WI-A6-SS12I-000H	Surface Soil	Soil samples will be collected from the surface (0 to 6 inches bgs) and two subsurface (at the top of the capillary fringe in the unsaturated soil and at another lithologic interface encountered during drilling)		1	
	WI-A6-SB12I-XXYY	Subsurface Soil			1	
	WI-A6-SB12I-XXYY				1	
TBD	TBD	Subsurface Soil	TBD Soil samples will be collected during the drilling of new on-Base monitoring wells. Samples will be collected to be representative of the range of lithologies through which PFAS may be migrating.	Geotechnical Parameters (ASTM D422, ASTM D2937, API RP40, Walkley Black)	10	**Worksheet #21**

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

Well Name	Sample ID	Matrix	Depth[a] (feet bgs)	Analytical Group	Number of Samples[a] (Identify FDs)	Sampling SOP Reference
Vadose Zone Porewater Samples						
WI-A6-LYS01	WI-A6-LYS01-VZW-MMYY	VZW	Lysimeter Porous Cap Depths TBD	PFAS (LC-MS/MS compliant in accordance with DoD QSM 5.3, Table B-15[b])	3 (MS/MSD)	**Worksheet #21**
	WI-A6-LYS01-VZW-MMYY-MS					
	WI-A6-LYS01-VZW-MMYY-MSD					
WI-A6-LYS02	WI-A6-LYS02-VZW-MMYY				1	
WI-A6-LYS03	WI-A6-LYS03-VZW-MMYY				2 (FD)	
	WI-A6-LYS03P-VZW-MMYY					
	WI-A6-LYS03-SS03-000H	Surface Soil	Soil samples will be collected from the surface (0 to 6 inches bgs) and two subsurface (at the top of the capillary fringe in the unsaturated soil and at another lithologic interface encountered during drilling)		2 (FD)	
	WI-A6-LYS03-SS03P-000H					
	WI-A6-LYS03-SB03-XXYY	Subsurface Soil			3 (MS/MSD)	
	WI-A6-LYS03-SB03-XXYY-MS					
	WI-A6-LYS03-SB03-XXYY-MSD					
	WI-A6-LYS03-SB03-XXYY				1	
Surface Water and Sediment[c] Samples						
WI-A6-SWSD01	WI-A6-SW01-MMYY	Surface Water	Surface	PFAS (LC-MS/MS compliant in accordance with DoD QSM 5.3, Table B-15[b])	1	**Worksheet #21**
	WI-A6-SD01-MMYY	Sediment[c]	0 to 6 inches bgs		3 (MS/MSD)	
	WI-A6-SD01-MMYY-MS					
	WI-A6-SD01-MMYY-MSD					

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

Well Name	Sample ID	Matrix	Depth[a] (feet bgs)	Analytical Group	Number of Samples[a] (Identify FDs)	Sampling SOP Reference
WI-A6-SWSD02	WI-A6-SW02-MMYY	Surface Water	Surface	PFAS (LC-MS/MS compliant in accordance with DoD QSM 5.3, Table B-15[b])	1	**Worksheet #21**
	WI-A6-SD02-MMYY	Sediment[c]	0 to 6 inches bgs		1	
WI-A6-SWSD03	WI-A6-SW03-MMYY	Surface Water	Surface		2 (FD)	
	WI-A6-SW03P-MMYY					
	WI-A6-SD03-MMYY	Sediment[c]	0 to 6 inches bgs		1	
WI-A6-SWSD04	WI-A6-SW04-MMYY	Surface Water	Surface		1	
	WI-A6-SD04-MMYY	Sediment[c]	0 to 6 inches bgs		2 (FD)	
	WI-A6-SD04P-MMYY					
WI-A6-SWSD05	WI-A6-SW05-MMYY	Surface Water	Surface		3 (MS/MSD)	
	WI-A6-SW05-MMYY-MS					
	WI-A6-SW05-MMYY-MSD					
	WI-A6-SD05-MMYY	Sediment[c]	0 to 6 inches bgs		1	
Newly Installed Off-Base Groundwater Monitoring Wells						
6-S-63	WI-A6-6-S-63-MMYY	Groundwater	Middle of well screen; well screen settings TBD	PFAS (LC-MS/MS compliant in accordance with DoD QSM 5.3, Table B-15[b])	3 (MS/MSD)	**Worksheet #21**
	WI-A6-6-S-63-MMYY-MS					
	WI-A6-6-S-63-MMYY-MSD					
6-I-13	WI-A6-GW13I-MMYY				2 (FD)	
	WI-A6-GW13IP-MMYY					
					2 (FD)	
					1	
					1	

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

Well Name	Sample ID	Matrix	Depth[a] (feet bgs)	Analytical Group	Number of Samples[a] (Identify FDs)	Sampling SOP Reference
TBD	TBD	Groundwater	Middle of well screen; well screen settings TBD	PFAS (LC-MS/MS compliant in accordance with DoD QSM 5.3, Table B-15[b])	2 (FD)	**Worksheet #21**
TBD	TBD				1	
TBD	TBD				1	
TBD	TBD				1	
TBD	TBD				1	
TBD	TBD				1	
TBD	TBD	Groundwater	Depths of vertical profile samples will be determined based on field observations		5 (MS/MSD)	
TBD	TBD				3	
TBD	TBD				3	
TBD	TBD				3	
TBD	TBD				3	

[a] 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 AM and the NAVFAC Northwest RPM, and are shown here for informational purposes only.

[b] Analytical method is compliant with DoD QSM 5.3 Table B-15 (DoD, 2019a) by Vista Analytical.

[c] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

MMYY = month/year

XX = depth

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SAP Worksheet #19—Analytical Standard Operating Procedure Requirement Table

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Containers	Sample Volume	Preservation Requirements	Maximum Holding Time[a] (Preparation/ Analysis)
Groundwater/ Surface Water/ Vadose Zone Porewater	PFAS	PFAS by LC-MS/MS compliant with QSM 5.3 Table B-15[b]/Preparation and Analysis for the Determination of Per and Poly-Fluorinated Compounds	2 times 250 mL HDPE bottle	2 times 250 mL	Temperature must be above freezing and less than or equal to 10°C when received at the laboratory. Samples stored in the laboratory must be held at or below 6°C until extraction but should not be frozen.	14 days to extraction/ 28 days to analysis
Soil/Sediment	PFAS	PFAS by LC-MS/MS compliant with QSM 5.3 Table B-15[b]/Preparation and Analysis for the Determination of Per and Poly-Fluorinated Compounds	One 8-ounce HDPE jar	20 grams	Temperature must be above freezing and less than or equal to 10°C when received at the laboratory. Samples stored in the laboratory must be held at or below 6°C until extraction but should not be frozen.	14 days to extraction/ 28 days to analysis
Soil	Dry Bulk Density	ASTM D2937/Dry or Native Bulk Density	1- x 2-inch diameter by 6-inch long sleeve, or equivalent	100 g	Cool to ≤6°C	N/A
Soil	Total Porosity	API RP40/Porosity; Total and Air-Filled				
Soil	Fractional Organic Carbon	Walkley Black/ Total Organic Carbon				
Soil	Grain Size	ASTM D422/Particle Size by Mechanical Sieve				

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

[b] Analytical method is compliant with DoD QSM 5.3 Table B-15 (DoD, 2019a) by Vista Analytical.

HDPE = high density polyethylene

mL = milliliter(s)

SAP Worksheet #20—Field Quality Control Sample Summary Table

Matrix	Analytical Group	Number of Sampling Locations[a]	Number of FDs[a]	Number of MS/MSDs[a]	Number of Field Blanks[a]	Number of Equipment Blanks[a]	Number of Trip Blanks[a]	Total Number of Samples to Laboratory[a]
Existing Groundwater Monitoring Wells and GETR Pumping Wells								
Groundwater	PFAS	33	4	3/3	1	8	N/A	50
Newly Installed On-Base Groundwater Monitoring Well Samples and Depth-discrete Grab Groundwater Samples								
Groundwater	PFAS	20	2	1/1	1	4	N/A	29
Soil	PFAS	12	2	1/1	1	4	N/A	21
Soil	Geotechnical parameters	10	N/A	N/A	N/A	N/A	N/A	10
Vadose Zone Porewater Samples								
VZW	PFAS	3	1	1/1	1	1	N/A	8
Soil	PFAS	3	1	1/1	1	1	N/A	8
Surface Water and Sediment[b] Samples								
Sediment[b]	PFAS	5	1	1/1	1	1	N/A	10
Surface Water	PFAS	5	1	1/1	1	1	N/A	10
Newly Installed Off-Base Groundwater Monitoring Wells and Depth-discrete Grab Groundwater Samples								
Groundwater	PFAS	23	3	2/2	1	6	N/A	37

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

[b] If hydric soils, standing water, or wetland vegetation are not present, the sample will be considered surface soil.

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SAP Worksheet #21—Project Sampling Standard Operating Procedure References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SOP CH2M-1	Logging of Soil Borings Rev. February 2022	CH2M	None	No	Guides staff members in accurately and consistently recording the field data necessary to characterize soil borings and recovered soil samples, to guide CH2M staff members in accurately and consistently recording the field data necessary to characterize soil borings and recovered soil samples.
SOP CH2M-2	Water Level Measurements Rev. February 2022	CH2M	Transducer and datalogger	No	Describes procedure for collecting continuous water level measurements. Only PFAS-free equipment will be used.
SOP CH2M-3	Multi RAE PID Rev. February 2022	CH2M	Multi RAE PID	No	Provides general reference information for using the Multi RAE PID in the field.
SOP CH2M-4	Groundwater Sampling for Per- and Polyfluoroalkyl Substances (PFAS) Rev. December 2021	CH2M	Teflon-free tubing, Teflon-free bailer (If using bailer), PFAS-free pump, sample bottles (HDPE bottle with HDPE screw cap), laboratory pre-filled HDPE bottles containing field blank water, loose leaf paper without waterproof coating, clip board, pen (not Sharpie), nitrile or latex gloves.	No	Provides guidance for groundwater sample collection for samples that will be analyzed for PFAS by Vista Analytical via LC-MS/MS compliant with DoD QSM 5.3 Table B-15 (for Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-5	Rotosonic Groundwater Sample Collection for Per- and Polyfluoroalkyl Substances Rev. March 2019	CH2M	Teflon-free tubing, Teflon-free bailer (if using bailer), PFAS-free pump, sample bottles (HDPE bottle with HDPE screw cap), laboratory pre-filled HDPE bottles containing field blank water, loose leaf paper without waterproof coating, clip board, pen (not Sharpie), nitrile or latex gloves	No	Provides guidance for groundwater sample collection for samples that will be analyzed for PFAS by Vista Analytical via LC-MS/MS in compliant with DoD QSM 5.3 Table B-15 for Navy CLEAN projects under Contract N62470-16-D-9000.

SAP Worksheet #21—Project Sampling Standard Operating Procedure References Table (continued)

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SOP CH2M-6	Soil Sampling for Per- and Polyfluoroalkyl Substances Rev. December 2021	CH2M	Sample jars (HDPE bottle with HDPE screw cap), laboratory pre-filled HDPE bottles containing field blank water, loose leaf paper without waterproof coating, clip board, pen (not Sharpie), nitrile or latex gloves.	No	Provides guidance for soil sample collection for samples that will be analyzed for PFAS by Vista Analytical via LC-MS/MS compliant with DoD QSM 5.3 Table B-15 for Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-7	Soil Sampling Rev. February 2022	CH2M	Thin walled sampling tube, drilling rig or soil-coring rig.	No	Provides guidelines for collection of undisturbed soil samples (for geotechnical analysis) via Shelby Tube.
SOP CH2M-8	Surface Water Sampling for Per- and Polyfluoroalkyl Substances Rev. December 2021	CH2M	Sample jars (HDPE bottle with HDPE screw cap), laboratory pre-filled HDPE bottles containing field blank water, loose leaf paper without waterproof coating, clip board, pen (not Sharpie), nitrile or latex gloves.	No	Provides guidelines for surface water sample collection for samples that will be analyzed for PFAS by Vista Analytical via LC-MS/MS. compliant with DoD QSM 5.3 Table B-15. For Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-9	Sediment Sampling for Per- and Polyfluoroalkyl Substances Rev. December 2021	CH2M	Sample jars (HDPE bottle with HDPE screw cap), laboratory pre-filled HDPE bottles containing field blank water, loose leaf paper without waterproof coating, clip board, pen (not Sharpie), nitrile or latex gloves.	No	Provides guidance for sediment sample collection for samples that will be analyzed for PFAS by Vista Analytical via LC-MS/MS compliant with DoD QSM 5.3 Table B-15 for Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-10	Lysimeter Installation and Soil Moisture Sampling Procedures Rev. April 2022	CH2M	Single or dual chamber suction lysimeter and casing, silica flour, fine sand seal, grout, vacuum pump, sample containers.	No	Provides guidance for the installation of single or multi-completion lysimeters and collection of VZW samples for PFAS for Navy CLEAN projects.

SAP Worksheet #21—Project Sampling Standard Operating Procedure References Table (continued)

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SOP I-A-1	Planning Field Sampling Activities, Rev. February 2015	NAVFAC Northwest	None	No	Establishes SOPs for planning and scheduling field sampling activities.
SOP I-A-7	IDW Management, Rev. February 2015	NAVFAC Northwest	None	No	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. February 2015	NAVFAC Northwest	All field equipment	No	Defines organization and structure of sample collection, identification, recordkeeping, field measurements, and data collection.
SOP I-A-10	Monitoring/Sampling Location Recording, Rev. February 2015	NAVFAC Northwest	Loose leaf paper and clipboard	No	Establishes guidelines for generating information to be recorded for each physical location where sampling is conducted.
SOP I-A-11	Sample Naming, Rev. February 2015	NAVFAC Northwest	None	No	Describes the naming convention to be used for samples collected, analyzed, and reported for NAVFAC Northwest projects.
SOP I-C-01	Monitoring Well and Piezometer Installation, Rev. March 2015	NAVFAC Northwest	Piezometer, drilling equipment	No	Outline the methods by which all NAVFAC Northwest personnel and their contractors will conduct monitoring well and piezometer installation.
SOP I-C-02	Monitoring Well Development, Rev. March 2015	NAVFAC Northwest	Pumps, monitoring equipment.	No	Describes the SOP for monitoring well development to be used by all NAVFAC Northwest personnel and their contractors.

SAP Worksheet #21—Project Sampling Standard Operating Procedure References Table (continued)

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SOP I-C-05	Low-Flow Groundwater Purging and Sampling, Rev. March 2015	NAVFAC Northwest	Pumps, sampling equipment, monitoring equipment	No	Describes the conventional monitoring well sampling procedures to be used by all NAVFAC Northwest personnel and contractors.
SOP I-C-07	Aquifer Tests, Rev. March 2015	NAVFAC Northwest	Pumps, monitoring equipment, calibrated meters, storage containers	No	Establish standard methods by which NAVFAC Northwest personnel and contractors should conduct aquifer tests.
SOP I-D-05	Water Level Measurements, Rev. March 2015	NAVFAC Northwest	Interface Probe, water level indicator	No	Establish standard protocols for all NAVFAC Northwest field personnel for use in making water level measurements.
SOP I-D-7	Field Parameter Measurements, Rev. March 2015	NAVFAC Northwest	Water quality meters	No	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-G-1	Land Surveying, Rev. August 2014	NAVFAC Northwest	Surveying equipment	No	Describes the methods by which NAVFAC Northwest field personnel and their contractors will conduct land surveying.
SOP III-B	Field QC Samples (Water, Soil, Sediment, Tissue), Rev. April 2015	NAVFAC Northwest	Sampling equipment	No	Describes the number and types of field QC samples that will be collected during NAVFAC Northwest site fieldwork.

SAP Worksheet #21—Project Sampling Standard Operating Procedure References Table (continued)

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SOP III-D	Logbooks, Rev. April 2015	NAVFAC Northwest	Loose leaf paper and clipboard	No	Describes the activities and responsibilities of NAVFAC Northwest personnel and/or their contractors pertaining to the identification, use, and control of logbooks and associated field data records.
SOP III-E	Record Keeping, Sample Labeling, and Chain-of-Custody Procedures, Rev. April 2015	NAVFAC Northwest	Logbooks, sampling equipment, shipping equipment	No	Establishes standard protocols for all NAVFAC Northwest 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 used, and completing chain-of-custody/analytical request forms.
SOP III-G	Sample Handling, Storage, and Shipping, Rev. April 2015	NAVFAC Northwest	Samples	No	Sets forth the methods for use by NAVFAC Northwest field personnel and their contractors engaged in handling, storing, and transporting water, soil and/or sediment 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	Yes	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. Rinse water will be certified PFAS-free.

SAP Worksheet #21—Project Sampling Standard Operating Procedure References Table (continued)

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SOP III-J	Equipment Calibration, Operation, and Maintenance, Rev. April 2015	NAVFAC Northwest	Field meters	No	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.
N/A	Final Environmental Restoration Program Recordkeeping Manual, February 2017	NAVFAC	None	No	Provides instructions on how to submit documents for inclusion in the program's Environmental Document Management System and information about compiling, documenting, managing, and maintaining CERCLA environmental restoration administrative record files, post decision files, site files and petroleum, oil and lubricant files.

PID = photoionization detector

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

Field Equipment	Activity[a]	Frequency	Acceptance Criteria	CA	Resp. Person	SOP Reference[b]	Comments
Horiba U-52 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 I-D-7	**Appendix C**
Horiba U-52 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 I-D-7	**Appendix C**
Horiba U-52 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 I-D-7	**Appendix C**
Horiba U-52 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 I-D-7	**Appendix C**
Horiba U-52	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 I-D-7	**Appendix C**

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

Field Equipment	Activity[a]	Frequency	Acceptance Criteria	CA	Resp. Person	SOP Reference[b]	Comments
Transducers and data loggers	Calibrate	Prior to start of fieldwork	Calibrated by manufacturer	Contact manufacturer technical support for calibration errors.	FTL	SOP CH2M-2, SOP-III-J	**Appendix C**
Multi RAE PID	Calibrate using ambient air and isobutylene 100 ppm calibration gas	Daily and as needed	Isobutylene reads 100 ppm Methane reads 50 percent lower explosive level Oxygen reads 20.9 percent Hydrogen sulfide reads 25 ppm Carbon monoxide reads 50 ppm	Contact manufacturer technical support for calibration errors.	FTL	SOP CH2M-3, SOP-III-J	**Appendix C**
Transducers and data loggers	Calibrate	Prior to start of fieldwork	Calibrated by manufacturer	Contact manufacturer technical support for calibration errors.	FTL	SOP CH2M-2, SOP-III-J	**Appendix C**
Groundwater and VZW 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 CH2M-11, SOP-III-J	**Appendix C**

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

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

± = plus or minus

ppm = part(s) per million

SAP Worksheet #23—Analytical Standard Operating Procedure References Table

Laboratory SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work (Yes/No)
SOP-49	Preparation and Analysis for the Determination of Per and Poly-Fluorinated Compounds, 01/06/22, Rev. 24	Definitive	Soil/Groundwater/ Surface Water/Sediment/ Vadose Zone Porewater/ PFAS	LC-MS/MS	Vista Analytical	Yes[a]
SOP-10	Instrument Maintenance Logbooks, and Schedule, 09/21/21, Rev. 5	N/A	Soil/Groundwater/ Surface Water/Sediment/ Vadose Zone Porewater/ PFAS	N/A	Vista Analytical	No
SOP-12	Sample Receiving and Sample Control, 12/10/21, Rev. 21	N/A	Soil/Groundwater/ Surface Water/Sediment/ Vadose Zone Porewater/ PFAS	N/A	Vista Analytical	No
SOP-14	Bottle Order Preparation, 07/14/21, Rev. 8	N/A	Soil/Groundwater/ Surface Water/Sediment/ Vadose Zone Porewater/PFAS	N/A	Vista Analytical	No
SOP-Dry or Native Bulk Density	Dry or Native Bulk Density, 07/22/20	Screening	Soil/Geotech	Gravimetric	Core Laboratories	No
SOP-Porosity; Total and Air-Filled	Porosity: Total and Air-Filled, 07/22/20	Screening	Soil/Geotech	Gravimetric	Core Laboratories	No
SOP-Total Organic Carbon	Total Organic Carbon, 07/22/20	Screening	Soil/Geotech	Titration	Core Laboratories	No
SOP-Particle Size by Mechanical Sieve	Particle Size by Mechanical Sieve, 07/22/20	Screening	Soil/Geotech	N/A	Core Laboratories	No

[a] Laboratory SOPs meet DoD QSM 5.3 (DoD, 2019a, Attachment 4) requirements. This project is analyzing for the analytes include in UCMR5, which includes analytes that are not in DoD QSM 5.3. Vista Analytical is DoD ELAP certified for the listed analytes in the SAP. Select analytes are not included in QSM Tables C-44 and C-45 for LCS limits: Perfluoro-2-methyl-3-oxahexanoic acid (HFPO-DA), 4,8-dioxa-3H-perfluorononanoic acid (ADONA), 9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS), 11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS), Nonafluoro-3,6-dioxaheptanoic acid (NFDHA), Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA), Perfluoro-4-methoxybutanoic acid (PFMBA), and Perfluoro-3-methoxypropanoic acid (PFMPA).

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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)	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 (for example, 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. Samples with > 1% solids may require centrifugation prior to SPE extraction. Pre-screening of separate aliquots of aqueous samples is recommended.	N/A	Analyst/ Laboratory Project Manager	SOP-49 DoD QSM 5.3
	Solid Sample Preparation	Each sample and associated batch QC samples.	Entire sample received by the laboratory must be homogenized prior to subsampling.	N/A		
	Sample Cleanup Procedure	Each sample and associated batch QC samples. Not applicable to AFFF and AFFF mixture samples.	ENVI-Carb$^{\text{TM}}$ or equivalent must be used on each sample and batch QC sample. Cleanup should reduce bias from matrix interference.	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)	Initial demonstration of PFOA branched versus linear profile	Qualitative standard, used to identify branched isomers, analyzed whenever a new instrument is installed, as an annual check, or whenever changes are made that affect the elution order. Prior to analyzing any field samples.	Identify retention times of branched isomers of PFOA. This qualitative PFOA standard is not used for quantitation.	N/A	Analyst/ Laboratory Project Manager	SOP-49 DoD QSM 5.3
	Mass Calibration	Instrument must have a valid mass calibration prior to any sample analysis. Mass calibration is verified after each mass calibration, prior to 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 atomic mass unit of the true value, by acquiring a full scan continuum mass spectrum of a PFAS stock standard. The mass calibration is updated on an as-needed basis (e.g., QC failures, ion masses fall outside of the ±0.5 amu of the true value, major instrument maintenance is performed, or the instrument is moved).	If the mass calibration fails, recalibrate. If it fails again, consult manufacturer instructions on corrective maintenance. Problem must be corrected. No samples may be analyzed under a failing mass calibration.		

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)	Mass Spectral Acquisition Rate	Each analyte, EIS analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	N/A	Analyst/ Laboratory Project Manager	SOP-49 DoD QSM 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 include 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 (that is, accounting for peaks that are identified as linear and branched isomers) and relying on the ICAL that uses the linear isomer quantitative standard. Standards containing both branched and linear isomers are to be used during method validation and when reestablishing retention times, to ensure the total response is quantitated for that analyte. Technical grade standards cannot be used for quantitative analysis.			

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)	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 to 150%. Signal-to-noise ratio 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). PFAS identified with ion ratios that fail acceptance criteria must be flagged. Any quantitation ion peak that does not meet the maximization criteria shall be included in the summed integration and the resulting data flagged as "estimated, biased high." For example: Ion ratio = (quant ion abundance/confirm ion abundance) Calculate the average ratio (A) and standard deviation (SD) using the ICAL standards. An acceptance range of ratio could a within A ±3SD for confirmation of detection.	N/A	Analyst/ Laboratory Project Manager	SOP-49 DoD QSM 5.3

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)	Ion Transitions (Precursor-> 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 (for example, alternate transition was used due to observed interferences).	N/A	Analyst/ Laboratory Project Manager	SOP-49 DoD QSM 5.3

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)	ICAL	At instrument set-up and after ICV or CCV failure, prior to sample analysis.	The isotopically labeled analog of an analyte (EIS 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 EIS 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 to 130% of their true value for each calibration standard. ICAL must meet one of the two options below: Option 1: The relative standard deviation of the response factors for all analytes must be ≤ 20%. Option 2: Linear or nonlinear calibrations must have r 2 ≥ 0.99 for each analyte. No samples shall be analyzed until ICAL has passed. External Calibration is not allowed for any analyte. Calibration can be linear (minimum of 5 standards) or quadratic (minimum of 6 standards); weighting is allowed.	Correct problem, then repeat ICAL.	Analyst/ Laboratory Project Manager	SOP-49 DoD QSM 5.3

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)	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. Calculated for each analyte and EIS.	N/A	Analyst/ Laboratory Project Manager	SOP-49 DoD QSM 5.3
	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 minute of the associated EIS. This criterion applies only to analyte and labeled analog pairs. Calculated for each analyte and EIS.	Correct problem and reanalyze samples.		
	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. No samples shall be analyzed until ISC has met acceptance criteria. ISC can serve as the initial daily CCV.	Correct problem, rerun ISC. If problem persists, repeat ICAL.		
	ICV	Once after each ICAL, analysis of a second source standard prior to sample analysis.	Analyte concentrations must be within ±30% of their true value. No samples shall be analyzed until calibration has been verified.	Correct problem, rerun ICV. If problem persists, repeat ICAL.		

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)	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. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. Results may not be reported without valid CCVs. Instrument sensitivity check (ISC) can serve as a bracketing CCV.	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 CAs 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.	Analyst/ Laboratory Project Manager	SOP-49 DoD QSM 5.3

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)	Instrument Blanks	Immediately following the highest standard analyzed and daily prior to sample analysis.	Concentration of each analyte must be ≤ 1/2 the LOQ. Instrument Blank must contain EIS to enable quantitation of contamination. Flagging is only appropriate in cases when the sample cannot be reanalyzed and when there is no more sample left. No samples shall be analyzed until instrument blank has met acceptance criteria. Note: Successful analysis following the highest standard analyzed determines the highest concentration that carryover does not occur. When the highest standard analyzed is not part of the calibration curve, it cannot be used to extend out the calibration range, it is used only to document a higher concentration at which carryover still does not occur.	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 are 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	SOP-49 DoD QSM 5.3

Notes:

The specifications in this table meet the requirements of DoD QSM 5.3 (DoD, 2019a).

≥ = more than or equal to

CCV = continuing calibration verification

EIS = extracted internal standard

ICAL = initial calibration

ICV = initial calibration verification

ISC = instrument sensitivity check

NEtFOSAA = n-ethylperfluoro-1-octancesulfonamidoacetic acid

NMeFOSAA = n-methylperfluoro-1-octanesulfonamidoacetic acid

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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
UPLC	Change column	PFAS	ICAL and CCV	As needed	Acceptable calibration and verification results	Perform additional maintenance; recalibrate instrument	Analyst/ supervisor	SOP-10
TQS-Micro & API-4000Q Trap	Source cleaning	PFAS	ICAL and CCV	As needed	Acceptable calibration and verification results	Perform additional maintenance; recalibrate	Analyst/ supervisor	SOP-10
TQS-Micro	Sample/gas cone cleaning	PFAS	Sample/gas cone cleaning	As needed	N/A	Replace with clean sample/gas cone	Analyst/ supervisor	SOP-10
Aquity UPLC	Needle replacement	PFAS	Visual inspection contamination	As needed	Leak test in software	Repeat if leak test fails	Analyst/ supervisor	SOP-10
TQS-Micro & API-4000Q Trap	Source heater	PFAS	Source not at 150°C	As needed	Source maintains correct temperature	Replace with new heater if sources do not heat	Analyst/ supervisor	SOP-10

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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 C**.
Sample Packaging (Personnel/Organization): Project field team, FTL/CH2M. Field SOPs are in **Appendix C**.
Coordination of Shipment (Personnel/Organization): FTL/CH2M.
Type of Shipment/Carrier: Federal Express (FedEx) Priority Overnight PFAS samples will be shipped directly to Vista Analytical Laboratory. Geotechnical samples will be shipped directly to Core Laboratories.
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Receiving/Vista Analytical Laboratory, Core Laboratories
Sample Custody and Storage (Personnel/Organization): Sample Receiving/Vista Analytical Laboratory, Core Laboratories
Sample Preparation (Personnel/Organization): Sample Preparation Staff/Vista Analytical Laboratory, Core Laboratories
Sample Determinative Analysis (Personnel/Organization): Analyst/Vista Analytical Laboratory, Core Laboratories
SAMPLE ARCHIVING
Field Sample Storage (Number of days from sample collection): 60 days from receipt
Sample Extract/Digestate Storage (Number of days from extraction/digestion): 28 days after extraction/digestion
Biological Sample Storage (Number of days from sample collection): N/A
SAMPLE DISPOSAL
Personnel/Organization: Sample Disposal/Vista Analytical Laboratory, Core Laboratories
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):

Field Sample collection procedures will follow the PFAS SOPs in **Worksheet #21** and used PFAS-free materials while sampling. 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 for USEPA 537.1 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.

Refer to **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 Vista Analytical for PFAS samples and to CORE Laboratories for geotechnical samples.

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

Laboratory sample custody procedures include the receipt of samples, archiving, and disposal. Custody of samples will be maintained, and custody transfer will be documented from the time of sample receipt through sample disposal by the analytical laboratory consistent with the analytical laboratory's SOPs.

The analytical laboratories will have established custody procedures, which include the following:

- Designation of a sample custodian
- Completion by the custodian of the chain-of-custody record, any sample tags, and laboratory request sheets, including documentation of sample condition upon receipt
- Laboratory sample tracking and documentation procedures
- Secure sample storage with the appropriate environment (for example, refrigerated, dry), consistent with analytical method requirements
- Proper data logging and documentation procedures, including custody of original laboratory records

Upon arrival of the samples at the analytical laboratory, a sample custodian will take custody of the samples, assess the integrity of sample containers, and verify that the information on the sample labels matches the information on the associated chain-of-custody record. The laboratory will restrict access to the storage areas to authorized laboratory personnel only, to prevent unauthorized contact with samples, extracts, or documentation. The sample custodian will maintain security of the samples in accordance with the analytical laboratory SOP.

Soil and water samples will be retained for 30 days after final sample results are reported, unless a request to archive a sample has been made, or previous arrangements have been made to archive the sample. The sample custodian will dispose of samples consistent with the analytical laboratory SOP.

Sample 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—Laboratory Quality Control Sample Table

Matrix: Soil/Groundwater/Surface Water/ Vadose Zone Porewater/Sediment
Analytical Group: PFAS
Analytical Method/SOP Reference: PFAS by LC-MS/MS Compliant with DoD QSM 5.3 Table B-15/SOP-49

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	MPC
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 SPE, added to final dilution of samples prior to analysis. EIS 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.	Correct problem. If required, re-extract and reanalyze associated field and QC samples. If recoveries are acceptable for QC samples, but not field samples, the field samples must be reextracted and analyzed (greater dilution may be needed). Samples may be reextracted and analyzed outside of hold times, as necessary for corrective action associated with QC failure. Apply Q-flag and discuss in the Case Narrative only if reanalysis confirms failures in exactly the same manner. Failing analytes shall be thoroughly documented in the Case Narrative. EIS should be 96% (or greater) purity. When the impurity consists of the unlabeled analyte, the EIS can result in a background artifact in every sample, standard and blank, if the EIS is fortified at excessive concentrations.	Analyst/ Supervisor	Precision/ Accuracy/ Bias	SOP-49DoD QSM 5.3

SAP Worksheet #28—Laboratory Quality Control Sample Table (continued)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	MPC
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. Results may not be reported without a valid MB. Flagging is only appropriate in cases where the samples cannot be reanalyzed.	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. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Analyst/ Supervisor	Bias/ Contamination	SOP-49 DoD QSM 5.3

SAP Worksheet #28—Laboratory Quality Control Sample Table (continued)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	MPC
LCS	One per preparatory batch.	Blank spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. DoD QSM 5.3 limits; (**Worksheet #15**) If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	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. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.	Analyst/ Supervisor	Precision/ Accuracy/ Bias	SOP-49 DoD QSM 5.3
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. DoD QSM 5.3 limits; (Refer to **Worksheet #15** for control limits) If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	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. For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference (i.e., matrix effect or analytical error).	Analyst/ Supervisor	Precision/ Accuracy/ Bias	SOP-49 DoD QSM 5.3

SAP Worksheet #28—Laboratory Quality Control Sample Table (continued)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	MPC
MSD or 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. DoD QSM 5.3 limits; (Refer to **Worksheet #15** for control limits) If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified. 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. The data shall be evaluated to determine the source of difference. For Sample/MD: RPD criteria only apply to analytes whose concentration in the sample is ≥ LOQ. The MD is a second aliquot of the field sample that has been prepared by serial dilution.	Analyst/ Supervisor	Precision/ Accuracy/ Bias	SOP-49 DoD QSM 5.3
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 post spike for that analyte must recover within 70 to 130% of its true value. When analyte concentrations are calculated as < LOQ, results may not be reported without acceptable post spike recoveries.	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 are met.	Analyst/ Supervisor	Bias/ Contamination	SOP-49 DoD QSM 5.3

SAP Worksheet #28—Laboratory Quality Control Sample Table (continued)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	MPC
LOD verification	Quarterly for every analyte	Spike a quality system matrix at concentration two to four times the DL. Must meet 3 to 1 signal-to-noise ratio, or for data systems that do not measure noise, results must be at least three standard deviations greater than the mean MB 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.	Analyst/ Supervisor	Accuracy	SOP-49 DoD QSM 5.3
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.	Analyst/ Supervisor	Precision/ Bias	SOP-49 DoD QSM 5.3

MB = method blank

MD = matrix duplicate

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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 (such as 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 (such as 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
Groundwater	PFAS	**Worksheet #18**	LC-MS/MS compliant with DoD QSM 5.3, Table B-15[a]	28 Days/72 hour[b]	Vista Analytical Laboratory 1104 Windfield Way El Dorado Hills, California 95762 POC – Karen Volpendesta (916) 673-1520	TBD
Soil				28 days		
Surface water				28 days		
Sediment				28 days		
Vadose Zone Porewater				28 days		
Soil	Dry Bulk Density		ASTM D2937	28 days	Core Laboratories 3437 Landco Drive Bakersfield, California 93308 Brett Elliott (661) 325-5657	TBD
Soil	Total Porosity		API RP40			
Soil	Fractional Organic Carbon		Walkley Black			
Soil	Grain Size		ASTM D422			

[a] Analytical method is compliant with DoD QSM 5.3 Table B-15 (DoD, 2019a).

[b] Select groundwater profiling samples will be sent to the laboratory for an expedited TAT for decision making purposes.

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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	AM CH2M	FTL CH2M	AM CH2M	AM CH2M
Field Document Review	Daily during sampling event	Internal	CH2M	AM or TM CH2M	FTL CH2M	AM CH2M	AM 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
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	Within 2 months of audit	Memorandum	TBD by Perry Johnson Laboratory Accreditation, Inc.	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:

____
____
____
____
____

Cause of problem, if known or suspected:

____
____
____
____
____

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

____
____
____
____
____

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 Number: ______________________________ 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 #33—Quality Assurance 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	AM CH2M	Included in project files
QA Management Report/Technical Memorandum	Once results have been assessed for data usability	To be submitted with Final RI report	AM CH2M	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 not included in the laboratory SOP and therefore not included in the DoD ELAP accreditation letter are not permitted for this project work. Any laboratory method deviation not covered under the current DoD ELAP accreditation letter will be resubmitted to the accrediting body for review and approval prior to sample collection, and resubmitted to the Navy QAO for review.	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 percent check, an additional 25 percent 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 Data Validator during the DV process. This is verification that they were generated and applicable to the data packages.	Data Validator/EDS	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

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]
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.	AM/CH2M PC/CH2M	Step I	Internal
CA reports	CA reports will be reviewed by the PC or AM and placed into the project file for archival at project closeout.	AM/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 PM 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 DV narrative and will be included in the associated project report.	Laboratory QAO	Step I	Internal

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]
Sample chronology	Holding times from collection to extraction or analysis and from extraction to analysis will be considered during the DV process.	Data Validator/EDS	Step IIa and IIb	External
Raw data	Ten percent Stage 4 review of raw data to confirm laboratory calculations. For a recalculated result, the Data Validator 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. If errors are found during the 10 percent check, an additional 20 percent of the raw data will be checked to confirm calculations. Any discrepancies will be addressed in the DV narrative.	Data Validator/EDS	Step IIa	External
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 DV narrative.	Data Validator/EDS	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 are for screening purposes only and will be reviewed by the PC and project team.	PC/CH2M	Step I	Internal

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]
Analytical data for PFAS analyzed for soil, groundwater, surface water, sediment, and vadose zone porewater[d]	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. 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, 2017), may also be applicable.	Data Validator/EDS	Step IIa and IIb	External
Analytical data for dry bulk density, total porosity, fractional organic carbon, and grain size	Dry bulk density, total porosity, fractional organic carbon, and grain size analytical data will not undergo third-party validation but are subject to all other data review protocols detailed above.	N/A	Step IIa and IIb	Internal

[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 MPC 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 CA needed. This memo will be sent to the laboratory, or applicable party, and maintained in the project file.

[d] Stage 4 DV will be performed on 10 percent of all definitive analyses that will include recalculated results from the raw data to verify calculations. The remaining (90 percent) of the definitive data will have Stage 2B DV 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 LOQs, LODs, and DLs in **Worksheet #15** were achieved. If LOQs, LODs, and DLs 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 X by the data validator as recommended for rejection, and is not considered usable for project decisions. The DV narrative will be reviewed by the project team along with the data quality objectives, and the X qualifier may be replaced with an R qualifier as rejected data.
    - 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 hard copy 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 data quality indicator.
- 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 Quality Indicators

  Quantifiable criteria, known as measurement performance criteria, are presented in Worksheet #12. The PARCCS criteria will be the qualitative and quantitative indicators of data quality. The PARCCS criteria are defined and discussed as follows.

- Precision

  Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision will be measured by using laboratory duplicates and MS/MSD samples. It will be expressed in terms of the RPD as follows:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

  where:

  RPD = relative percent difference
  C1 = concentration of sample or MS
  C2 = concentration of duplicate or MSD

- Accuracy

  Accuracy is the degree of agreement of an observed measurement (or an average of the same measurement type) with an accepted reference or true value. Accuracy of analytical determinations will be measured using laboratory QC analyses such as LCSs and surrogate spikes. Accuracy will be measured by evaluating the actual result against the known concentration added to a spiked sample and will be expressed as %R as shown below:

$$\%R = \frac{S - U}{C_{sa}} \times 100$$

  where:

  %R = Percent Recovery
  S = Measured concentration of spiked aliquot
  U = Measured concentration of unspiked aliquot
  C_{sa} = Concentration of spike added

- Representativeness

  Representativeness is the reliability with which a measurement or measurement system reflects the true conditions under investigation. Representativeness is influenced by the number and location of the sampling points, sampling timing and frequency of monitoring efforts, and the field and laboratory procedures. The representativeness of data will be maintained using established field and laboratory procedures and their consistent application.

SAP Worksheet #37—Usability Assessment (continued)

- Comparability

  Comparability expresses the confidence with which one data set can be compared to another based on using USEPA-defined procedures, where available. If USEPA procedures are not available, the procedures have been defined or referenced in this SAP.

  The comparability of data will be established through well documented methods and procedures, standard reference materials, QC samples, performance-evaluation study results, and by reporting each data type in consistent units.

- Completeness

  Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions. Analytical data validation and DQA will determine which data will be valid and which data will be rejected. Percent completeness will be defined as follows:

$$Percent\ Completeness = \frac{V}{T} \times 100$$

  where:

  V = Number of valid (not rejected) measurements over a given time
  T = Total number of planned measurements

- The completeness goal for this project will be 90% for valid, usable data. If the completeness goal of the project is not achieved, a discussion on the limitations on the use of the project data will be included in the Usability Assessment section of the final report.

- Sensitivity

  Sensitivity is the measure of a concentration at which an analytical method can positively identify and report analytical results. The sensitivity of an analytical method will be indicated by the project-required reporting limits, as compared to the PSLs.

- Detection and Quantitation Limits

  The DL is the minimum concentration of an analyte that can be demonstrated to be different from zero or a blank concentration with 99% confidence from background noise for a specific analytical method (that is, 1% chance of false positive). The LOD is the minimum concentration of an analyte that can be demonstrated to be present with 99% confidence from background noise (that is, 1% chance of false negative). The LOQ represents the lowest concentration of an analyte that can be quantified within specified limits of precision and accuracy during routine laboratory operating conditions in a sample matrix. The LOQs are contractually specified minimum quantitation limits for specific analytical methods and sample matrices, such as soil or water, and will typically be several times the DL to allow for sample matrices.

  Selected analytical methods and associated LOQs are typically capable of quantifying contaminants of concern at concentrations below the most stringent screening criteria. The LOQs will reflect the maximum sensitivity of current, routinely used analytical methods.

SAP Worksheet #37—Usability Assessment (continued)

For this project, concentrations will be reported as estimated values ("J" qualified) if the concentrations are less than the LOQs but greater than the DLs or LODs. Concentrations below the DL will be reported as "U" to the LOD. The DLs listed in Worksheet #15 are using the best technologies available that are DoD ELAP-certified. If there is a nondetect for an analyte with a DL greater than the PSL, it will be discussed in the uncertainty analysis.

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

The usability assessment process will consist of reviewing the analytical data validation reports for usable analytical data (that is, no validation qualifications or estimated "J"/"UJ" qualifications) and rejected ("R" qualified) analytical data, as well as evaluating the field and analytical data for discrepancies or deviations. This assessment will evaluate the impact of the discrepancies or deviations on the usability of the data and assesses whether the necessary information has been provided for use in the decision-making process. The assessment will evaluate whether there were deviations in sampling activities (for example, incorrect sample location, improper or malfunctioning sampling equipment, or incorrect analysis performed), chain-of-custody documentation, or holding times; compromised samples (that is, damaged or lost samples) and the need to resample; or changes to SOPs or methods that could potentially affect data quality.

An evaluation of QC sample results will be performed to assess whether unacceptable QC results (for example, blank contamination) affect data usability.

Other parameters to be evaluated during the usability assessment may include, but will not be limited to, the following:

- Matrix effects—matrix conditions that might have affected the performance of the extraction or analytical method
- Site conditions—unusual weather conditions or site conditions that might have affected the sampling plan
- Identifying critical and non-critical samples or target analytes
- Background or historical data
- Data restrictions—data that do not meet the project DQOs or were "X" qualified might be restricted, but usable, as qualitative values for limited decision-making purposes

The data will be evaluated for overall PARCCS criteria for each matrix, analytical group, and concentration level, and data use limitations will be discussed in the DQA report for data that do not meet the project DQOs or DQIs.

Identify the personnel responsible for performing the usability assessment.

The CH2M team, including the AM 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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LEGEND

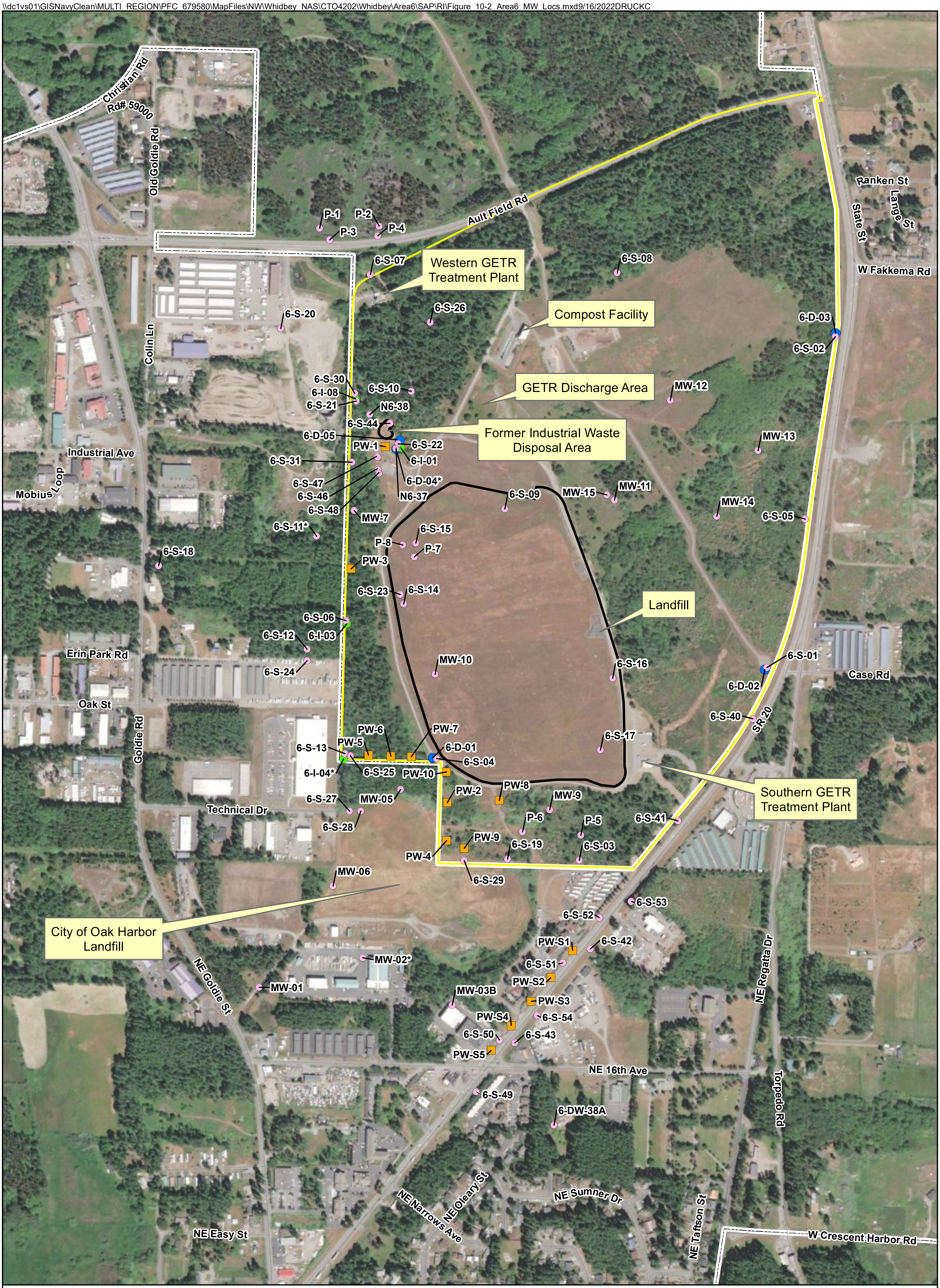
- ● City
- State Highway
- Local Connecting Road
- Important Local Road
- Site Boundary
- Base Boundary

1 inch = 1.25 miles

IMAGERY SOURCE:
ESRI ArcGIS Online Web Service,
World Imagery, Maxar, 2021

Figure 10-1
Base Location Map
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation
Area 6
Naval Air Station Whidbey Island
Oak Harbor, WA

\\dc1vs01\GISNavyClean\MULTI REGION\PFC 679580\MapFiles\NW\Whidbey NAS\CTO4202\Whidbey\Area6\SAP\RI\Figure 10-2 Area6 MW Locs.mxd9/16/2022DRUCKC



LEGEND

- ● Shallow Aquifer Well
- ● Intermediate Aquifer Well
- ● Deep Aquifer Well
- ■ GETR Well
- ▭ Area 6 Boundary
- ▭ Base Boundary

NOTES:
GETR - groundwater extraction, treatment, and recharge
* Asterisk in well name indicates that well has been abandoned

IMAGERY SOURCE:
ESRI ArcGIS Online Web Service,
World Imagery, Maxar, 2021

N

0 300 600 Feet

1 inch = 600 feet

Figure 10-2
Area 6 Existing Monitoring Well Location Map
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation
Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington

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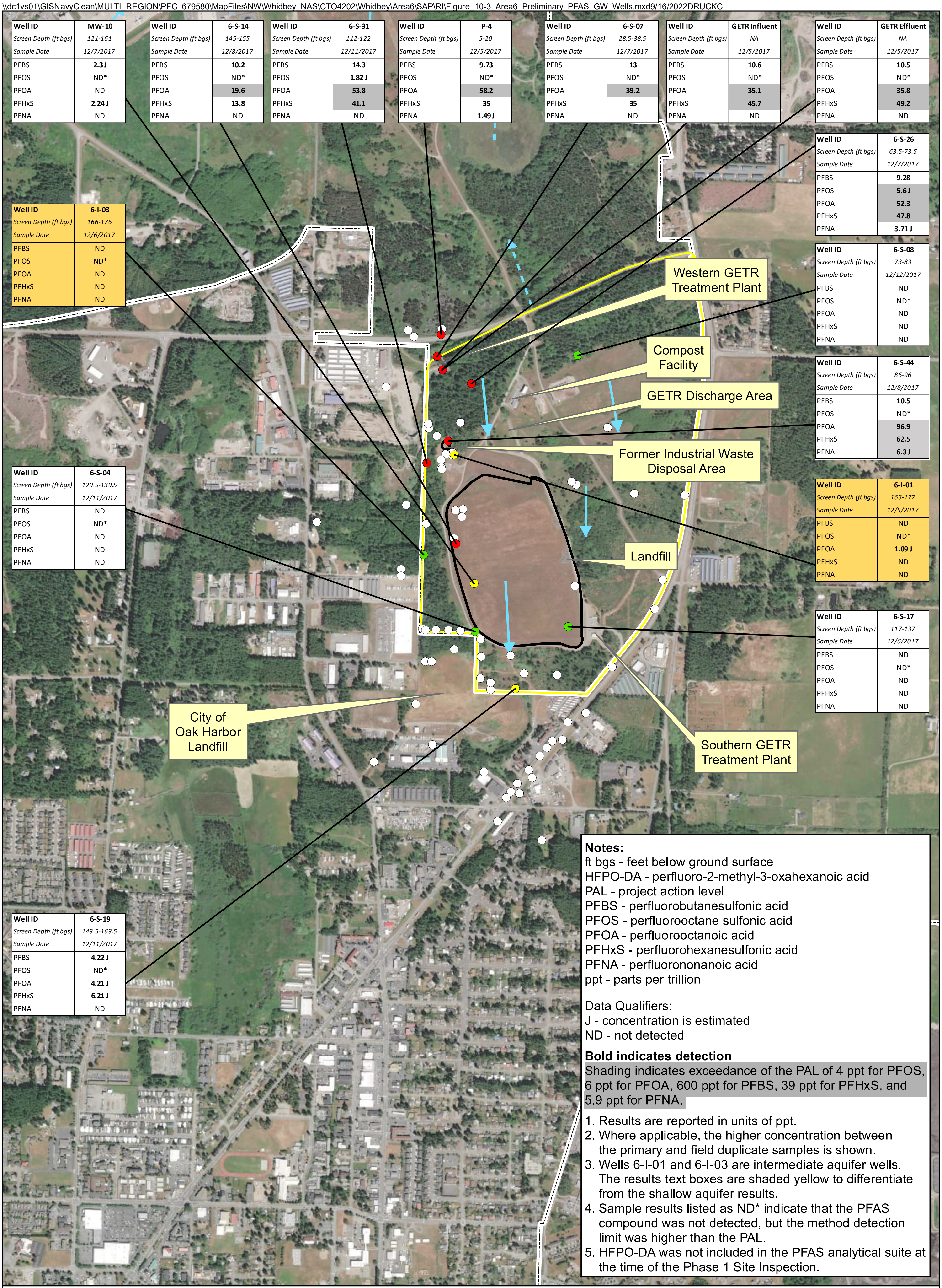

Well ID	MW-10
Screen Depth (ft bgs)	*121-161*
Sample Date	*12/7/2017*
PFBS	**2.3 J**
PFOS	ND*
PFOA	ND
PFHxS	**2.24 J**
PFNA	ND

Well ID	6-S-14
Screen Depth (ft bgs)	*145-155*
Sample Date	*12/8/2017*
PFBS	**10.2**
PFOS	ND*
PFOA	**19.6**
PFHxS	**13.8**
PFNA	ND

Well ID	6-S-31
Screen Depth (ft bgs)	*112-122*
Sample Date	*12/11/2017*
PFBS	**14.3**
PFOS	**1.82 J**
PFOA	**53.8**
PFHxS	**41.1**
PFNA	ND

Well ID	P-4
Screen Depth (ft bgs)	*5-20*
Sample Date	*12/5/2017*
PFBS	**9.73**
PFOS	ND*
PFOA	**58.2**
PFHxS	**35**
PFNA	**1.49 J**

Well ID	6-S-07
Screen Depth (ft bgs)	*28.5-38.5*
Sample Date	*12/7/2017*
PFBS	**13**
PFOS	ND*
PFOA	**39.2**
PFHxS	**35**
PFNA	ND

Well ID	GETR Influent
Screen Depth (ft bgs)	*NA*
Sample Date	*12/5/2017*
PFBS	**10.6**
PFOS	ND*
PFOA	**35.1**
PFHxS	**45.7**
PFNA	ND

Well ID	GETR Effluent
Screen Depth (ft bgs)	*NA*
Sample Date	*12/5/2017*
PFBS	**10.5**
PFOS	ND*
PFOA	**35.8**
PFHxS	**49.2**
PFNA	ND

Well ID	6-I-03
Screen Depth (ft bgs)	*166-176*
Sample Date	*12/6/2017*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-S-26
Screen Depth (ft bgs)	*63.5-73.5*
Sample Date	*12/7/2017*
PFBS	**9.28**
PFOS	**5.6 J**
PFOA	**52.3**
PFHxS	**47.8**
PFNA	**3.71 J**

Well ID	6-S-08
Screen Depth (ft bgs)	*73-83*
Sample Date	*12/12/2017*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-S-44
Screen Depth (ft bgs)	*86-96*
Sample Date	*12/8/2017*
PFBS	**10.5**
PFOS	ND*
PFOA	**96.9**
PFHxS	**62.5**
PFNA	**6.3 J**

Well ID	6-S-04
Screen Depth (ft bgs)	*129.5-139.5*
Sample Date	*12/11/2017*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-I-01
Screen Depth (ft bgs)	*163-177*
Sample Date	*12/5/2017*
PFBS	ND
PFOS	ND*
PFOA	**1.09 J**
PFHxS	ND
PFNA	ND

Well ID	6-S-17
Screen Depth (ft bgs)	*117-137*
Sample Date	*12/6/2017*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-S-19
Screen Depth (ft bgs)	*143.5-163.5*
Sample Date	*12/11/2017*
PFBS	**4.22 J**
PFOS	ND*
PFOA	**4.21 J**
PFHxS	**6.21 J**
PFNA	ND

Notes:
ft bgs - feet below ground surface
HFPO-DA - perfluoro-2-methyl-3-oxahexanoic acid
PAL - project action level
PFBS - perfluorobutanesulfonic acid
PFOS - perfluorooctane sulfonic acid
PFOA - perfluorooctanoic acid
PFHxS - perfluorohexanesulfonic acid
PFNA - perfluorononanoic acid
ppt - parts per trillion

Data Qualifiers:
J - concentration is estimated
ND - not detected

Bold indicates detection

Shading indicates exceedance of the PAL of 4 ppt for PFOS, 6 ppt for PFOA, 600 ppt for PFBS, 39 ppt for PFHxS, and 5.9 ppt for PFNA.

1. Results are reported in units of ppt.
2. Where applicable, the higher concentration between the primary and field duplicate samples is shown.
3. Wells 6-I-01 and 6-I-03 are intermediate aquifer wells. The results text boxes are shaded yellow to differentiate from the shallow aquifer results.
4. Sample results listed as ND* indicate that the PFAS compound was not detected, but the method detection limit was higher than the PAL.
5. HFPO-DA was not included in the PFAS analytical suite at the time of the Phase 1 Site Inspection.

LEGEND

- 🔴 Location with Project Action Level exceedance
- 🟡 Location with no exceedance of Project Action Level
- 🟢 No detections of PFOS, PFOA, PFBS, PFHxS, or PFNA
- ○ Location Not Sampled During Phase 1 Site Inspection
- ➜ Approximate Flow Direction in the Shallow Aquifer (Dashed where uncertain)
- 🟨 Area 6 Boundary
- ⬚ Base Boundary

IMAGERY SOURCE:
ESRI ArcGIS Online Web Service,
World Imagery, Maxar, 2021

N

0 0.1 0.2
Miles

1 inch = 0.2 miles

Figure 10-3
Summary of PFAS Results from Groundwater Monitoring Wells
Phase 1 Site Inspection
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation
Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington

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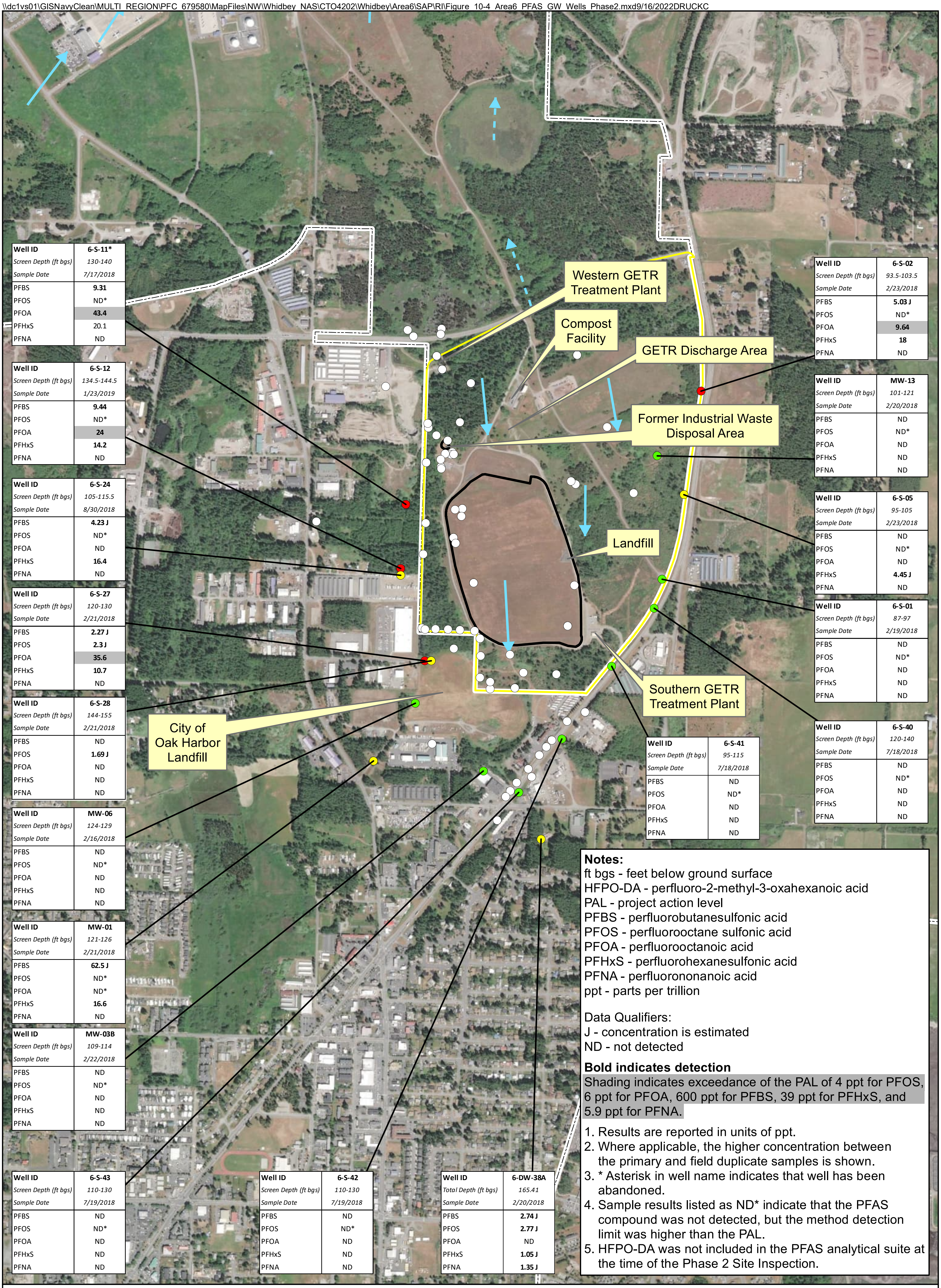


Well ID	6-S-11*
Screen Depth (ft bgs)	*130-140*
Sample Date	*7/17/2018*
PFBS	**9.31**
PFOS	ND*
PFOA	**43.4**
PFHxS	20.1
PFNA	ND

Well ID	6-S-12
Screen Depth (ft bgs)	*134.5-144.5*
Sample Date	*1/23/2019*
PFBS	**9.44**
PFOS	ND*
PFOA	**24**
PFHxS	**14.2**
PFNA	ND

Well ID	6-S-24
Screen Depth (ft bgs)	*105-115.5*
Sample Date	*8/30/2018*
PFBS	**4.23 J**
PFOS	ND*
PFOA	ND
PFHxS	**16.4**
PFNA	ND

Well ID	6-S-27
Screen Depth (ft bgs)	*120-130*
Sample Date	*2/21/2018*
PFBS	**2.27 J**
PFOS	**2.3 J**
PFOA	**35.6**
PFHxS	**10.7**
PFNA	ND

Well ID	6-S-28
Screen Depth (ft bgs)	*144-155*
Sample Date	*2/21/2018*
PFBS	ND
PFOS	**1.69 J**
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	MW-06
Screen Depth (ft bgs)	*124-129*
Sample Date	*2/16/2018*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	MW-01
Screen Depth (ft bgs)	*121-126*
Sample Date	*2/21/2018*
PFBS	**62.5 J**
PFOS	ND*
PFOA	ND*
PFHxS	**16.6**
PFNA	ND

Well ID	MW-03B
Screen Depth (ft bgs)	*109-114*
Sample Date	*2/22/2018*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-S-43
Screen Depth (ft bgs)	*110-130*
Sample Date	*7/19/2018*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-S-42
Screen Depth (ft bgs)	*110-130*
Sample Date	*7/19/2018*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-DW-38A
Total Depth (ft bgs)	*165.41*
Sample Date	*2/20/2018*
PFBS	**2.74 J**
PFOS	**2.77 J**
PFOA	ND
PFHxS	**1.05 J**
PFNA	**1.35 J**

Well ID	6-S-41
Screen Depth (ft bgs)	*95-115*
Sample Date	*7/18/2018*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-S-02
Screen Depth (ft bgs)	*93.5-103.5*
Sample Date	*2/23/2018*
PFBS	**5.03 J**
PFOS	ND*
PFOA	**9.64**
PFHxS	**18**
PFNA	ND

Well ID	MW-13
Screen Depth (ft bgs)	*101-121*
Sample Date	*2/20/2018*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-S-05
Screen Depth (ft bgs)	*95-105*
Sample Date	*2/23/2018*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	**4.45 J**
PFNA	ND

Well ID	6-S-01
Screen Depth (ft bgs)	*87-97*
Sample Date	*2/19/2018*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Well ID	6-S-40
Screen Depth (ft bgs)	*120-140*
Sample Date	*7/18/2018*
PFBS	ND
PFOS	ND*
PFOA	ND
PFHxS	ND
PFNA	ND

Notes:

ft bgs - feet below ground surface
HFPO-DA - perfluoro-2-methyl-3-oxahexanoic acid
PAL - project action level
PFBS - perfluorobutanesulfonic acid
PFOS - perfluorooctane sulfonic acid
PFOA - perfluorooctanoic acid
PFHxS - perfluorohexanesulfonic acid
PFNA - perfluorononanoic acid
ppt - parts per trillion

Data Qualifiers:
J - concentration is estimated
ND - not detected

Bold indicates detection

Shading indicates exceedance of the PAL of 4 ppt for PFOS, 6 ppt for PFOA, 600 ppt for PFBS, 39 ppt for PFHxS, and 5.9 ppt for PFNA.

1. Results are reported in units of ppt.
2. Where applicable, the higher concentration between the primary and field duplicate samples is shown.
3. * Asterisk in well name indicates that well has been abandoned.
4. Sample results listed as ND* indicate that the PFAS compound was not detected, but the method detection limit was higher than the PAL.
5. HFPO-DA was not included in the PFAS analytical suite at the time of the Phase 2 Site Inspection.

LEGEND

- 🔴 Location with Project Action Level exceedance
- 🟡 Location with no exceedance of Project Action Level
- 🟢 No detections of PFOS, PFOA, PFBS, PFHxS, or PFNA
- ○ Location Not Sampled During Phase 2 Site Inspection
- ➡ Approximate Flow Direction in the Shallow Aquifer (Dashed where uncertain)
- ▭ Area 6 Boundary
- ⬚ Base Boundary

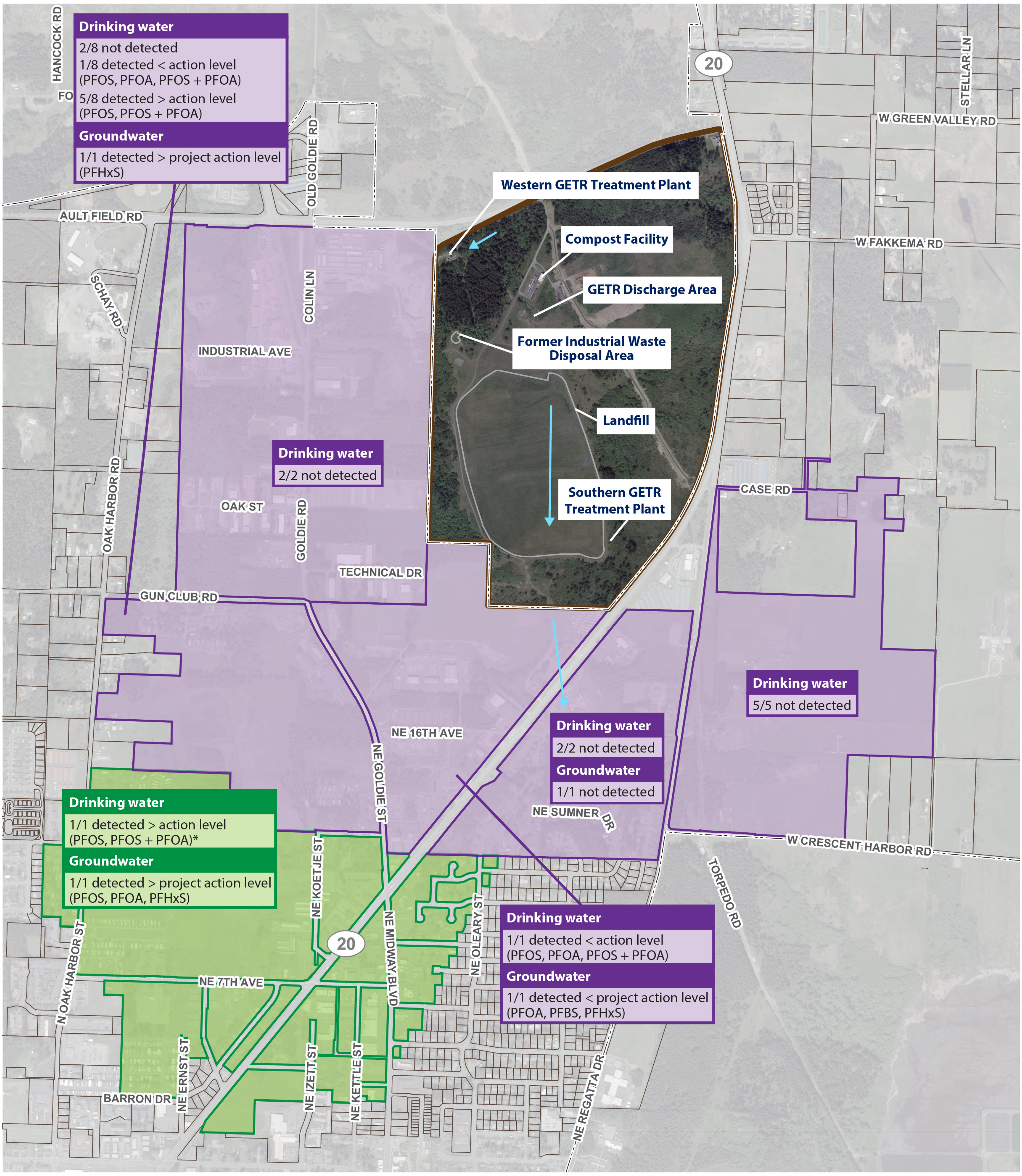
IMAGERY SOURCE:
ESRI ArcGIS Online Web Service,
World Imagery, Maxar, 2021

N

0 0.1 0.2
Miles

1 inch = 0.2 miles

Figure 10-4
Summary of PFAS Results from Groundwater Monitoring Wells
Phase 2 Site Inspection
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation
Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington



LEGEND

- ⬚ Base boundary
- ▭ Area 6 boundary
- 🟪 Phase 1 Sampling Area
- 🟩 Phase 2 Sampling Area
- → Groundwater flow direction

North

0 0.25 0.5

Approximate scale in miles

Notes:

HFPO-DA = perfluoro-2-methyl-3-oxahexanoic acid
PFAS = per- and polyfluoroalkyl substances
PFBS = perfluorobutanesulfonic acid
PFHxS = perfluorohexanesulfonic acid
PFNA = perfluorononanoic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonic acid
ppt = parts per trillion

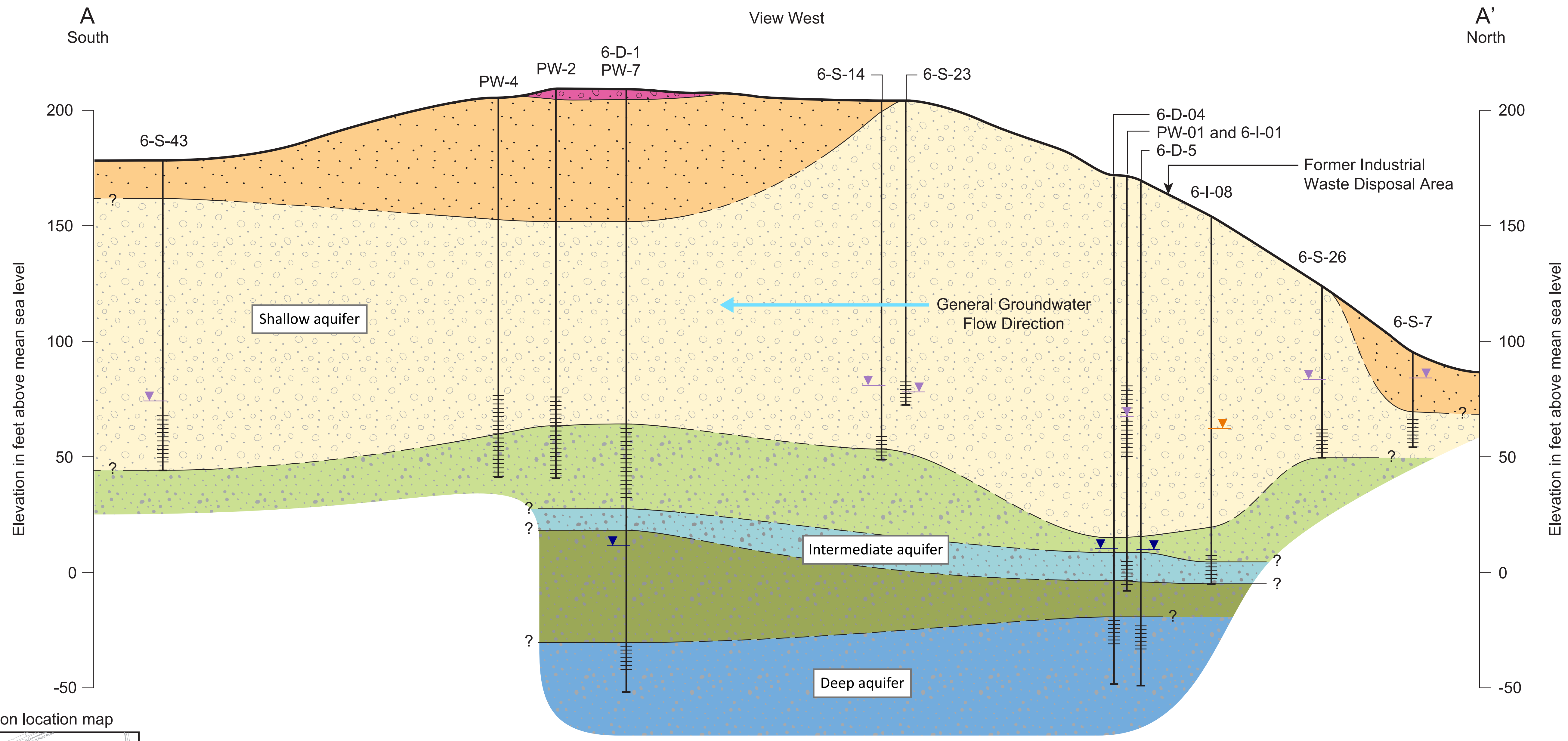
* This drinking water exceedance was identified through the routine drinking water sampling program.

1. The action level for drinking water wells for PFOS, PFOA, or PFOS + PFOA is the 2016 United States Environmental Protection Agency lifetime drinking water health advisory level of 70 ppt.

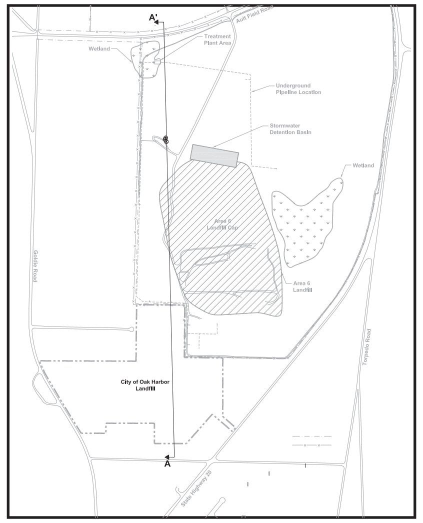
2. The project action levels for groundwater are: 4 ppt for PFOS, 6 ppt for PFOA, 600 ppt for PFBS, 39 ppt for PFHxS, and 5.9 ppt for PFNA. The specific PFAS with an exceedance or detection are shown.

3. HFPO-DA was not included in the PFAS analytical suite at the time of the Phase 1 and 2 Off-Base Investigations.

Figure 10-5.
Summary of Phase 1 and 2 Off-Base Drinking and Groundwater Well PFAS Results
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation, Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington



Cross-section location map



LEGEND

- 🟥 Vashon recessional outwash
- 🟧 Vashon till
- 🟨 Vashon advance outwash
- 🟩 Whidbey #1
- 🟦 Whidbey #2
- 🟩 Whidbey #3
- 🟦 Whidbey #4
- ▼ Shallow aquifer groundwater level during drilling
- ▼ Intermediate aquifer groundwater level during drilling
- ▼ Deep aquifer groundwater level during drilling
- ╪ Screen interval of well

North

0 500 1,000

Approximate horizontal scale in feet
Vertical exaggeration = 10x

Note: Figure modified from: URS-AECOM, 2018.

Figure 10-6.
Area 6 Lithologic Cross-section
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation, Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington

LEGEND

80	Groundwater contour	●	Monitoring well
-·-·-	NAS Whidbey Island boundary	○	Piezometer
MW-6	Monitoring well identification	□	Production well
76.91	Groundwater elevation in feet NAVD88	▣	Production well not operating
→	Groundwater flow direction		

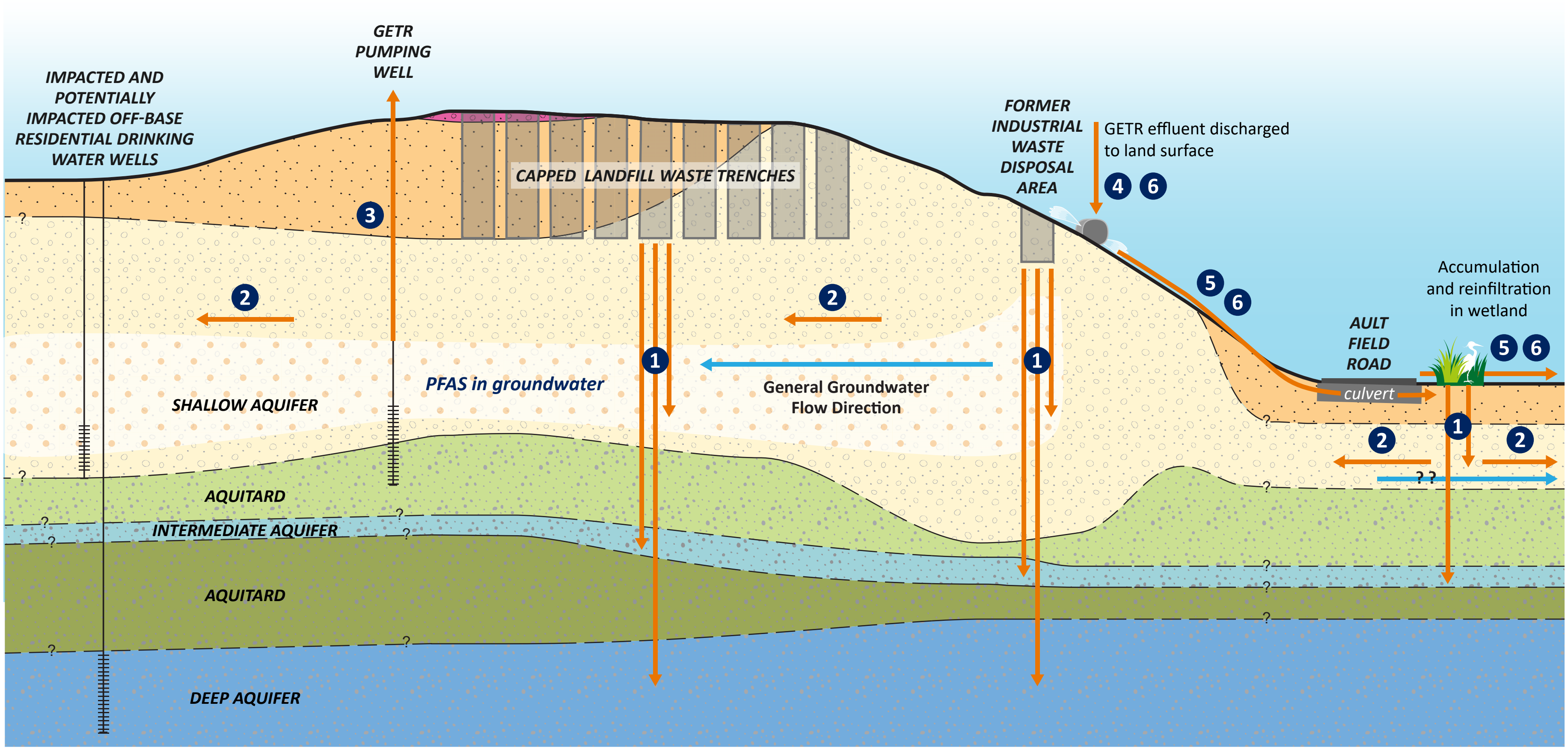
Notes:
FEET NAVD88 = feet above the North American Vertical Datum of 1988

1. Water levels were measured on January 27, 2020.
2. Pumping levels of production wells were not contoured.
3. Figure modified from Sealaska, 2020

North

0 250 500
Approximate scale in feet

Figure 10-7.
Shallow Aquifer Groundwater Elevations
January 2020
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation, Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington



To be evaluated during the RI:

① Leaching of PFAS from subsurface soil to groundwater

② Transport via advection in groundwater

③ Capture of groundwater containing PFAS by GETR pumping wells

④ Direct release of PFAS to surface water via treated GETR effluent discharge to land surface

⑤ Transport of PFAS via surface water

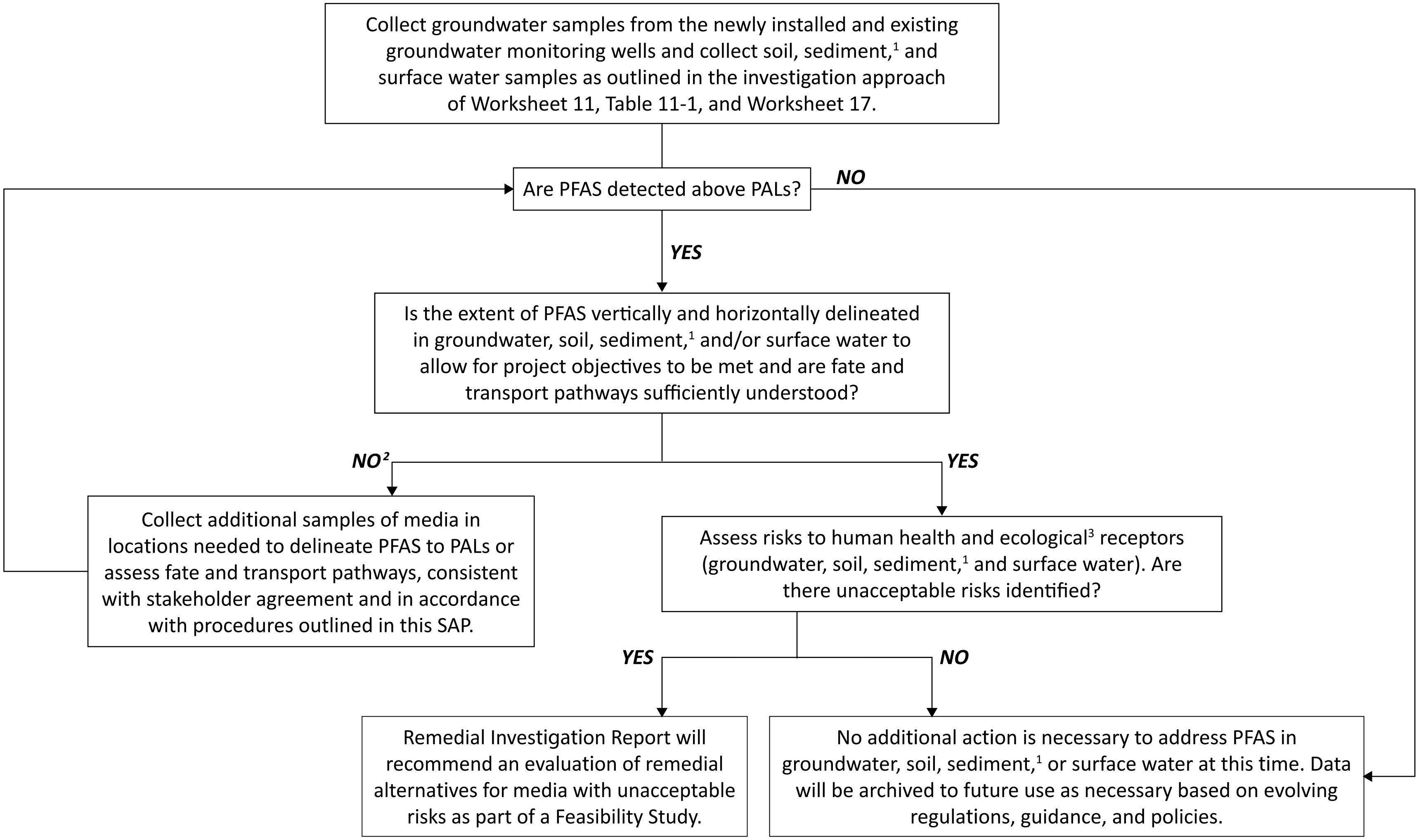
⑥ Partitioning from surface water to sediment

Notes:

1. Figure shows migration pathways only (not exposure pathways).
2. Impacts to drinking water wells are evaluated through the routine drinking water sampling program.

GETR = groundwater extraction, treatment, and recharge

Figure 10-8.
Conceptual Site Model
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation, Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington



Collect groundwater samples from the newly installed and existing groundwater monitoring wells and collect soil, sediment,[1] and surface water samples as outlined in the investigation approach of Worksheet 11, Table 11-1, and Worksheet 17.

Are PFAS detected above PALs?

Is the extent of PFAS vertically and horizontally delineated in groundwater, soil, sediment,[1] and/or surface water to allow for project objectives to be met and are fate and transport pathways sufficiently understood?

Collect additional samples of media in locations needed to delineate PFAS to PALs or assess fate and transport pathways, consistent with stakeholder agreement and in accordance with procedures outlined in this SAP.

Assess risks to human health and ecological[3] receptors (groundwater, soil, sediment,[1] and surface water). Are there unacceptable risks identified?

Remedial Investigation Report will recommend an evaluation of remedial alternatives for media with unacceptable risks as part of a Feasibility Study.

No additional action is necessary to address PFAS in groundwater, soil, sediment,[1] or surface water at this time. Data will be archived to future use as necessary based on evolving regulations, guidance, and policies.

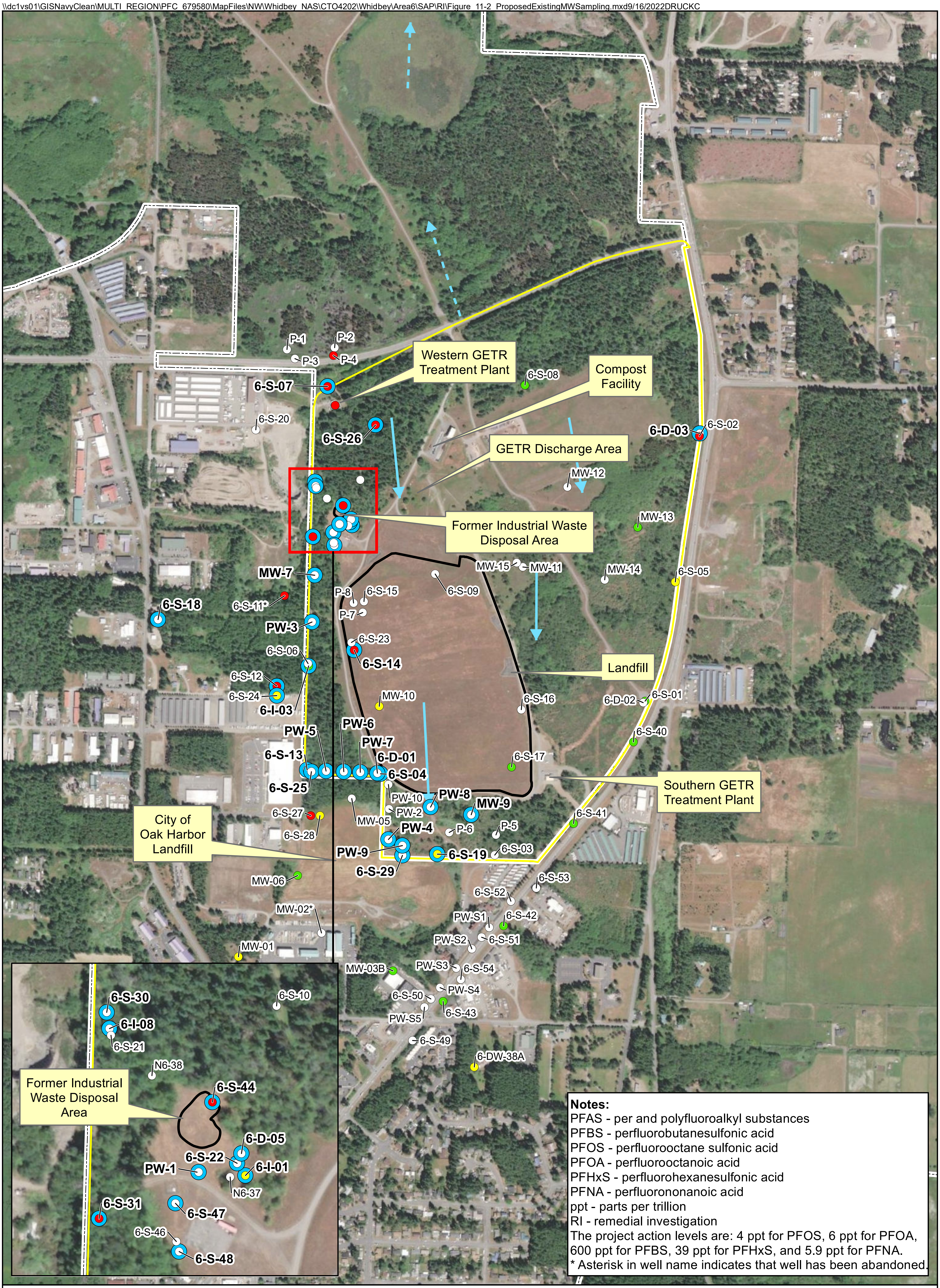
Figure 11-1.
Decision Logic for Project Quality Objectives
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation, Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington

1 If no hydric soils, standing water, or wetland vegetation are present, the sample will be considered surface soil.

2 Any additional field work stages needed to accomplish the objectives of the RI will be included in a SAP Addendum or Field Change Request.

3 If it is determined that the GETR wetland north of Ault Field Road is hydraulically connected to groundwater and that groundwater in the wetland area flows to the north, then this groundwater transport pathway to downgradient freshwater streams will be considered in a revised CSM and subsequent risk evaluations. PFAS will be evaluated within the applicable DoD, Navy, and/or EPA policy, guidance, or directives using the state-of-the-science toxicological information available and current at the time the RI is prepared for both the Human Health and Ecological Risk Assessments. Prior to conducting an ecological risk screening, the ecological screening values that will be used for comparison to site media will be reviewed based on current science and relevancy to site-specific receptors (e.g., relevant ecological receptors present). Ecological screening values selected for the screening will be presented in a technical memo or other documented form for regulatory review and acceptance.

\\dc1vs01\GISNavyClean\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4202\Whidbey\Area6\SAP\RI\Figure_11-2_ProposedExistingMWSampling.mxd9/16/2022DRUCKC



Notes:
PFAS - per and polyfluoroalkyl substances
PFBS - perfluorobutanesulfonic acid
PFOS - perfluorooctane sulfonic acid
PFOA - perfluorooctanoic acid
PFHxS - perfluorohexanesulfonic acid
PFNA - perfluorononanoic acid
ppt - parts per trillion
RI - remedial investigation
The project action levels are: 4 ppt for PFOS, 6 ppt for PFOA, 600 ppt for PFBS, 39 ppt for PFHxS, and 5.9 ppt for PFNA.
* Asterisk in well name indicates that well has been abandoned.

LEGEND

- ● Proposed RI PFAS Sample Location

Results for Previous Existing Well Samples

- ○ Location Not Sampled
- ● Location with Project Action Level exceedance
- ● Location with no exceedance of Project Action Level
- ● No detections of PFOS, PFOA, PFBS, PFHxS, or PFNA
- → Approximate Flow Direction in the Shallow Aquifer (Dashed where uncertain)
- ▭ Area 6 Boundary
- ▭ Base Boundary

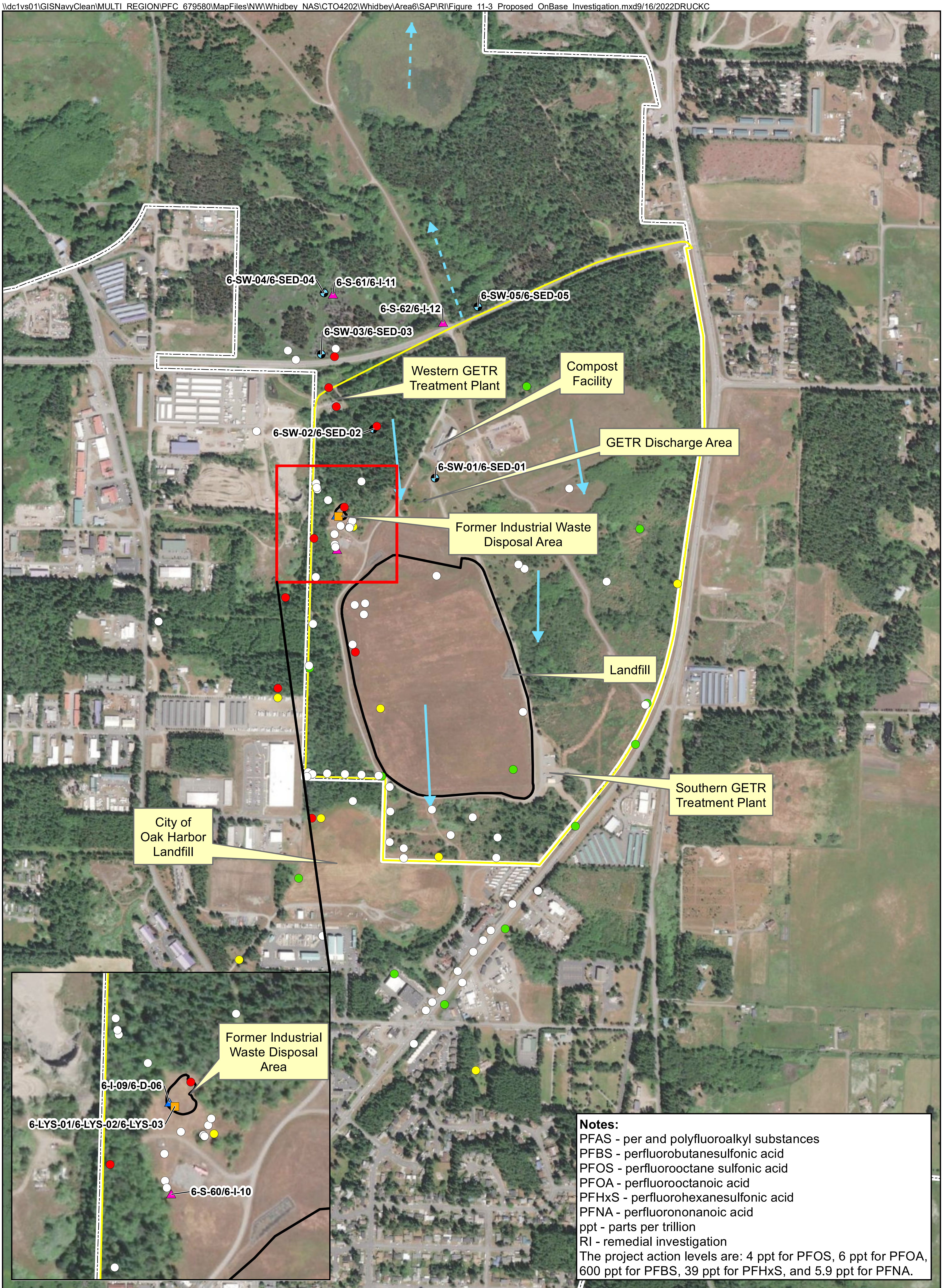
IMAGERY SOURCE:
ESRI ArcGIS Online Web Service,
World Imagery, Maxar, 2021

N

0 375 750
Feet

1 inch = 750 feet

Figure 11-2
Stage 1 Proposed Existing Monitoring Well Sample Locations
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation
Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington



Notes:
PFAS - per and polyfluoroalkyl substances
PFBS - perfluorobutanesulfonic acid
PFOS - perfluorooctane sulfonic acid
PFOA - perfluorooctanoic acid
PFHxS - perfluorohexanesulfonic acid
PFNA - perfluorononanoic acid
ppt - parts per trillion
RI - remedial investigation
The project action levels are: 4 ppt for PFOS, 6 ppt for PFOA, 600 ppt for PFBS, 39 ppt for PFHxS, and 5.9 ppt for PFNA.

LEGEND

Results for Previous Existing Well Samples
- ○ Location Not Sampled
- ● Location with Project Action Level exceedance
- ● Location with no exceedance of Project Action Level
- ● No detection of PFOS, PFOA, PFBS, PFHxS, or PFNA

Stage 1 Proposed Sample Locations
- ● Proposed Sediment/Surface Soil and Surface Water Sample Location
- ▲ Proposed Intermediate and Deep Aquifer Well Pair
- ▲ Proposed Shallow and Intermediate Aquifer Well Pair
- ■ Proposed Triple Completion Lysimeter
- → Approximate Flow Direction in the Shallow Aquifer (Dashed where uncertain)

- ☐ Area 6 Boundary
- ☐ Base Boundary

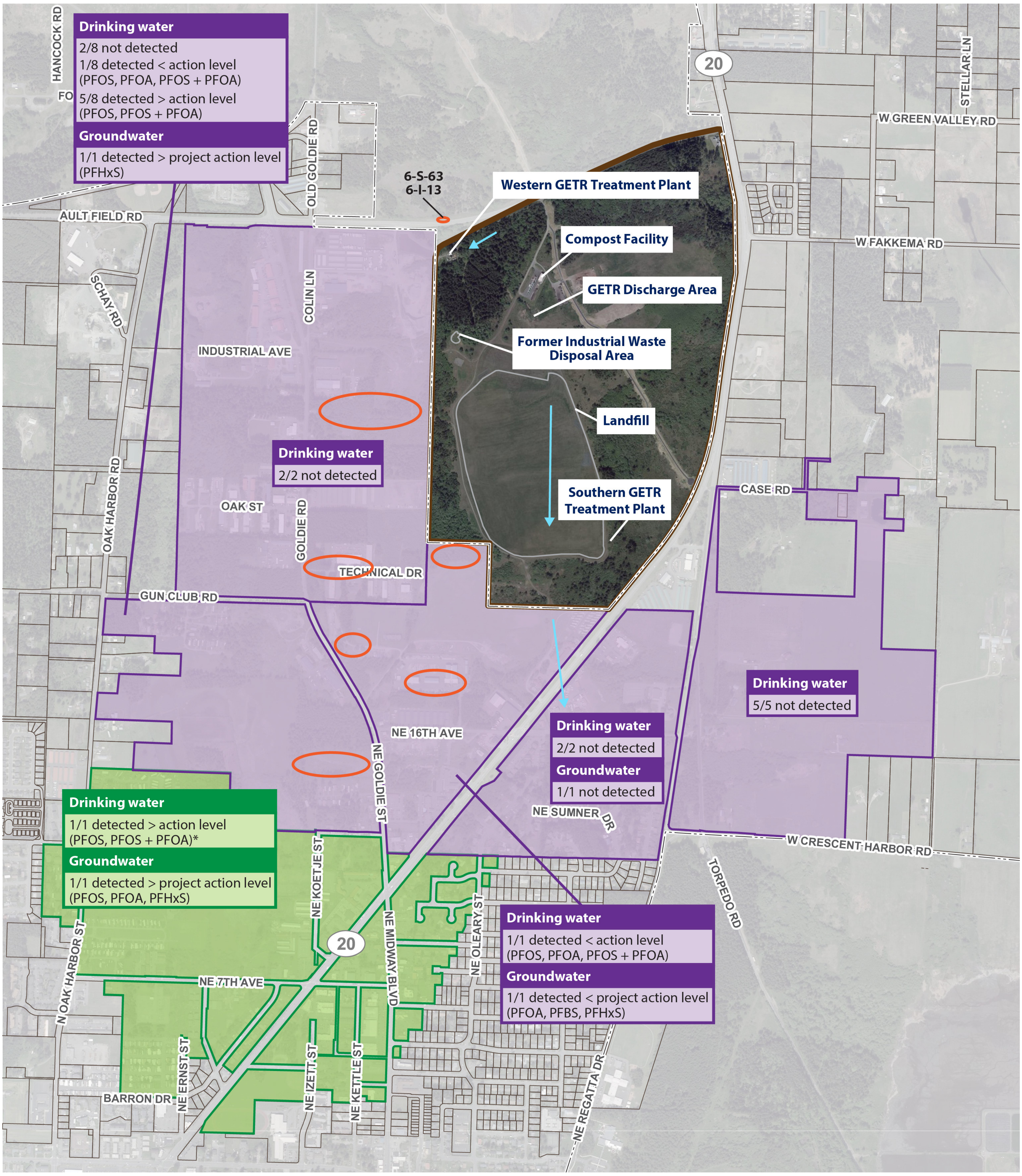
IMAGERY SOURCE:
ESRI ArcGIS Online Web Service,
World Imagery, Maxar, 2021

N

0 375 750 Feet

1 inch = 750 feet

Figure 11-3
Stage 1 Proposed Drilling and Sample Locations
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation
Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington



LEGEND

- ⬚ Base boundary
- ▬ Area 6 boundary
- 🟪 Phase 1 Sampling Area
- 🟩 Phase 2 Sampling Area
- → Groundwater flow direction
- ○ Target off-base monitoring well area

North

0 0.25 0.5
Approximate scale in miles

Notes:

PFAS = per- and polyfluoroalkyl substances
PFBS = perfluorobutanesulfonic acid
PFHxS = perfluorohexanesulfonic acid
PFNA = perfluorononanoic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonic acid
ppt = parts per trillion

* This drinking water exceedance was identified through the routine drinking water sampling program.

1. The action level for drinking water wells for PFOS, PFOA, or PFOS + PFOA is the 2016 United States Environmental Protection Agency lifetime drinking water health advisory level of 70 ppt.

2. The project action levels for groundwater are: 4 ppt for PFOS, 6 ppt for PFOA, 600 ppt for PFBS, 39 ppt for PFHxS, and 5.9 ppt for PFNA. The specific PFAS with an exceedance or detection are shown.

3. HFPO-DA was not included in the PFAS analytical suite at the time of the Phase 1 and 2 Off-Base Investigations.

Figure 11-4.
Stage 2 Proposed Off-Base Well Areas
Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances
Remedial Investigation, Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington

Appendix A-1
Naval Air Station Whidbey Island Area 6 Remedial Investigation Scoping – November 17, 2021 (Stakeholders)

Challenging today.
Reinventing tomorrow.

Naval Air Station Whidbey Island

Area 6 RI Scoping

November 17, 2021

Agenda

- Health and Safety Moment
- Site Background
- Previous Investigations
- Previous Remedial Actions
- Summary of PFAS Site Inspection
- Remedial Investigation Objectives
- Investigation Strategy
- Schedule

Fort Casey Historical State Park

Health and Safety Moment – Mountain Lion Safety

- On the trail:
  - Travel in groups, wear bright and highly contrasting clothing
  - Ask park/trail personnel about recent sightings
  - Avoid low-light times of day (dusk-dawn)
  - Make noise (bells)
  - Keep children and pets close, stay vigilant
- At home:
  - Keep pets indoors, supervise outdoors dusk – dawn
  - Take steps to keep prey out of yard (deer resistant landscaping, secure refuse bins, do not store pet food outside)
  - Let neighbors know about sightings
- If encountered:
  - Seem as large as possible and make noise, waive your arms, waive sticks/branches, throw stones – discourage animals hunting instinct
  - Never turn your back, crouch, or run
  - Slowly create distance – give animal a path of retreat

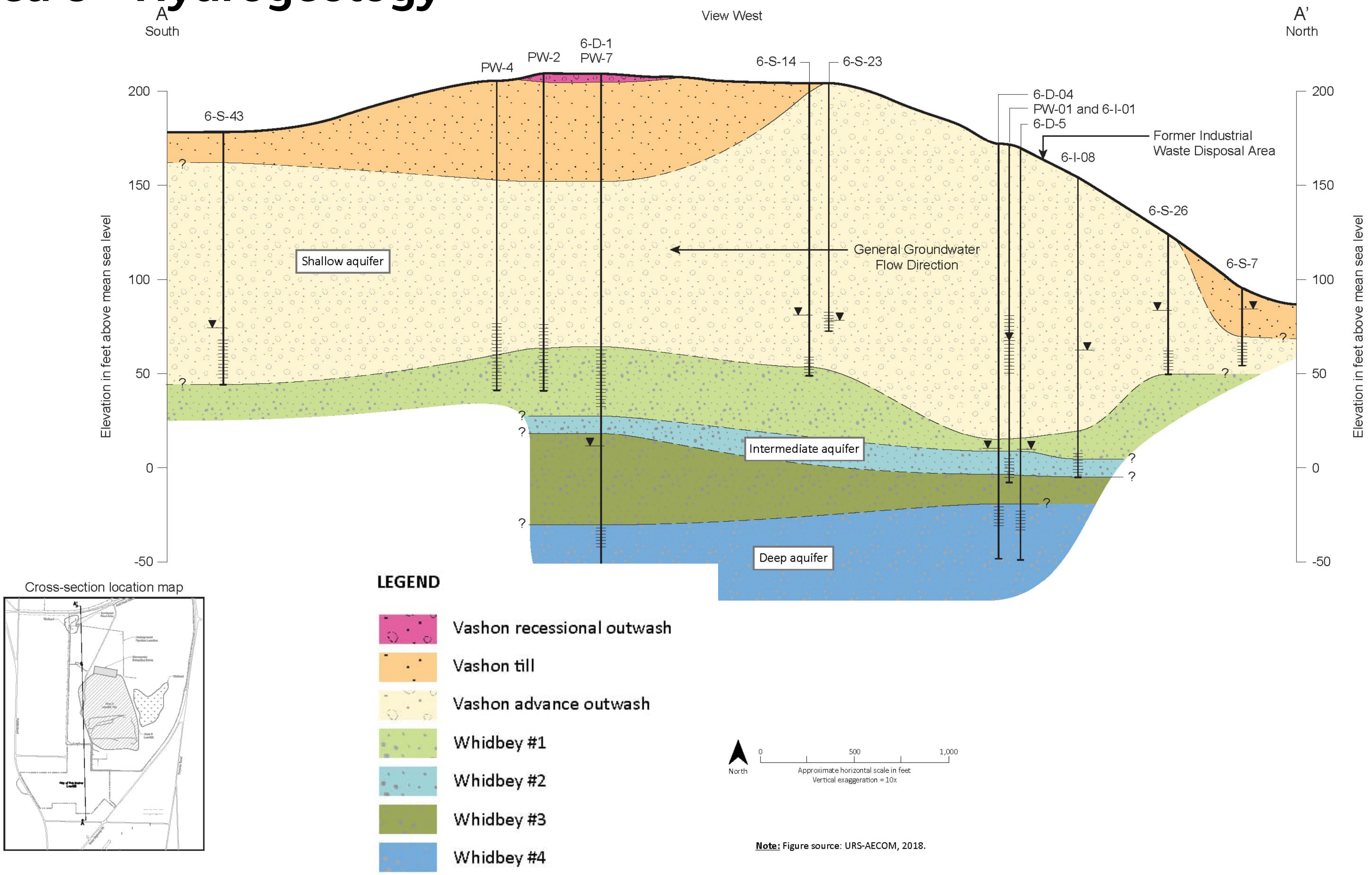
https://mountainlion.org/

Area 6 Background, Investigation, and Remediation History

Area 6 - Description

- Southeastern corner of Ault Field, 260-acres
- Residential areas to east/southeast, including Auld Holland Inn
- City of Oak Harbor landfill to south
- Various residential and commercial developments to west

Area 6 - Hydrogeology



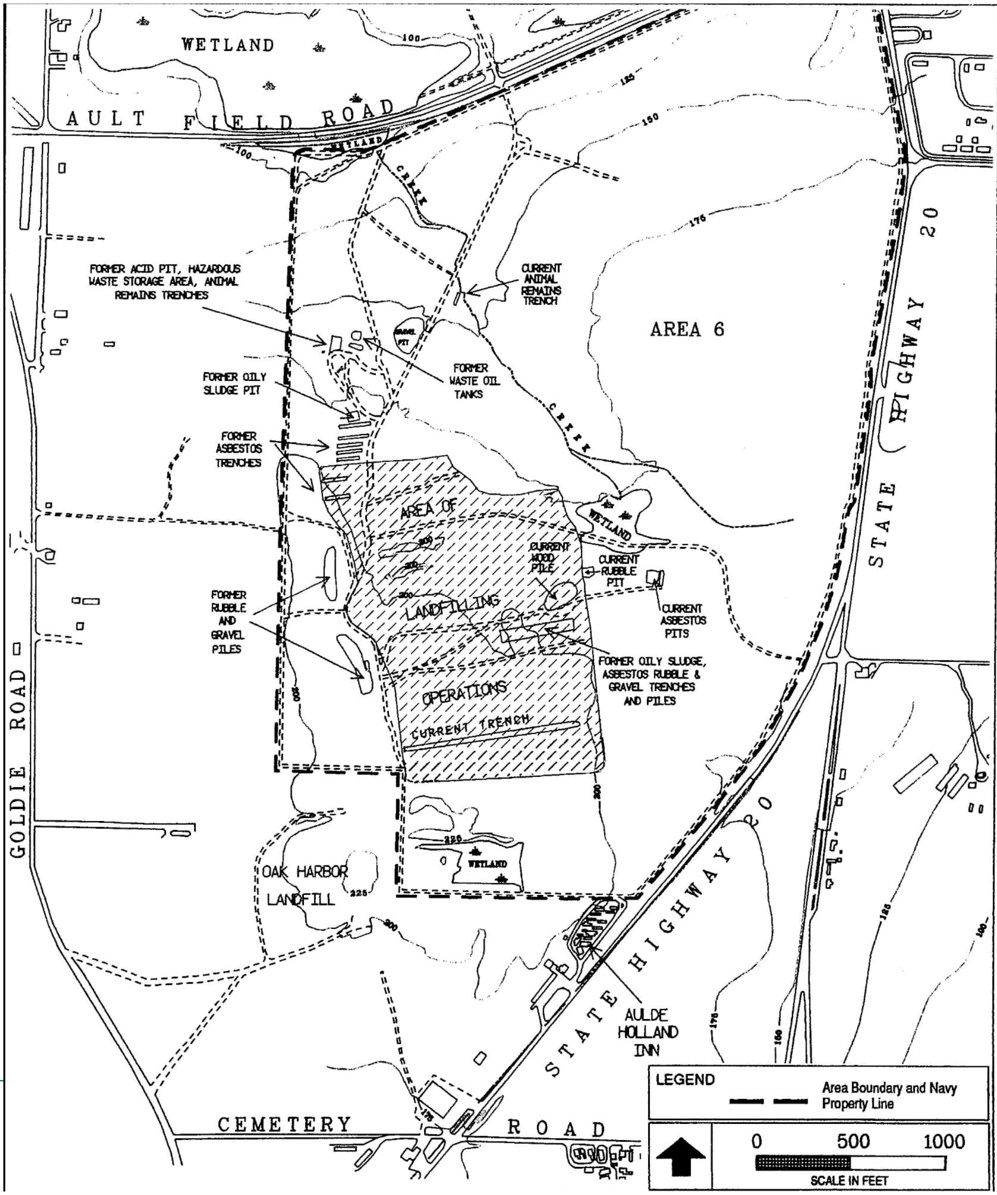
Note: Figure source: URS-AECOM, 2018.

Area 6 – Groundwater Flow Direction

- GW flow in the shallow aquifer is generally to the south with some components of flow to the southeast and southwest
  - GW divide to the north, location uncertain
- Limited distribution of intermediate and deep aquifer monitoring wells
- RI data from early 1990’s suggest:
  - GW flow in intermediate aquifer interpreted as predominantly to the southeast
  - GW flow in deep aquifer ranges from southeast to southwest
- Downward vertical hydraulic gradients between aquifer units
  - Vertical head difference of 5 to 20 feet between shallow and intermediate and 50 feet between the shallow and deep aquifer

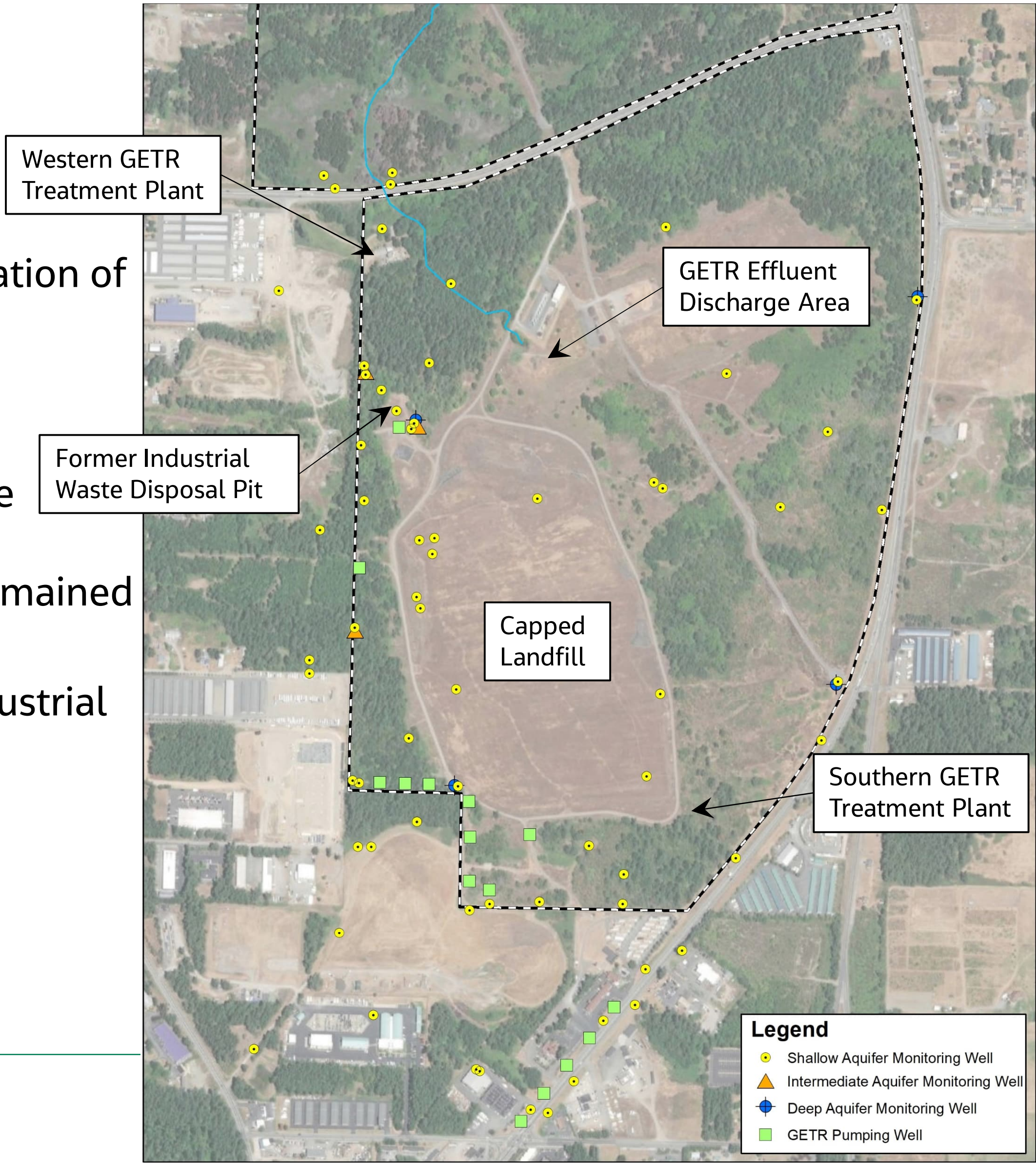
Area 6 –History

- Main landfill - 1969 to 1992
  - Most of the landfill received and contains Navy household municipal waste
  - Includes Navy sanitary & industrial wastes, construction debris, yard debris, non-hazardous soil and sediment from Ault Field, airfield dredge sediments
  - Consisted of 23 cut-and-fill trenches
- Former industrial waste disposal area
  - Acid pit and oily sludge pit
  - 300,000 to 700,000 gallons of acids, caustics, and solvents 1970's to 1980's
  - 100,000 to 600,000 gallons of liquid sludge between 1969 and mid-1970's
  - Approximately 15 x 40 feet
  - During operation, it was a pit (10-ft deep), also called the former waste oil pit



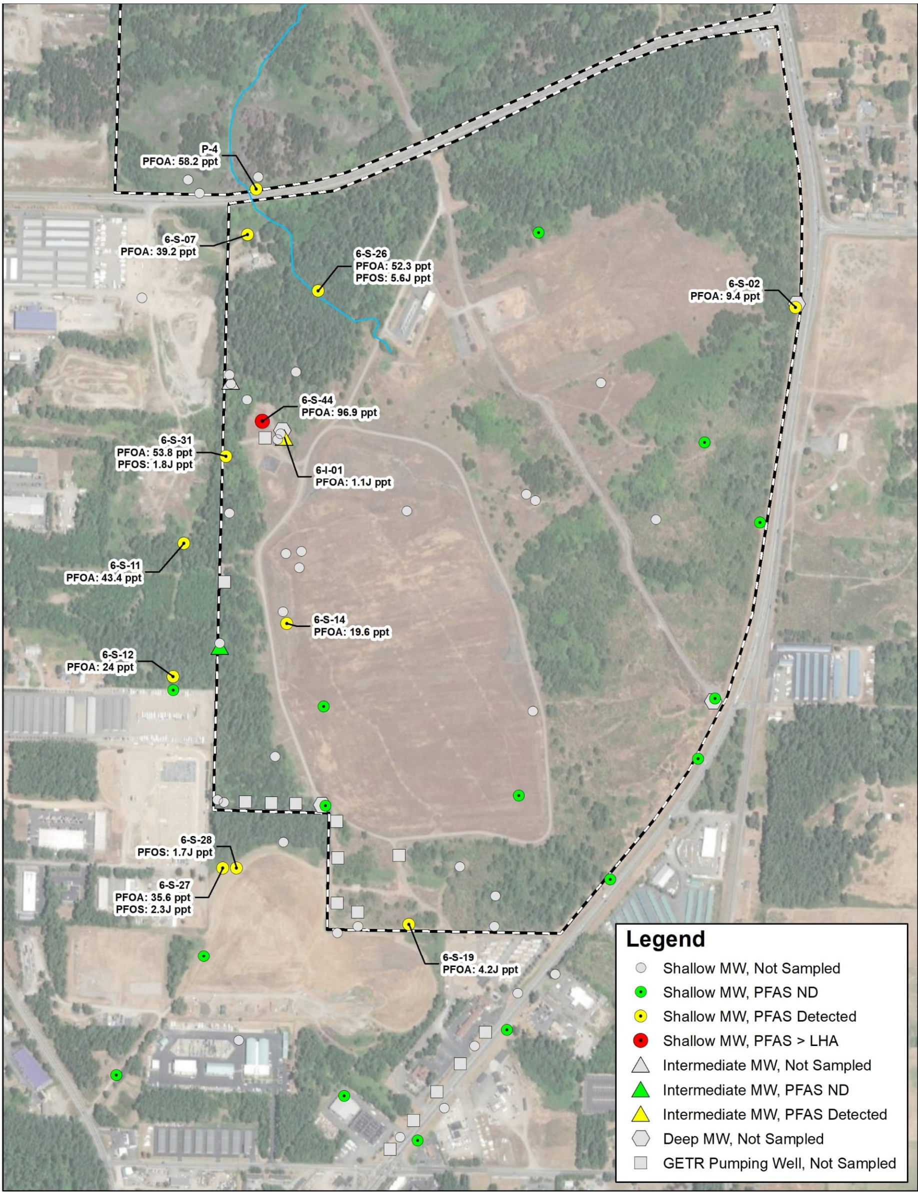
Area 6 – Remediation History

- Area 6 is a CERCLA site due to VOCs in GW
- Landfill was capped in mid-1990's to prevent infiltration of COCs to GW
- GETR (western air stripper system) operating since mid-1990's
- Interim soil removal action at former industrial waste disposal pit completed in 2001
  - Confirmation samples indicated elevated VOCs remained in soil
- ISCO pilot study conducted in 2014 near former industrial waste disposal area
  - One round of injections
- ROD Amendment in 2019 to change GW remedy to Advanced Oxidation
- Design of upgrade to the western GETR is on-going
- Southern GETR plant has been constructed, began operation in October 2021



Area 6 – PFAS Investigation History Groundwater Monitoring Wells

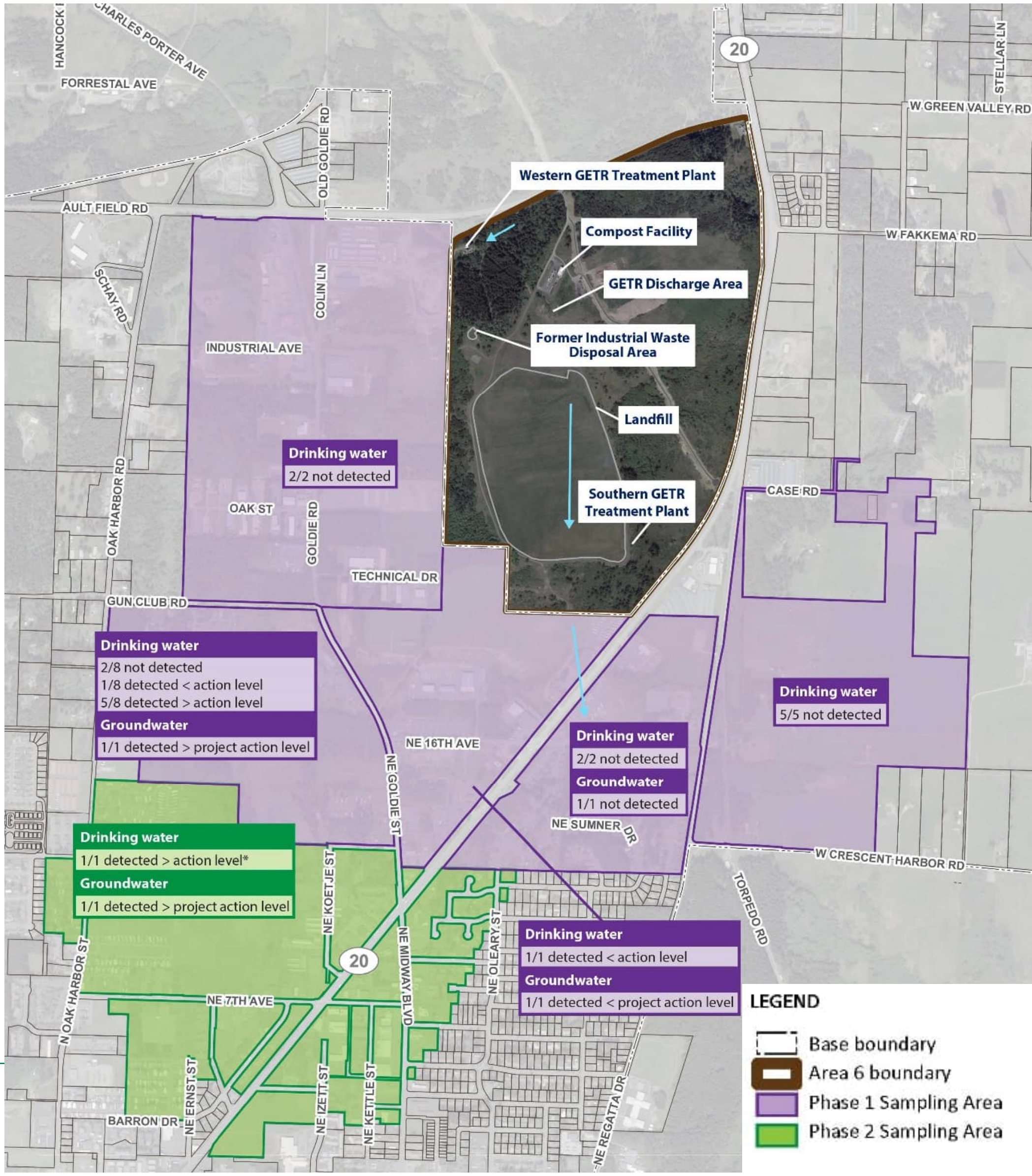
- Initial MW Sampling in 2017, additional MW sampling 2018
- Sampled 30 MWs and GETR influent/effluent
  - PFBS detected at 15 wells and GETR samples, none exceeded the RSL*
  - PFOA detected at 12 wells and GETR samples, exceeded LHA at one well (former industrial waste disposal area)
  - PFOS detected at 5 wells, none exceeded LHA



*PFBS data collected during the Area 6 SI were compared to the prior RSL of 400,000 ppt rather than the 2021 RSL

Area 6 – PFAS Investigation History Off-Base

- Phase 1; 2018
  - Off-base MWs and private wells within ½-mile of Area 6, downgradient
- Phase 2; 2019
  - Parcels within ½-mile of Phase 1 exceedance area (SW)
- 22 private wells sampled
  - PFBS detected at 10 wells, none exceeded the RSL
  - PFOA detected at 10 wells, none exceeded LHA
  - PFOS detected at 9 wells, 3 wells exceeded LHA
  - PFOS+PFOA exceeded LHA at 5 wells
- One additional exceedance identified as part of DW sampling program; 2019



Drinking water
2/2 not detected

Drinking water
2/8 not detected
1/8 detected < action level
5/8 detected > action level
Groundwater
1/1 detected > project action level

Drinking water
2/2 not detected
Groundwater
1/1 not detected

Drinking water
5/5 not detected

Drinking water
1/1 detected > action level*
Groundwater
1/1 detected > project action level

Drinking water
1/1 detected < action level
Groundwater
1/1 detected < project action level

Area 6 Remedial Investigation Scope

Area 6 – Remedial Investigation Objectives

- Improve understanding of site stratigraphy and lithologic characteristics of the hydrostratigraphic units
  - How does Area 6 stratigraphy correlate to regional setting?
- Improve understanding of GW flow directions in each aquifer
  - Where is the GW divide north of Area 6?
- Obtain data to estimate aquifer properties and to evaluate degree of hydraulic connection between the site aquifers
- Improve characterization of PFAS contamination in GW, horizontally and vertically
- Identify potential vadose zone source areas contributing PFAS mass to the underlying aquifer system
  - Former industrial waste disposal area? Capped landfill?
- Improve understanding of potential PFAS migration pathways between on-Base potential source areas and off-Base drinking water well exceedances

Area 6 – Remedial Investigation Scope

- Install up to 10 wells on-Base (up to 250 ft bgs)*
  - Up to 3 soil samples at 5 locations
  - Vertical profiling (grab GW samples) at 5 locations
- Sampling of up to 25 existing and 10 new monitoring wells
- One aquifer test at newly installed 4-inch well
- Synoptic groundwater level survey and land survey
- Collect sediment and surface water samples to support human health and ecological risk assessment
- Install up to 5 wells off-Base (up to 150 ft bgs)*
- Sampling of large diameter well north of Coachman Inn

*There is contractual flexibility to shift the number of wells between on-/off-base locations as needed to meet RI objectives

Area 6 – Proposed Investigation at On-Base Source Area and Downgradient of Source Area

Item/ Task	Location	Rationale	Comments
Intermediate/deep well pair	Within former industrial waste disposal area, adjacent to 6-S-44	Evaluate vertical distribution of PFAS in potential source area.	GW profile sampling; soil sampling
Lysimeter cluster	Within former industrial waste disposal area, near 6-S-44	Evaluate potential on-going vadose zone source area.	
Shallow/intermediate well pair	South of former industrial waste disposal area	Evaluate PFAS concentrations downgradient from potential source area.	GW profile sampling; soil sampling
Intermediate well	Southwestern corner of Area 6, adjacent to 6-S-13 and 6-S-25	Evaluate PFAS concentrations in intermediate aquifer at Area 6 boundary, upgradient from City of Oak Harbor landfill.	GW profile sampling; soil sampling
Sediment & SW sampling	GETR effluent discharge area; SW flowing north	Evaluate potential PFAS transport in GETR effluent.	

Area 6 – Proposed Investigation at On-Base Source Area and Downgradient of Source Area

Legend

- ⚪ Shallow MW, Not Sampled
- 🟢 Shallow MW, PFAS ND
- 🟡 Shallow MW, PFAS Detected
- 🔴 Shallow MW, PFAS > LHA
- △ Intermediate MW, Not Sampled
- ▲ Intermediate MW, PFAS ND
- ▲ Intermediate MW, PFAS Detected
- ⬜ GETR Pumping Well, Not Sampled

Potential Drilling Location

- 🟧 Lysimeter cluster
- ⊕ Single Well
- ● Well Pair
- ▲ Sediment/Surface Water

Area 6 – Proposed Investigation North of Ault Field Road

Item/ Task	Location	Rationale	Comments
Shallow/intermediate well pair	Within wetland area, near P-4	Evaluate PFAS concentrations in aquifer along GETR discharge stream. Inform GW flow directions and location of GW divide.	GW profile sampling; soil sampling *May not be feasible given access issues associated with wetland area* Drill deep for lithology
Shallow/intermediate well pair	North of wetland area along access road.	Evaluate PFAS concentrations in aquifer along GETR discharge stream. Inform GW flow directions and location of GW divide.	GW profile sampling Drill deep for lithology *Specific location TBD based on site access*
Shallow/intermediate well pair	North of Ault Field Road, along main access road	Evaluate PFAS concentrations in aquifer north of Area 6. Inform GW flow directions and location of GW divide.	Drill deep for lithology *May be omitted if wells near P-4 can be installed*
Shallow well	Southeastern corner of facility	Evaluate PFAS concentrations in aquifer north of Area 6. Inform GW flow directions and location of GW divide. Evaluate potential PFAS infiltration from ditch along Ault Field Road.	
Sediment & SW sampling	Wetland; stream flowing north; ditch flowing east	Evaluate potential PFAS transport in GETR effluent.	

Area 6 – Potential Drilling Locations; North of Ault Field Road

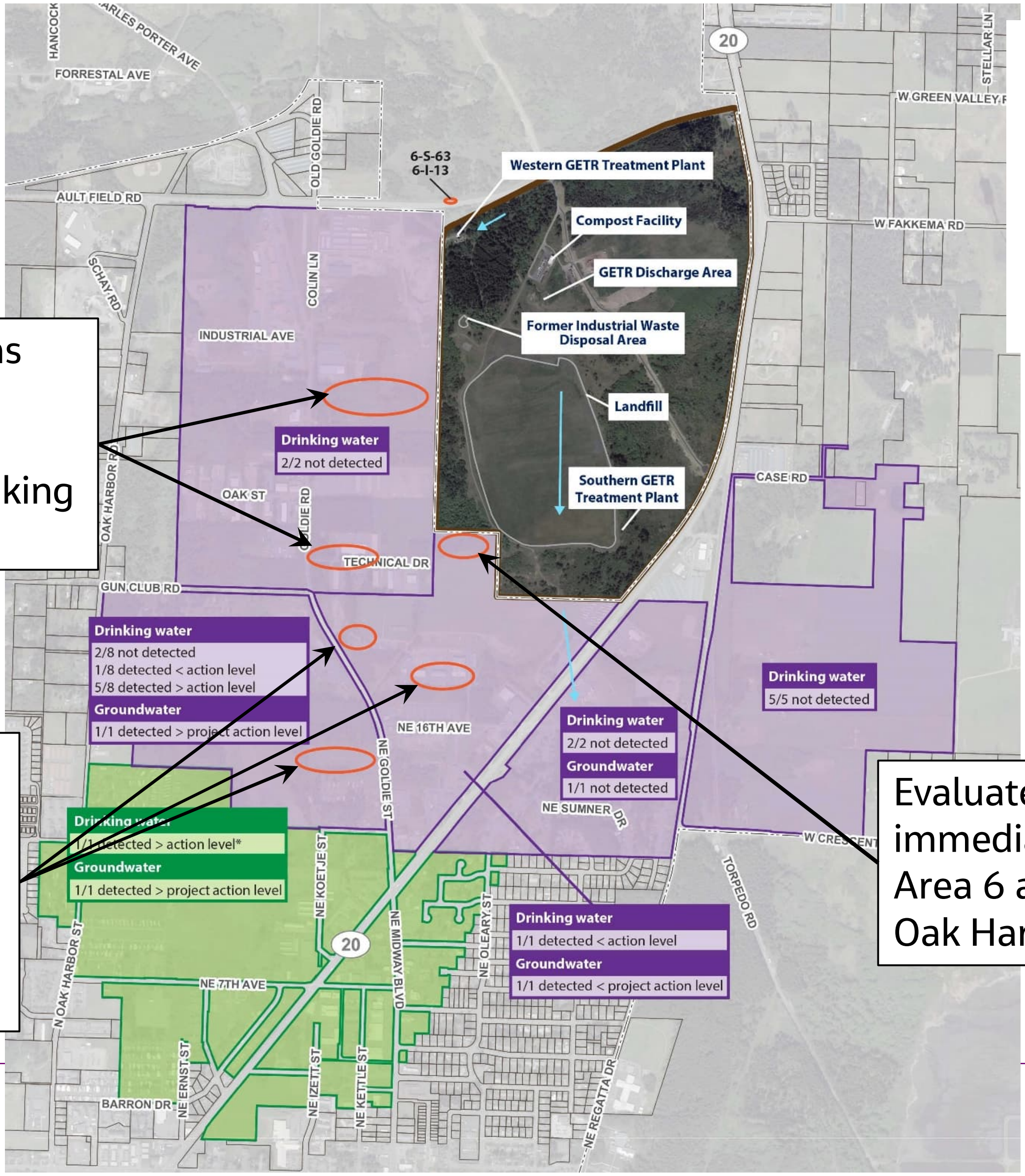
Legend

- ⚪ Shallow MW, Not Sampled
- 🟢 Shallow MW, PFAS ND
- 🟡 Shallow MW, PFAS Detected
- 🔴 Shallow MW, PFAS > LHA
- △ Intermediate MW, Not Sampled
- ▲ Intermediate MW, PFAS ND
- ▲ Intermediate MW, PFAS Detected
- ◻ GETR Pumping Well, Not Sampled

Potential Drilling Location

- 🟧 Lysimeter cluster
- ⊕ Single Well
- ● Well Pair
- ▲ Sediment/Surface Water

Area 6 – Proposed off-Base Locations



Evaluate PFAS concentrations downgradient of the former industrial waste disposal pit between Area 6 and the drinking water exceedance area

Evaluate PFAS concentrations downgradient of Area 6 between the Oak Harbor landfill and the drinking water exceedance area

Evaluate PFAS concentrations immediately downgradient of Area 6 and upgradient of the Oak Harbor landfill

LEGEND

- ▭ Base boundary
- ▭ Area 6 boundary
- 🟪 Phase 1 Sampling Area
- 🟩 Phase 2 Sampling Area
- → Groundwater flow direction
- ○ Target off-base monitoring well area

Area 6 – RI Report and Modeling

- **Data Evaluation**
  - Analysis and processing of aquifer test data, groundwater level data, and PFAS data (all media)
  - Refinement of CSM (plume maps and geologic cross-sections)
  - Area 6 – development of local-scale GW flow and solute transport model (PFOS, PFOA, and PFBS), evaluation of source area conditions (vadose zone modeling), incorporation of information from existing USGS and AECOM models to the extent feasible
- **RI Report**
  - Includes Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA)
  - Navy and Stakeholder review

South Whidbey State Park

Schedule


Penn Cove, Coupeville

Project Schedule

- SAP
  - Stakeholder review, June 2022
  - Final SAP, early August 2022
- On-Base field investigation
  - August 2022 – November 2022
- Off-Base field investigation
  - February – April 2023
- Local-scale modeling
  - June – September 2023
- RI Report
  - Stakeholder review, February – March 2024
  - Final RI, April 2024

Deception Pass

Thank You!
Questions?

Jacobs

Challenging today.
Reinventing tomorrow.

Appendix A-2
Naval Air Station Whidbey Island Area 6 Remedial Investigation Scoping – December 17, 2021 (Naval Facilities Engineering Systems Command Atlantic)

Challenging today.
Reinventing tomorrow.

Naval Air Station Whidbey Island
Area 6 RI Scoping

December 17, 2021

Agenda

- Health and Safety Moment
- Site Background
- Previous Investigations
- Previous Remedial Actions
- Summary of PFAS Site Inspection
- Environmental Questions to be Answered
- Investigation Strategy
- Schedule

Fort Casey Historical State Park

Health and Safety Moment – Driving in Inclement Weather

- Plan ahead
  - Driving in inclement weather takes more time
  - Review your route, leave early
- Drive slowly
  - Reduce speeds
  - Buckle Up!
- Leave room in front
  - Double the "cushion" with vehicles in front of you
- Make sure your equipment is in working order
  - Tires, brakes, headlights, wipers
- Turn on your headlights
- Pull over if you need to
  - Rest your eyes
  - Wait for storm to pass

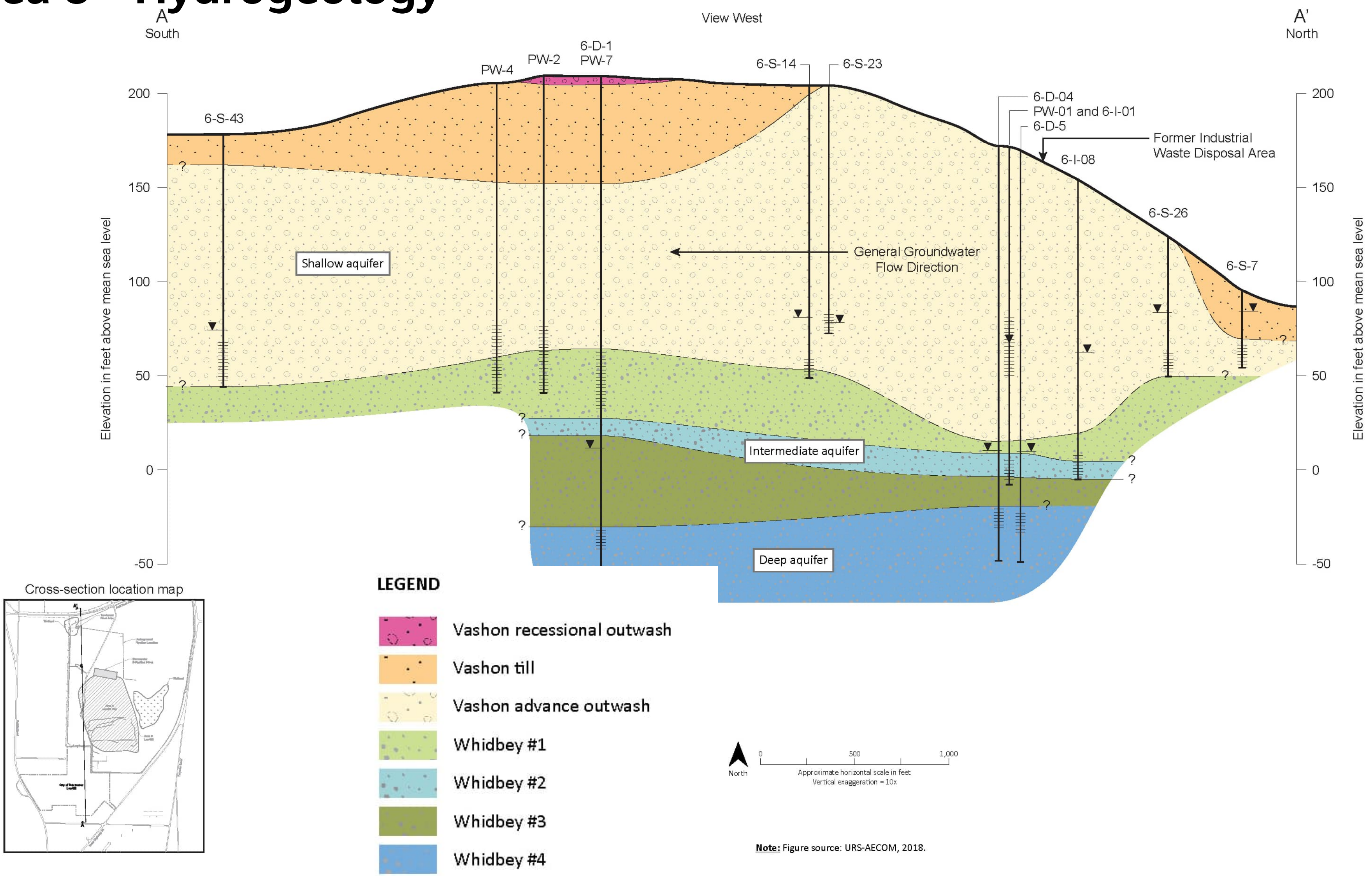
https://www.jdpower.com/cars/shopping-guides/safety-tips-for-driving-in-bad-weather

Area 6 Background, Investigation, and Remediation History

Area 6 - Description

- Southeastern corner of Ault Field, 260-acres
- Residential areas to east/southeast, including Auld Holland Inn
- City of Oak Harbor landfill to south
- Various residential and commercial developments to west

Area 6 - Hydrogeology



Note: Figure source: URS-AECOM, 2018.

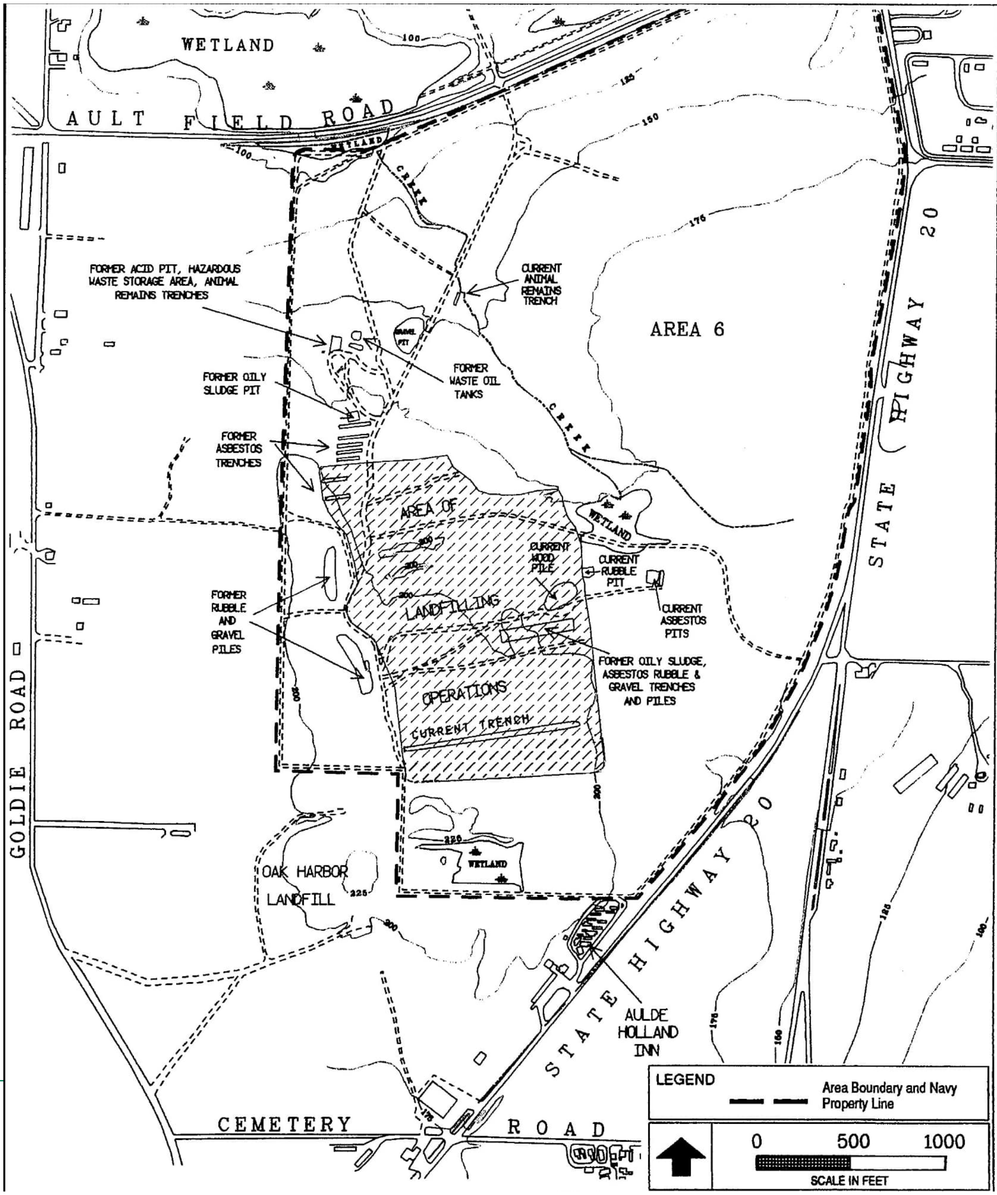
Area 6 – Groundwater Flow Direction

- GW flow in the shallow aquifer is generally to the south with some components of flow to the southeast and southwest
  - GW divide to the north, location uncertain
- Limited distribution of intermediate and deep aquifer monitoring wells
- RI data from early 1990’s suggest:
  - GW flow in intermediate aquifer interpreted as predominantly to the southeast
  - GW flow in deep aquifer ranges from southeast to southwest
- Downward vertical hydraulic gradients between aquifer units
  - Vertical head difference of 5 to 20 feet between shallow and intermediate and 50 feet between the shallow and deep aquifer

Shallow Aquifer
January 2020

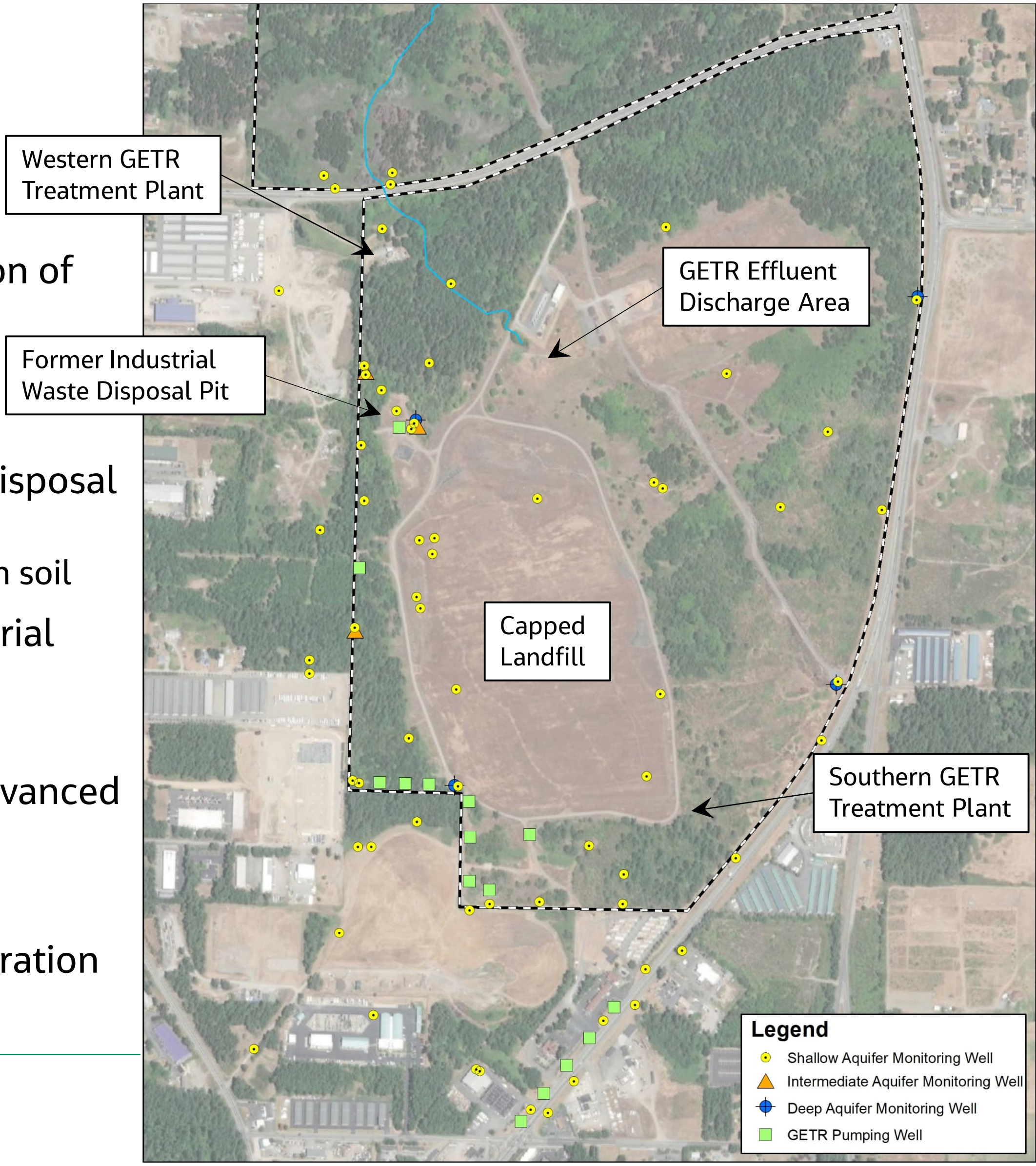
Area 6 –History

- Main landfill - 1969 to 1992
  - Most of the landfill received and contains Navy household municipal waste
  - Includes Navy sanitary & industrial wastes, construction debris, yard debris, non-hazardous soil and sediment from Ault Field, airfield dredge sediments
  - Consisted of 23 cut-and-fill trenches
- Former industrial waste disposal area
  - Acid pit and oily sludge pit
  - 300,000 to 700,000 gallons of acids, caustics, and solvents 1970's to 1980's
  - 100,000 to 600,000 gallons of liquid sludge between 1969 and mid-1970's
  - Approximately 15 x 40 feet
  - During operation, it was a pit (10-ft deep), also called the former waste oil pit



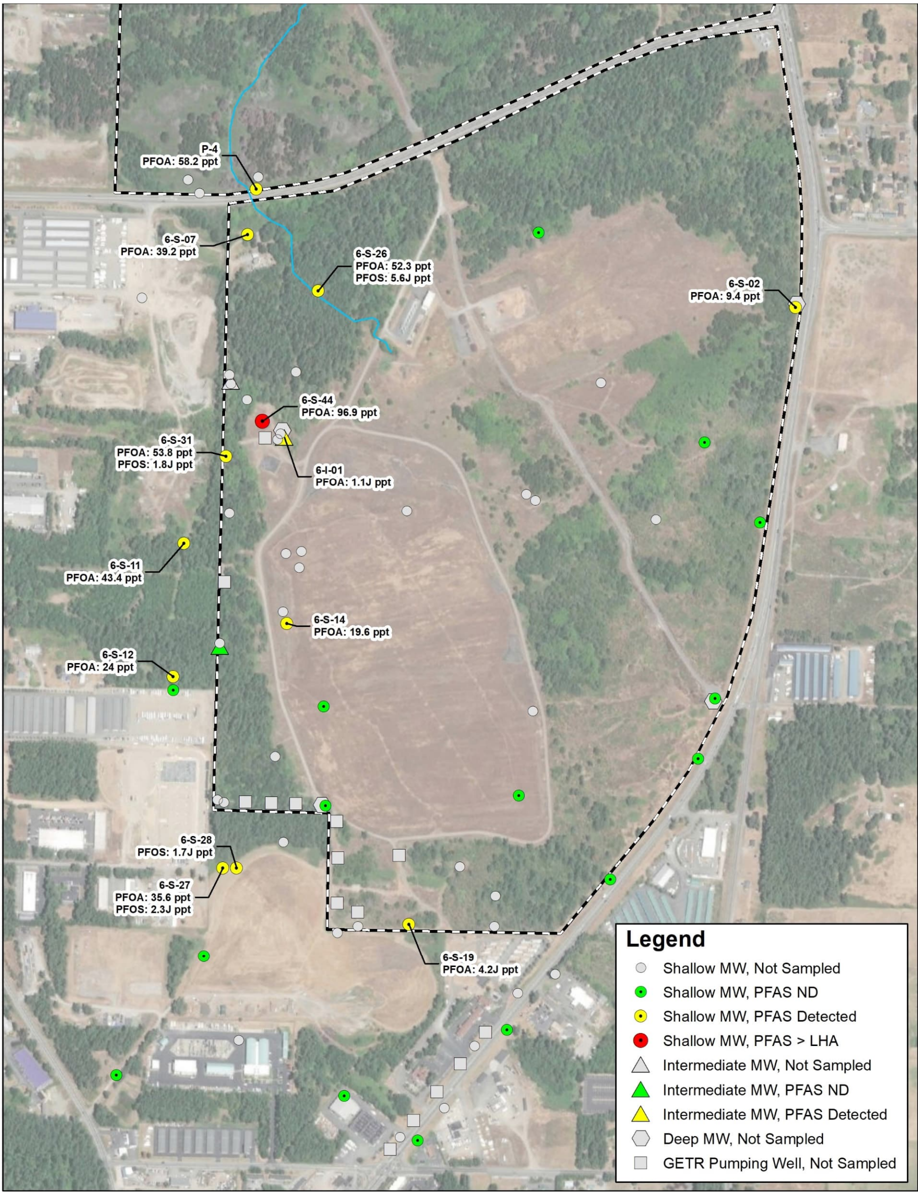
Area 6 – Remediation History

- Area 6 is a CERCLA site due to VOCs in GW
- Landfill was capped in mid-1990's to prevent infiltration of COCs to GW
- GETR (western air stripper system) operating since mid-1990's
- Interim soil removal action at former industrial waste disposal pit completed in 2001
  - Confirmation samples indicated elevated VOCs remained in soil
- ISCO pilot study conducted in 2014 near former industrial waste disposal area
  - One round of injections
- ROD Amendment in 2019 to change GW remedy to Advanced Oxidation
- Design of upgrade to the western GETR is on-going
- Southern GETR plant has been constructed, began operation in October 2021



Area 6 – PFAS Investigation History Groundwater Monitoring Wells

- Initial MW Sampling in 2017, additional MW sampling 2018
- Sampled 30 MWs and GETR influent/effluent
  - PFBS detected at 15 wells and GETR samples, none exceeded the RSL*
  - PFOA detected at 12 wells and GETR samples, exceeded Lifetime Health Advisory at one well (former industrial waste disposal area)
  - PFOS detected at 5 wells, none exceeded Lifetime Health Advisory



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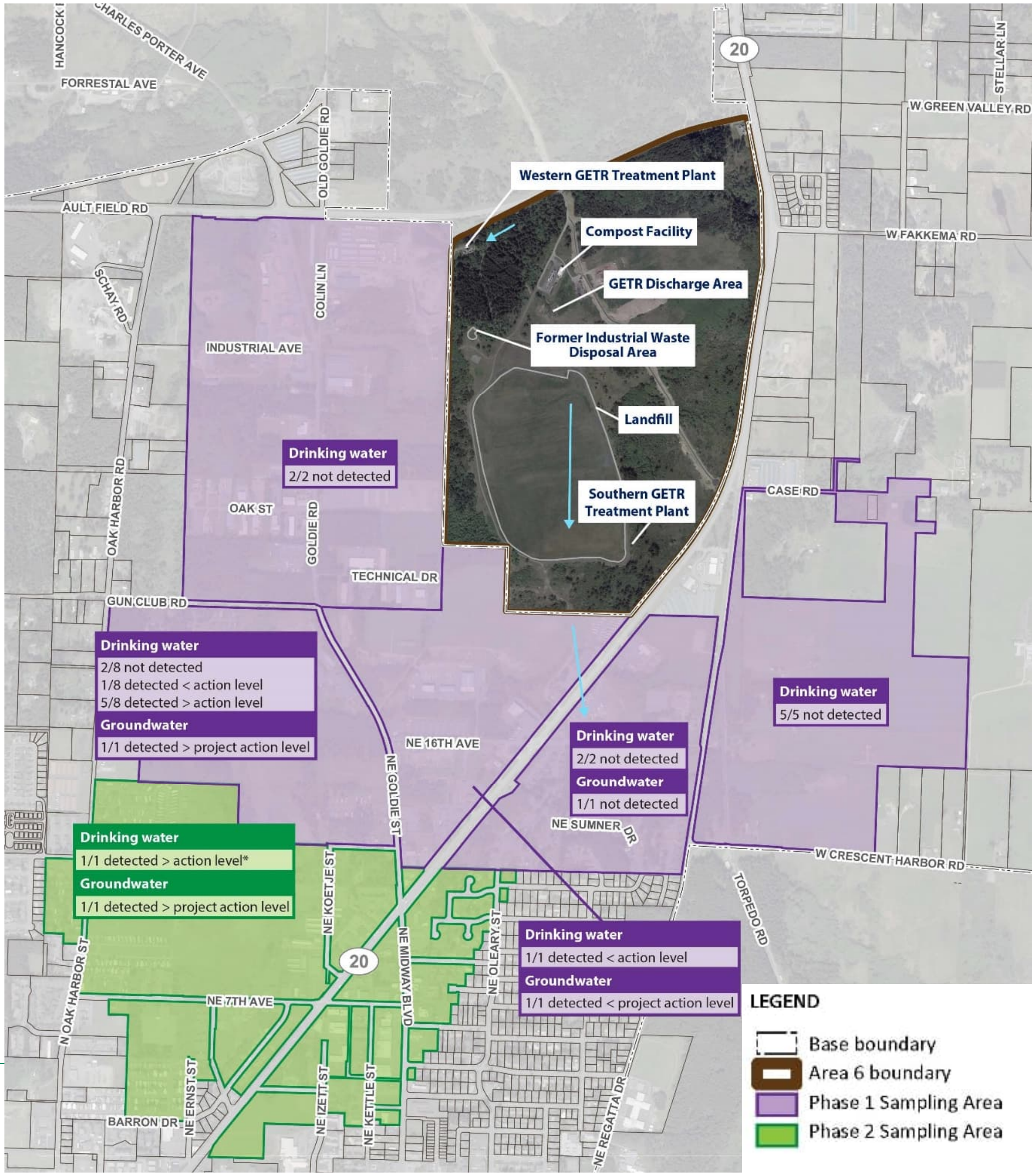
*PFBS data collected during the Area 6 SI were compared to the prior RSL of 400,000 ppt rather than the 2021 RSL of 600 ppt. The maximum detected PFBS concentration from monitoring well samples was 62.5 ppt.

Area 6 – PFAS Investigation History Off-Base

- Phase 1; 2018
  - Off-base private wells within ½-mile of Area 6, downgradient
- Phase 2; 2019
  - Parcels within ½-mile of Phase 1 exceedance area (SW)
- 22 private wells (drinking water and non-potable) sampled
  - PFBS detected at 10 wells, none exceeded the RSL
  - PFOA detected at 10 wells, none exceeded Lifetime Health Advisory
  - PFOS detected at 9 wells, 3 wells exceeded Lifetime Health Advisory
  - PFOS+PFOA exceeded Lifetime Health Advisory at 5 wells
- One additional exceedance identified as part of DW sampling program; 2019



Area 6 Remedial Investigation Scope

Area 6 – Project Quality Objectives

Problem Definition/Objective	Environmental Question	General Investigation Approach	PQO
PFOA and PFOS were detected in on- and off-Base groundwater monitoring wells located at/near Area 6 at concentrations above the SLs for PFOA and PFOS during the 2017 and 2018 sampling events; however, the extent of the PFAS in groundwater is uncertain. The first objective of this step is to define the nature and extent of this release area in excess of the PFAS PALs and assess risks to human health and ecological receptors. In 2018 and 2019, PFOA and PFOS was detected in six residential drinking water wells at concentrations exceeding the Lifetime Health Advisory southwest of Area 6. The second objective of this step is to refine the nature and extent of PFAS between the Area 6 base boundary and off-Base impacted drinking water wells.	What are the horizontal and vertical extents of PFAS exceeding SLs in the groundwater and are PFAS present at concentrations which pose unacceptable risk to human health and ecological receptors?	**Phase 1**. Installation of up to 8 new monitoring wells on-Base at Area 6 and Ault Field north of Ault Field Road (up to 250-ft bgs). Grab groundwater (vertical profiling) at up to 5 locations. **Phase 2**. Installation of up to 7 monitoring wells off-Base (up to 250-ft bgs on the north side of Ault Field Road, 150-ft bgs to the south and southwest of Area 6) **Phase 3**. Sampling of up to 25 existing wells and 15 new (on- and off-Base) monitoring wells. Evaluation of extents of PFAS exceeding PALs in each aquifer.	Data will be evaluated per the RI decision tree.

Area 6 – Project Quality Objectives, cont'd

Problem Definition/Objective	Environmental Question	General Investigation Approach	PQO
It is unknown whether PFAS is present in the vadose zone near the former industrial waste disposal area and whether this area represents an on-going source of PFAS mass loading to the underlying aquifer system. The objective of this step is to evaluate whether there is an on-going source of loading to the aquifer system from the vadose zone.	What is the horizontal and vertical extent of PFAS in vadose zone soil and vadose zone water that may be leaching to the aquifer system?	A triple completion lysimeter cluster will be installed near 6-S-44 in the former industrial waste disposal area. Vadose zone water samples will be collected and analyzed for PFAS. Soil samples will be collected during the drilling of boreholes at up to five locations. Soil samples will be collected at three depths: surface, water table, and one depth within the shallow aquifer at a lithologic interface.	If PFAS is detected in soil or vadose zone water samples, a 1-dimensional vadose zone leaching model may be used to evaluate potential mass loading to the aquifer (both concentration and timing). Depending on the extent and concentration of PFAS in soil, a future interim action may be warranted. If PFAS is not detected in soil or vadose zone water samples, it will be concluded that vadose zone source areas are not present in the vicinity of the sample locations.
There are limited lithologic data available outside of Area 6 to evaluate how the layered aquifer system at the site fits into the regional setting. The objective of this step is to evaluate the extents of the Area 6 aquifers to the north and west/southwest through which PFAS may be migrating.	Do the shallow, intermediate, and deep aquifers identified at Area 6, through which PFAS may be migrating, extend to areas north of Ault Field Road and off-Base south/southwest of the Area 6 boundary?	New on-Base monitoring wells will be drilled up to 250-feet bgs in order to collect lithologic data. New off-Base monitoring wells will be drilled up to 150-feet bgs in order to collect lithologic data.	Lithologic information collected during the RI field investigation will be integrated with existing lithologic data to generate cross-sections. These graphics will support evaluation of whether the aquifers at Area 6 are laterally extensive or whether they "pinch out" to the north of Ault Field Road and off-Base south/southwest of the Area 6 boundary.

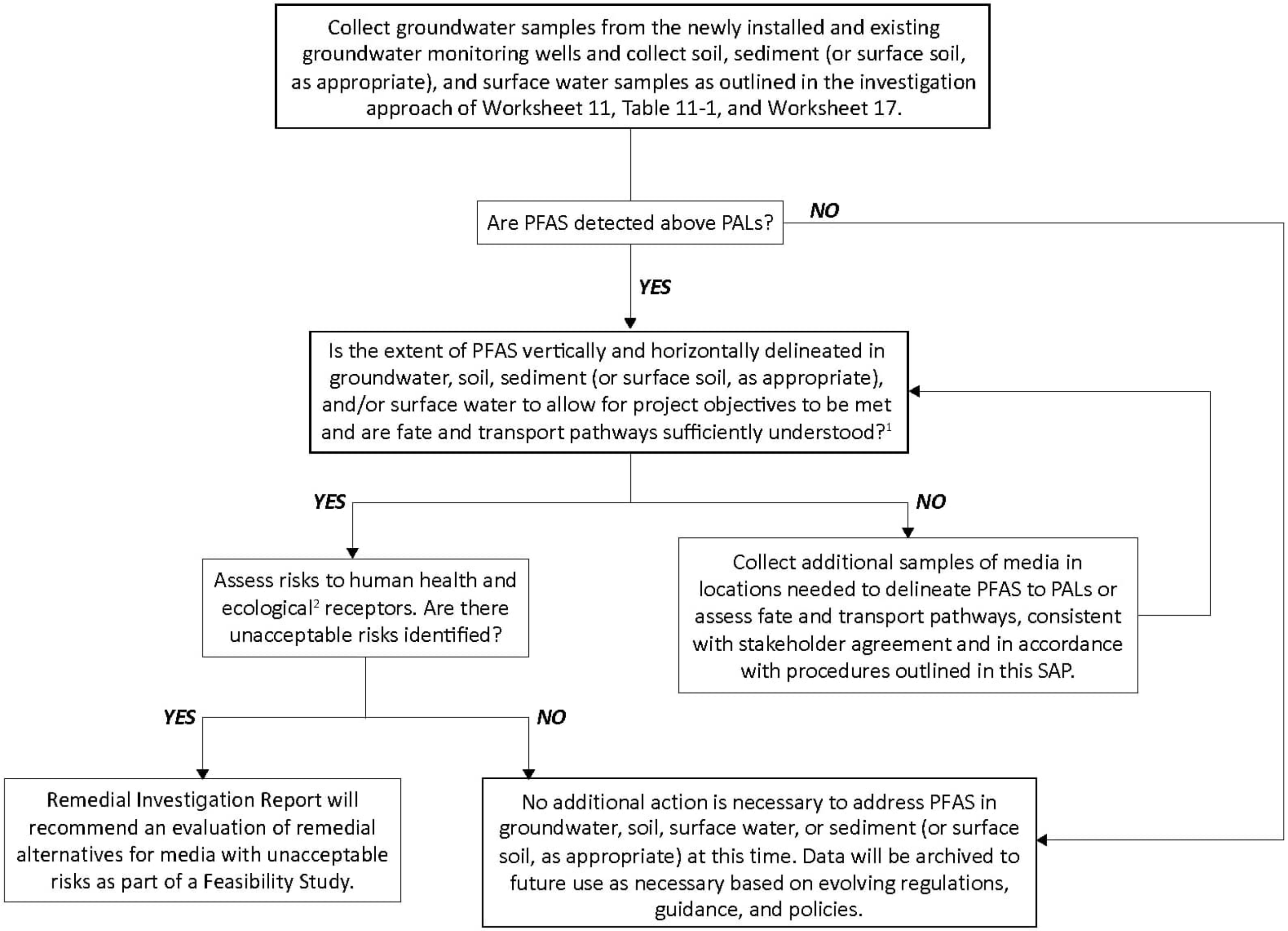
Area 6 – Project Quality Objectives, cont'd

Problem Definition/Objective	Environmental Question	General Investigation Approach	PQO
The western GETR has been operating at Area 6 since the mid-1990's. PFOA and PFBS were detected in GETR influent and effluent samples collected in 2017. PFOA and PFBS were detected in shallow aquifer samples from wells adjacent to the GETR effluent stream and within the wetland north of Ault Field Road. There are currently insufficient data to evaluate the lateral and vertical extent of PFAS in the surface water, sediment (or surface soil, as appropriate), and aquifer system that was released through the GETR effluent stream. The objective of this step is to define the nature and extent of this release area in excess of the PFAS PALs in surface water, sediment (or surface soil, as appropriate), and shallow groundwater and assess risks to human health and ecological receptors.	What are the concentrations of PFAS exceeding SLs in sediment (or surface soil, as appropriate) and surface water within the GETR effluent stream and if present, are concentrations indicative of risks to human health or ecological receptors? Is PFAS transported by the GETR surface water stream re-infiltrating to the underlying aquifer system north of Ault Field Road? If present, what is the extent of PFAS exceeding SLs and are concentrations indicative of risks to human health or ecological receptors?	Surface water and sediment (or surface soil, as appropriate) samples will be collected from up to 5 locations within the GETR effluent stream. Samples will be collected at the effluent discharge location, one location between the effluent discharge location and the Area 6 boundary, one location in the wetland north of Ault Field Road, one location in the effluent discharge stream north of the wetland, and one location in the ditch east of the wetland and north of Ault Field Road. Up to six wells (three well pairs) will be installed near the GETR effluent stream north of Ault Field Road and sampled/analyzed for PFAS.	If PFAS is detected in surface water and sediment (or surface soil) samples, the data will be compared to human health and ecological screening values to evaluate whether there is a potential risk to receptors. If concentrations are below risk thresholds, no further sampling will be conducted. If concentrations suggest a potential risk to receptors, additional sampling of these media may be performed. If PFAS is not detected in surface water or sediment (or surface soil) samples, it will be concluded that these are not potential PFAS migration pathways from Area 6. Groundwater data collected from monitoring wells north of Ault Field Road will be evaluated per the RI decision tree.

Area 6 – Project Quality Objectives, cont'd

Problem Definition/Objective	Environmental Question	General Investigation Approach	PQO
PFAS has been detected in residential drinking water wells at concentrations exceeding the Lifetime Health Advisory southwest of Area 6. There are currently insufficient data to evaluate potential PFAS migration pathways from Area 6 to off-Base receptors. The objective of this step is to refine the understanding of groundwater flow and potential PFAS migration pathways near Area 6.	What are the groundwater flow directions and potential PFAS migration pathways from Area 6 to potential off-Base receptors?	A synoptic groundwater level survey will be conducted to evaluate flow directions in the aquifer systems underlying Area 6. An aquifer test will be performed to evaluate aquifer properties and the interconnectivity of the aquifer systems underlying Area 6. Up to 10 geotechnical samples will be collected to obtain site-specific solute transport property data. A three-dimensional groundwater flow and solute transport model will be constructed to support evaluation of PFAS migration.	Synoptic groundwater elevation data, aquifer property data, PFAS concentrations (in all media), and aquifer solute transport property data will be used to update the CSM for groundwater flow and PFAS transport. These data will also be used to support construction of a groundwater flow and solute transport model of Area 6. The numerical model will be used to quantify groundwater pathways, flow rates, flow velocities, and both current and future PFAS migration pathways and mass flux through the soil source areas and aquifer system.

Area 6 – RI Data Evaluation Decision Tree



Collect groundwater samples from the newly installed and existing groundwater monitoring wells and collect soil, sediment (or surface soil, as appropriate), and surface water samples as outlined in the investigation approach of Worksheet 11, Table 11-1, and Worksheet 17.

Are PFAS detected above PALs?

Is the extent of PFAS vertically and horizontally delineated in groundwater, soil, sediment (or surface soil, as appropriate), and/or surface water to allow for project objectives to be met and are fate and transport pathways sufficiently understood?[1]

Assess risks to human health and ecological[2] receptors. Are there unacceptable risks identified?

Collect additional samples of media in locations needed to delineate PFAS to PALs or assess fate and transport pathways, consistent with stakeholder agreement and in accordance with procedures outlined in this SAP.

Remedial Investigation Report will recommend an evaluation of remedial alternatives for media with unacceptable risks as part of a Feasibility Study.

No additional action is necessary to address PFAS in groundwater, soil, surface water, or sediment (or surface soil, as appropriate) at this time. Data will be archived to future use as necessary based on evolving regulations, guidance, and policies.

[1] If the extent of PFOA, PFOS, and PFBS extends to areas that may be impacted from non-Navy sources, additional consideration will be warranted.

[2] The Navy currently requires the nature and extent of PFAS to be defined in an environmental medium prior to performing ecological risk evaluations. PFAS will be evaluated within the applicable DoD, Navy, and/or EPA policy, guidance, or directives using the state-of-the-science toxicological information available at the time that the RI is prepared.

Area 6 – Project Action Levels for All Media

- Analysis will be conducted using Liquid Chromatography/Tandem Mass Spectrometry (LC-MS/MS)
- Compliant with the most recent version of the DoD Quality Systems Manual for which the laboratory is accredited at the time of analysis, Table B-24
- The 40 analytes listed in Draft Method 1633 will be reported[1]
- Screening Levels (SLs) for PFOA, PFOS, and PFBS based on an HQ of 0.1:
  - PFOA: 40 ng/L (aqueous); 130 ng/kg (soil)
  - PFOS: 40 ng/L (aqueous); 130 ng/kg (soil)
  - PFBS: 600 ng/L (aqueous); 1,900 ng/kg (soil)
- No PALs for other PFAS compounds
- Ecological screening values will be developed at the time of the ecological risk assessment[2]
- SLs are based on the September 15, 2021 revision of the Assistant Secretary of Defense Memorandum entitled, "*Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program*" and "*Provisional Peer-Reviewed Toxicity Values for Perfluorobutane Sulfonic Acid (PFBS) and Related Compound Potassium Perfluorobutane Sulfonate (USEPA, 2021)*"

[1] Draft method is planned, but may not be used if laboratories do not have ELAP letters at the time of the RI field investigation.

[2] The Navy and stakeholders will have an opportunity to review the proposed ecological screening values and ecological risk assessment methodology

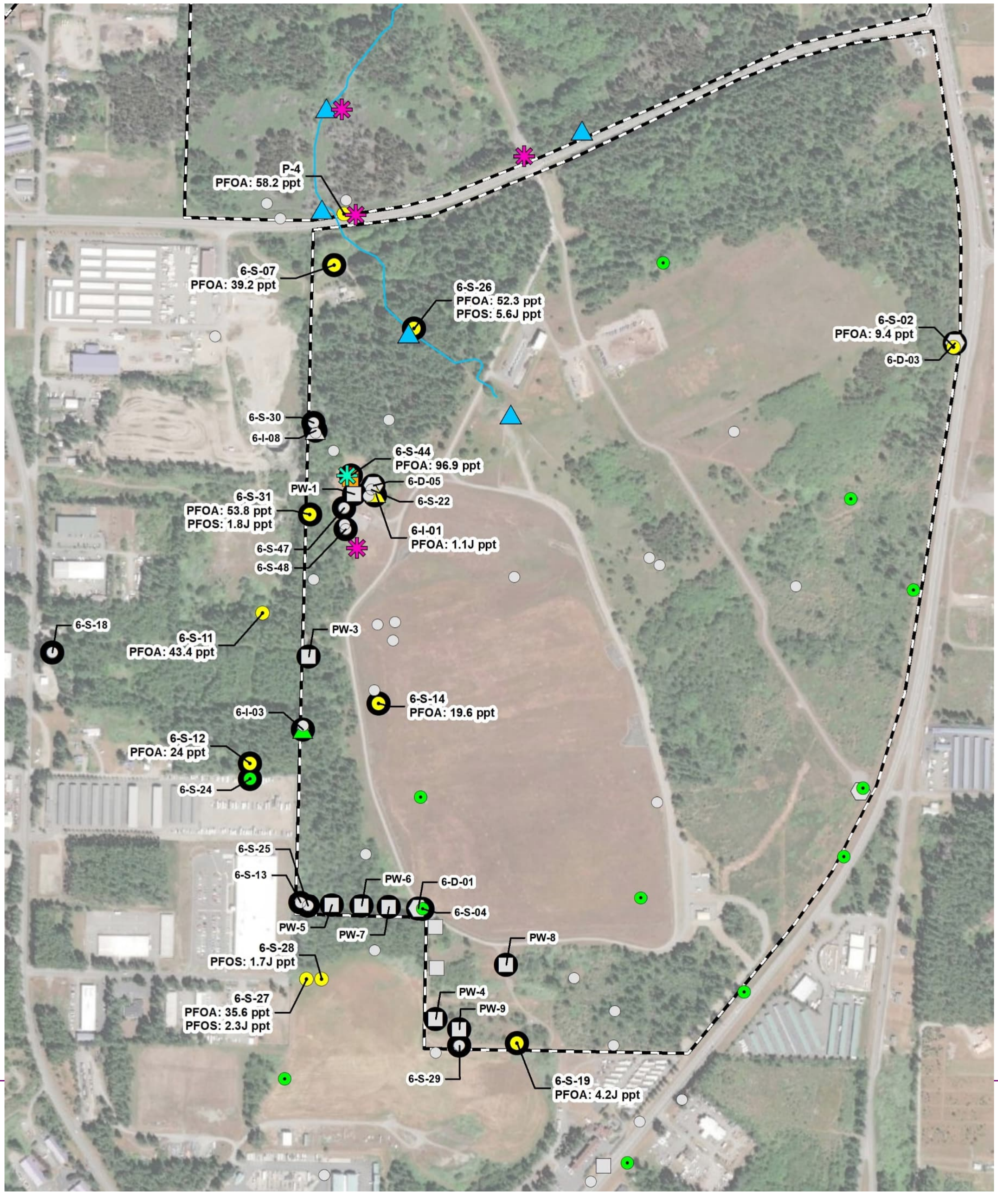
Area 6 – Proposed On-Base Investigation

Legend

- ○ Shallow MW, Not Sampled
- 🟢 Shallow MW, PFAS ND
- 🟡 Shallow MW, PFAS Detected
- 🔴 Shallow MW, PFAS > LHA
- △ Intermediate MW, Not Sampled
- ▲ Intermediate MW, PFAS ND
- ▲ Intermediate MW, PFAS Detected
- ⬡ Deep MW, Not Sampled
- ☐ GETR Pumping Well, Not Sampled

Proposed Drilling/Sampling Location

- ✳ Shallow/Intermediate Well Pair
- ✳ Intermediate/Deep Well Pair
- 🟧 Lysimeter Cluster
- ▲ Sediment/Surface Water
- ◯ Existing Monitoring Well Sample



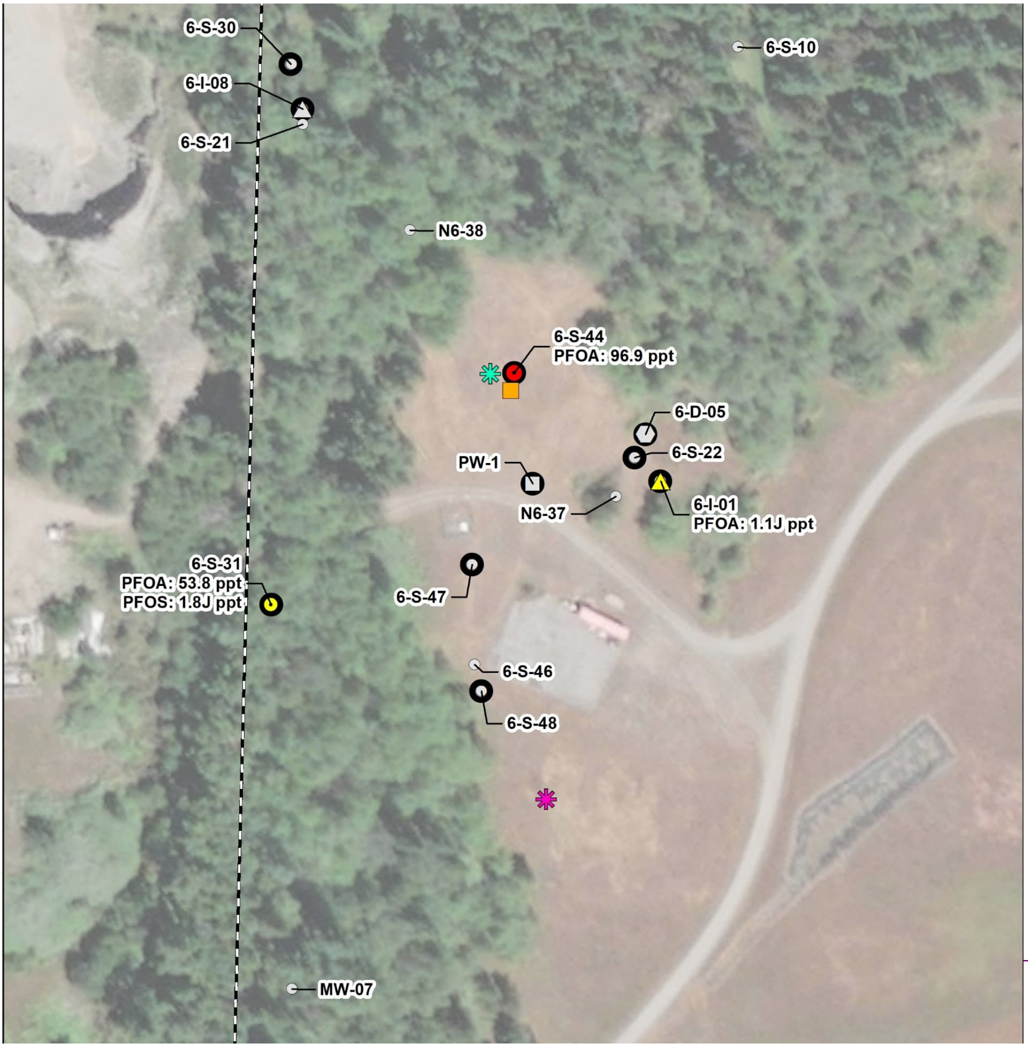
Area 6 – Proposed On-Base Investigation, Former Industrial Waste Disposal Area

Legend

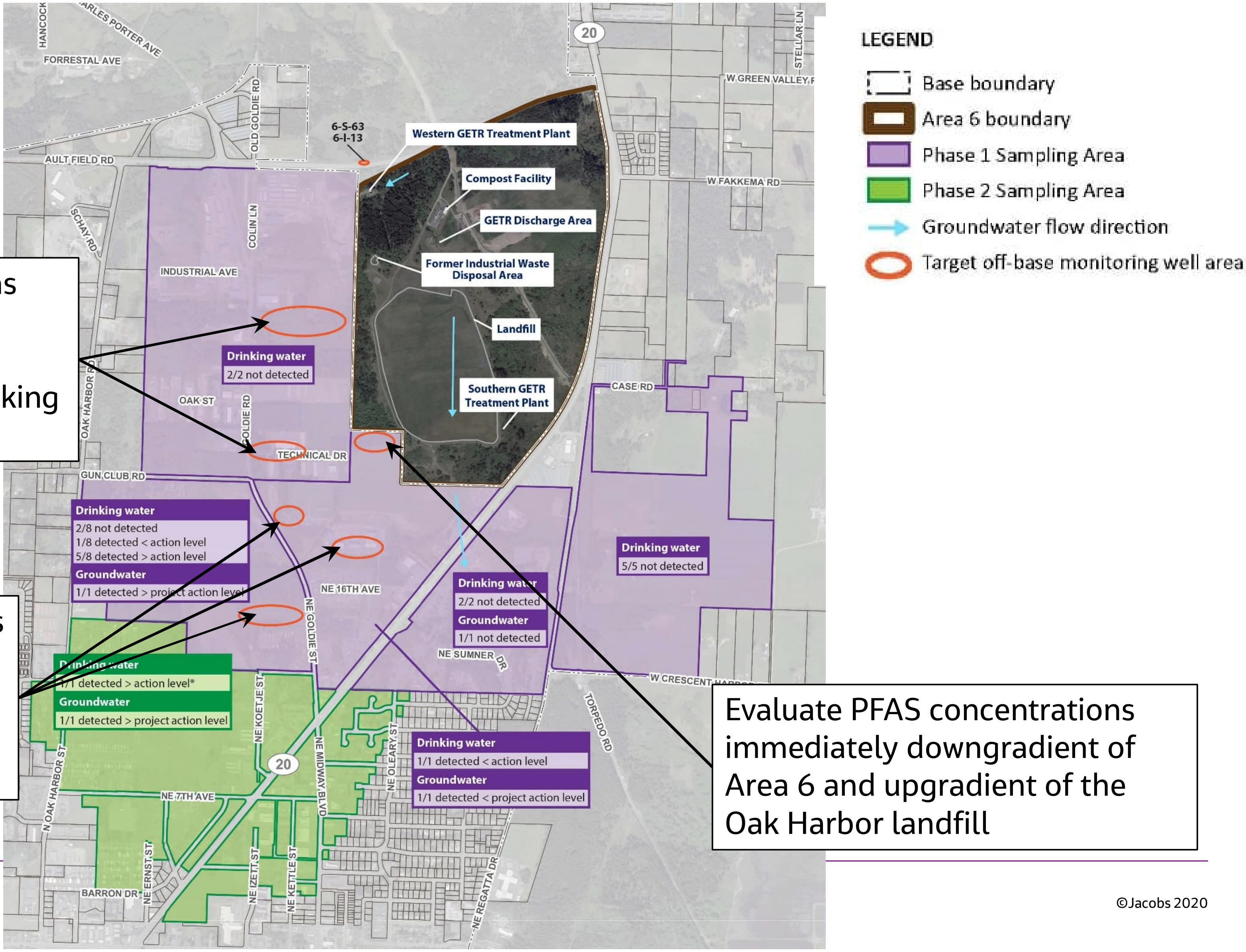
- ○ Shallow MW, Not Sampled
- 🟢 Shallow MW, PFAS ND
- 🟡 Shallow MW, PFAS Detected
- 🔴 Shallow MW, PFAS > LHA
- △ Intermediate MW, Not Sampled
- ▲ Intermediate MW, PFAS ND
- ▲ Intermediate MW, PFAS Detected
- ⬡ Deep MW, Not Sampled
- □ GETR Pumping Well, Not Sampled

Proposed Drilling/Sampling Location

- ✳ Shallow/Intermediate Well Pair
- ✳ Intermediate/Deep Well Pair
- 🟧 Lysimeter Cluster
- ▲ Sediment/Surface Water
- ◯ Existing Monitoring Well Sample



Area 6 – Proposed off-Base Locations

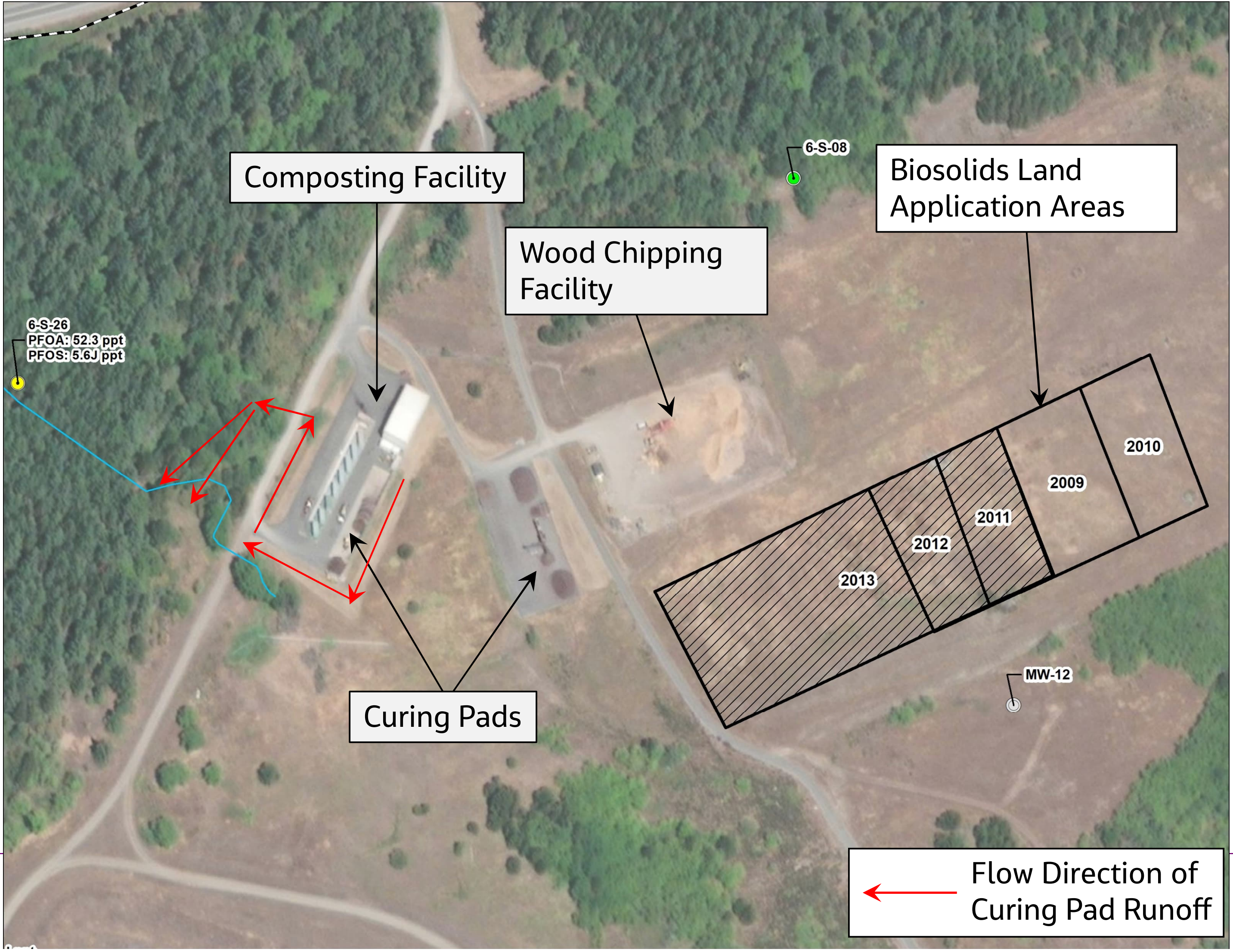


Evaluate PFAS concentrations downgradient of the former industrial waste disposal pit between Area 6 and the drinking water exceedance area

Evaluate PFAS concentrations downgradient of Area 6 between the Oak Harbor landfill and the drinking water exceedance area

Evaluate PFAS concentrations immediately downgradient of Area 6 and upgradient of the Oak Harbor landfill

Area 6 – New Potential Source Area, Biosolids Application and Staging



- Biosolids land applied at Area 6 2009 – 2013
- Biosolids continue to be staged on curing pads
- Runoff from curing pad to stormwater through 2015 (capture system installed)
- Potential Investigation
  - Composite surface soil sampling in each land application cell
  - Sample existing well MW-12
  - Consider installation of new shallow aquifer well to the west of MW-12
- Path forward for sediment sampling of curing pad runoff ditches?
- RI or SI type evaluation?

Area 6 – RI Report and Modeling

- **Data Evaluation**
  - Analysis and processing of aquifer test data and PFAS data (all media)
  - Refinement of CSM (plume maps and geologic cross-sections)
  - Area 6 – development of local-scale GW flow and solute transport model (PFOS, PFOA, and PFBS), evaluation of source area conditions (vadose zone modeling, if necessary), incorporation of information from existing USGS and AECOM models to the extent feasible
- **RI Report**
  - Includes Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA)


South Whidbey State Park

Team Consensus and Schedule


Penn Cove, Coupeville

Team Consensus and Project Schedule

Deception Pass

- Team in agreement?
- SAP
  - LANT review of Advance Worksheets, 2/11/2022 – 2/18/2022
  - QAO Review of SAP, March-April 2022
  - Final SAP, August 2022
- On-Base field investigation
  - August 2022 – November 2022
- Off-Base field investigation
  - February – April 2023, dependent on real estate actions
- Local-scale modeling
  - June – September 2023
- RI Report
  - LANT review, February – March 2024
  - Final RI, April 2024

Thank You!
Questions?

Challenging today.
Reinventing tomorrow.

Appendix B
Ecological Screening Values

Appendix B. Table 1. Ecological Data Quality Limits for PFAS

Chemical	Sediment[a] (Freshwater and Marine) (µg/kg)	Sediment Reference	Freshwater Surface Water (µg/L)	Surface Water Reference	Marine Surface Water (µg/L)	Surface Water Reference	Soil (µg/kg)	Soil Reference
PFOS	1.4	NOAEL-based value from Divine et al. 2020, based on food web model for tree swallow	0.117	Argonne (2021)	0.117	Argonne (2021); value for aquatic-dependent freshwater mammal	8.7	Argonne (2021)
PFOA	6.0	NOAEL-based value from Divine et al. 2020, based on food web model for little brown bat	370	Argonne (2021)	6.12	Argonne (2021); marine aquatic life	3,840	Argonne (2021)
PFBS	730	NOAEL-based value from Divine et al. 2020, based on food web model for tree swallow	400	Argonne (2021)	37[b]	Quality Standard (saltwater pelagic community) (Valsecchi et al., 2017)	817	Argonne (2021)
PFNA	10	NOAEL-based value from Divine et al. 2020, based on food web model for little brown bat	2.08	Argonne (2021)	2.08	Argonne (2021); value for aquatic-dependent freshwater mammal	24.2	Argonne (2021)
PFHxA	1,800	NOAEL-based value from Divine et al. 2020, based on food web model for little brown bat	28.8	Argonne (2021)	210	NOAEL-based value from Divine et al. 2020, based on food web model for little brown bat	6,200	Argonne (2021)
PFBA	1,600	NOAEL-based value from Divine et al. 2020, based on food web model for little brown bat	64.6	Argonne (2021)	11[c]	Quality Standard (saltwater pelagic community) (Valsecchi et al., 2017)	2,980	Argonne (2021)
PFDA	NA	NA	0.66	Argonne (2021)	0.66	Argonne (2021); value for aquatic-dependent freshwater mammal	67.7	Argonne (2021)

Appendix B. Table 1. Ecological Data Quality Limits for PFAS

Chemical	Sediment[a] (Freshwater and Marine) (µg/kg)	Sediment Reference	Freshwater Surface Water (µg/L)	Surface Water Reference	Marine Surface Water (µg/L)	Surface Water Reference	Soil (µg/kg)	Soil Reference
PFHpA	NA	NA	NA	NA	NA	NA	1,000	NOEC from Karnjanapiboonwong et al. 2018, adjusted with UF of 10 as recommended by Divine et al. 2020
PFHxS	NA	NA	5.50	Argonne (2021)	5.50	Argonne (2021); value for aquatic-dependent freshwater mammal	2.8	Argonne (2021)

[a] Applicable for both freshwater and marine habitats because of the limited availability of marine studies.

[b] Marine EC50 with an uncertainty factor of 10,000

[c] Freshwater LC50 with an uncertainty factor of 10,000

Notes:

The Navy currently recommends that initial nature and extent data for PFAS be gathered for an environmental medium prior to performing the initial steps (Steps 1-2 comprising a screening level ecological risk assessment and Step 3A refinement) of the ecological risk assessment process. The analytical data collected as part of this phase of the RI will be evaluated to determine complete exposure pathways and evaluate the potential for unacceptable risk to be present for ecological receptors. At the current time, EPA has not issued consensus-based ecological screening values for PFAS in any environmental medium. The initial ecological screening values listed are to ensure that data collected during the RI are suitable to meet the needs to complete a future ecological risk assessment; however, the final ecological screening values utilized for the initiation of a screening level ecological risk assessment completed during the overall RI will be reviewed and updated based on the state of the science at the time of the evaluation and presented to regulatory partners.

NA - not available

UF - uncertainty factor

NOEC - no observed effects concentration

EC50 – Effects concentration for 50 percent of test population

LC50 – Lethal concentration for 50 percent of test population

References

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Appendix C
Field 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, 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.

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 (coarse grained) or consistency (fine grained)
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)

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*.

VI. References

ASTM D2488-17e1, Standard Practice for Description and Identification of Soils (Visual-Manual Procedures), ASTM International, West Conshohocken, PA, 2017, www.astm.org

ASTM D1586 / D1586M-18, Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils, ASTM International, West Conshohocken, PA, 2018, www.astm.org

JACOBS	**PROJECT NUMBER**	**BORING NUMBER**
	SOIL BORING LOG	

PROJECT : LOCATION :
ELEVATION : DRILLING CONTRACTOR :
DRILLING METHOD AND EQUIPMENT USED :
ATD WATER LEVEL : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N')	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS PID Readings: Breathing Zone: Above Hole:

CH2M HILL

PROJECT NUMBER	**BORING NUMBER** SHEET OF

SOIL BORING LOG

PROJECT ______ LOCATION ______

ELEVATION ______ DRILLING CONTRACTOR ______

DRILLING METHOD AND EQUIPMENT ______

WATER LEVELS ______ START ______ FINISH ______ LOGGER ______

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Figure 1
SOIL BORING LOG,
FORM D1586

REV 11/89 FORM D1586

CH2M HILL

PROJECT NUMBER	BORING NUMBER	SHEET 1 OF 3
DEN 22371.G5	BL-3	

SOIL BORING LOG

PROJECT Howard Ave Landslide LOCATION Howard & 24th Ave, Centennial, CO.
ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colorado
DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drill rig
WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A. Michner

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	2.5					
	4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
	5.0					Driller notes very soft drilling 4ft. dark grey, wet silty cuttings.
5	6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft; strong H_2S odor, many fine roots up to about 1/4 inch	
	8.0					
	10.0	3-ST	1.3	—	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730 Driller notes rough drilling action and chatter @ 13 ft
15	15.0 15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
20	20.0 21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	Driller notes smoother, firm drilling @ 19 ft some angular rock chips @ bot tip of 6-S, poss boulders or rock Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	23.0 23.1	7-S	0	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM

REV 11 89 FORM D1586

Table 1
EXAMPLE SOIL DESCRIPTIONS

POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size

FAT CLAY (CH), dark gray, moist, stiff

SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine

WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max

POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense

ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica

SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max

INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick

SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill

SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation

LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff

WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Relative Density	Field Test
0-4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb hammer
>50	Very dense	Penetrated only a few inches with ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

STANDARD OPERATING PROCEDURE

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in piezometers and monitoring wells, even where a second phase of floating liquid (e.g., gasoline) is encountered, and on staff gauges in surface-water bodies. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers (see SOP *Use of Data Loggers and Pressure Transducers)*.

II. Equipment and Materials

- Electronic water-level meter (Solinst® or equivalent) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Interface probe (Solinst® Model 122 Interface Meter or equivalent)

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the piezometer or well until the probe just contacts the water surface; the unit will respond with a solid tone or light signal. Note the depth from a reference point indicated on the piezometer or well riser. Typically, this is the top of the PVC casing. If no reference is clearly visible, measure the depth to water from the northern edge of the PVC casing. If access to the top of the PVC casing is difficult, sight across the top of the locking casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface.

Measure the distance from this point to the closest interval marker on the tape and record the water level reading in the logbook. Water levels will be measured to the nearest 0.01-foot. Also, when specified in the project plans, measure and record the depth of the piezometer or well. The depth of the piezometer or well may be measured using the water-level probe with the instrument turned off.

Free product light or dense nonaqueous phase liquid may be present in the piezometer or well. If the presence of free product is suspected, the thickness of the product should be determined using appropriate equipment (e.g., Solinst® Model 122 Interface Meter). The depth to water also is determined with this equipment and the water-level meter should not be used in the piezometer or well as long as product is present. Typically, a constant sound is emitted from the device when free product is encountered and an alternating on/off beep sound is emitted when water is encountered.

The apparent elevation of the water level in the well or piezometer is determined by measuring both the apparent depth to water and the thickness of free product. The corrected water-level elevation is calculated by the following equation:

$$WL_c = Wl_a + (\text{Free-product thickness} \times 0.80)$$

Where WL_c = Corrected water-level elevation

Wl_a = Apparent water-level elevation

0.80 = Typical value for the density of petroleum hydrocarbon products.

If free product is detected on the surface of the water in the piezometer or well, the value of sampling should be reconsidered because of the potential for contaminating the sampling equipment.

Staff gauges may be installed in some surface-water bodies. These facilities typically are constructed by attaching a calibrated, marked staff gage to a wood or metal post, driving the post into the bottom of the surface-water body, and surveying the elevation of the top of the post to a resolution or 0.01-foot. The elevation of the water in the surface-water body then can be determined by reading off the distance the water level is from the top of the post. A shield or other protection may be needed to calm the fluctuations in water level if the gauge is installed at a location exposed to wind or wave.

IV. Attachments

None.

V. Key Checks

- Before each use, verify that the battery is charged by pressing the test button on the water-level meter.
- Verify that the unit is operating correctly by testing the probe in distilled or de-ionized water. Leave the unit turned off when not in use.

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.

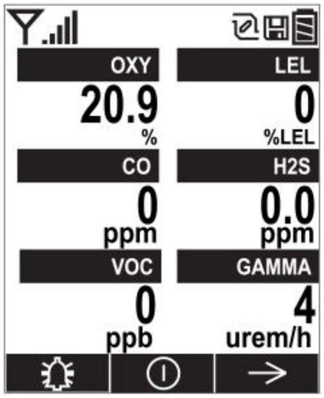
The following subsections will discuss Mini RAE calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

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
- A RAE Systems logo (or a company name) should appear first. This is followed by a progression of screens that tell you the MultiRAE's current settings:
    - Product name and model number, air flow type, and serial number
    - Application firmware version, build date, and build time
    - Sensor firmware, build date, build time
    - Installed sensors (including serial number/production/expiration/calibration date and alarm limit settings)
    - Current date, time, temperature, and relative humidity
    - User mode and operation mode
    - Battery type, voltage, shutoff voltage
    - Alarm mode and alarm settings
    - Datalog period (if it is activated) and interval
    - Policy Enforcement settings (whether calibration and/or bump testing are enforced)
- Then the MultiRAE's main reading screen appears. It may take a few minutes for sensors to show a reading, so if any have not warmed up by the time the main screen is shown, you will see "- - -" instead of a numerical value until the sensor provides data (typically less than 2 minutes). Then it displays instantaneous readings similar to the following screen (depending on the sensors installed) and is ready for use.

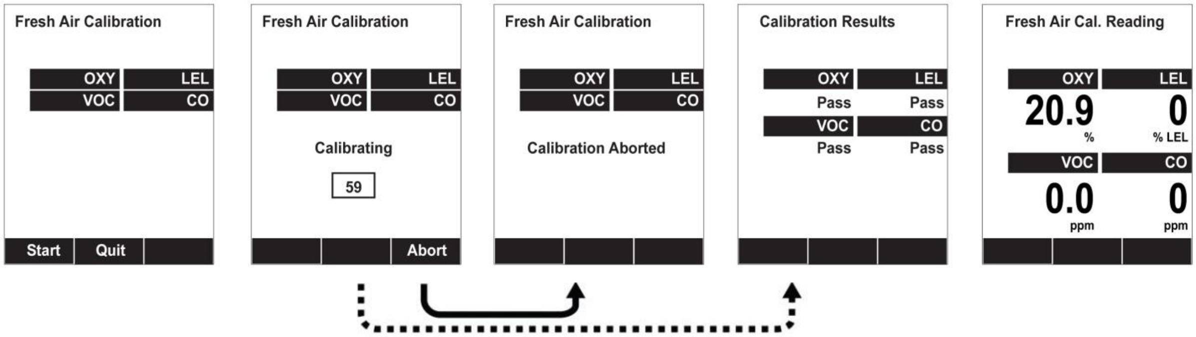


Calibration Check and Adjustment

Zero Calibration

- At the Calibration Menu, select “Fresh Air.” Press [Y/+] once to enter the fresh air calibration sub-menu.

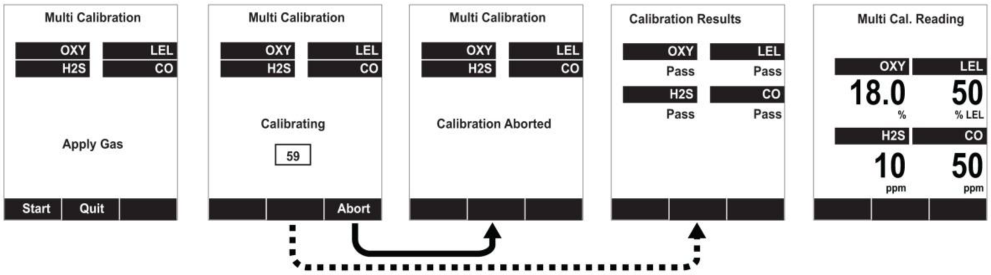
- Press **[Y/+]** to start fresh air calibration
- A countdown screen appears. You can abort the calibration at any time during the countdown by pressing [N/-].

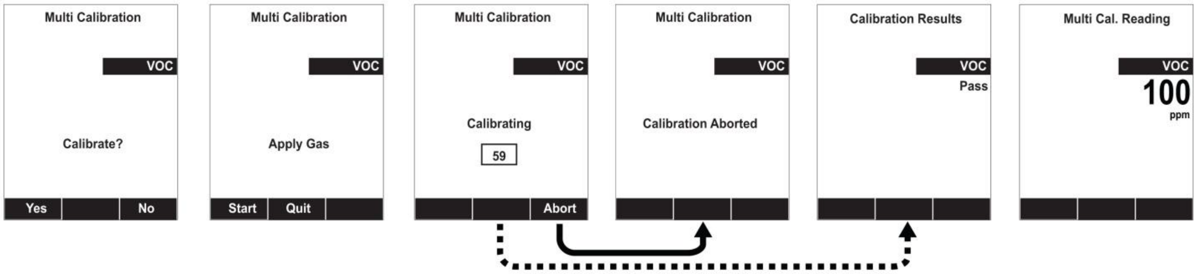


- Note: Dotted line indicates automatic progression
- If the calibration is not aborted, the display shows the sensor names and tells you whether the fresh air calibration passed or failed, followed by the sensors’ fresh air readings

Multi Sensor Span Calibration

- Depending on the configuration of your MultiRAE and span gas you have, you can perform a span calibration simultaneously on multiple sensors. You can define which sensors are calibrated together using the Multi Cal Select menu described in section 8.3.2.9.
- In case all sensors in the instrument cannot be calibrated with the same gas, the MultiRAE will intelligently split the span calibration process into several steps and will provide menu prompts accordingly.
- At the Calibration Menu, select "Multi Sensor Span."
- Install the calibration adapter and connect it to a source of calibration gas.
- Start the flow of calibration gas.
- Press **[Y/+]** to start calibrating or wait for calibration to start automatically.
- A countdown screen is shown. You can abort the calibration at any time during the countdown by pressing **[N/-]**.



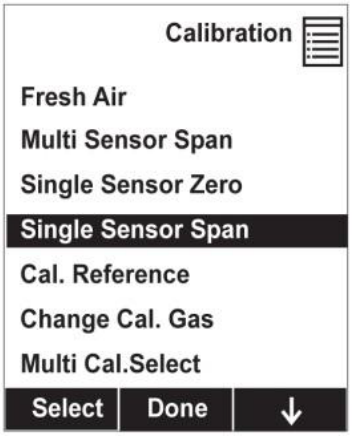


- Note: Dotted line indicates automatic progression
- If the calibration is not aborted, the display shows the sensor names and tells you whether the calibration passed or failed, followed by the sensor readings.

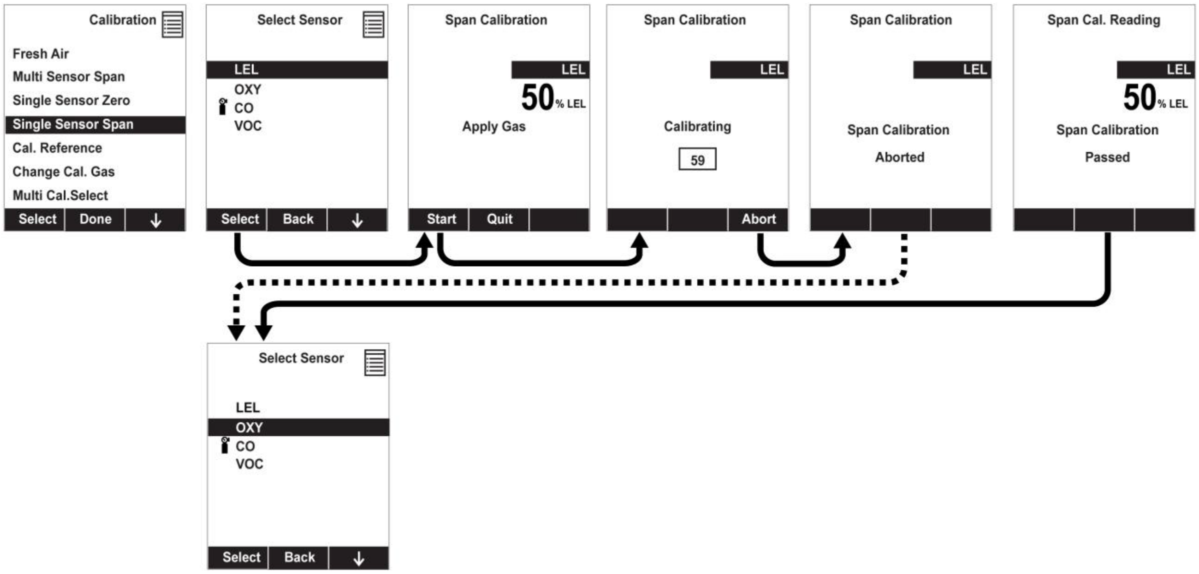
Single Sensor Span Calibration

- Instead of performing a span calibration on multiple sensors simultaneously, you can select a single sensor and perform a span calibration.
- To perform span calibration of an individual sensor, follow these steps:
- At the Calibration Menu, select "Single Sensor Span."
- Select a sensor to calibrate from the list.
- Install the calibration adapter and connect it to a source of calibration gas.
- Verify that the displayed calibration value meets the concentration specified on the gas cylinder.

- Start the flow of calibration gas.



- Press [Y/+] to start calibrating or wait for calibration to start automatically.
- A countdown screen appears. You can abort the calibration at any time during the countdown by pressing [N/-].



Apply Gas

Calibrating

Span Calibration Aborted

Span Calibration Passed

- Note: Dotted line indicates automatic progression
- Select the done button when calibration is complete.
- **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.

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 User's Guide, RAE Systems, Revision C, May 2013.

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 the most recent version of the Quality Systems Manual (QSM) for which the lab is certified. 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. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

A. 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])

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[1] Geotech and Waterra offer PFAS free bailer options

  - 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
    - 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) or tablet (see tablet use notes below)
- Metal clip board (if using loose-leaf paper)
- Pen (not Sharpie)
- Nitrile or latex gloves

B. 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.

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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.

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
- Non-Stick 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).

The use of electronics (e.g., cell phones and tablets) should be avoided without the implementation of precautionary measures outlined below:

- All devices should be used with clean, ungloved hands and an approved stylus (if desired).

Following the use of a device, hands must be washed with soap and water and clean gloves should be used prior to contact with sampling equipment (bottleware, tubing, etc.).

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.

A. 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. Do not fill the bottle past the middle of the bottle shoulder. 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).

B. 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) or un-coated aluminum foil, 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 and the Solinst Model 101 with the P2 meter have been shown to be fluorine free.

IV. 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, 2020. *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/November 2020 Update*. November.

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

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

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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.

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.

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
- Non-stick 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) Advance the drive-ahead sampler to the desired sampling depth and withdraw the 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) Deploy your sampling pump to mid-screen.

4) Purge the volume of water added to the well during drilling. If no water has been used, purge three well volumes from the casing. When using the drive-ahead sampler, calculate

the well volume as the volume of water in the drill rod (bullet a). When using a temporary well, calculate the well volume as the volume of water in the casing plus the volume of water in the sand pack (bullet b).

a) To calculate the volume of water in the drill rod, use the appropriate coefficient for the rod diameter given under “Well Casing Volume per Foot of Depth” on the attached reference sheet (Geotech, 2019). Then use the following formula:

   V (gallons) = coefficient * h (where h is the height of the water column in feet)

b) To calculate the volume of the temporary well casing and sand pack, first calculate the volume of the casing as above. Then calculate the volume of the annulus using the coefficients given under “Volume of Annulus” on the reference sheet (Geotech, 2019). The volume of the annulus is then multiplied by the porosity of the sand pack (a porosity of 0.35 can be assumed for this case). This is summarized in the following formula:

   V (gallons) = V_casing + (0.35 * V_annulus)

c) Note: If the sample interval / well is unable to produce enough water to generate three well volumes or if it goes dry, then the volume purge method will not be used. In this case, the casing will be pumped dry and allowed to recharge to 90% of the static water level (time permitting) before sampling.

5) Collect and record one set of water quality parameters prior to sampling.

6) 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.

7) 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

Geotech, 2019. *Water Measure Tables*. Web. 28 March 2019.

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*.*

Soil Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose

This SOP provides guidelines for soil sample collection and handling for samples that will be analyzed for per- and polyfluoroalkyl substances (PFAS) via LC/MS/MS Compliant with the most recent version of the Quality Systems Manual (QSM) for which the lab is certified at the time of analysis. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

A. Equipment and Materials Required

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 PFAS (such as Teflon, Viton, PTFE, or other fluorinated compounds). 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 labels (if available[1]) shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating or tablet (see notes on tablet use below)
- Metal clipboard (if using loose-leaf paper)
- Pen (not Sharpie)

Personal protection equipment (rubber or latex gloves, boots, etc.). Check with your SME prior to selecting PPE to ensure there are no fluorine-containing components.

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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.

Sample jars (sample jars should be made of high density polyethylene (HDPE) 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.

Laboratory-prepared deionized, certified PFAS-free water for field blank collection

B. 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).

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 (PTFE) or any other fluorine-containing substance. Biolube has been determined to be an acceptable substitute.

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
- Non-stick aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Contact your PFAS SME for an approved list of sunscreens and insect repellants.

The use of electronics (e.g., cell phones and tablets) should be avoided without the implementation of precautionary measures outlined below:

- All devices should be used with clean, ungloved hands and an approved stylus (if desired).

Following the use of a device, hands must be washed with soap and water and clean gloves should be used prior to contact with sampling equipment (bottleware, tubing, etc.).

III. Procedures and Guidelines

Once the area has been determined to be free of materials potentially containing PFAS, these steps can be followed to collect the soil samples:

Wear protective gear, as specified in the Health and Safety Plan.

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.

A. Samples On A Grid

1. 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.
2. Proceed to sample the points on the grid line.
3. 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.
4. Proceed to sample the points on the grid line as described in Section C below.
5. Make sure to stake location after sample collection in case professional surveying is to be completed.
6. Repeat 1c and 1e above until all samples are collected from the area.
7. Or, a GPS unit can be used to identify each location based on map coordinates, if available.

B. Non-Grid Samples

1. 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).
2. Note measurements, landmarks, and sampling point on a sketch in the field notebook, and on a site location map.
3. Proceed to sample as described in Section C below.
4. Make sure to stake location after sample collection in case professional surveying is to be completed.
5. Repeat 2a through 2d above until all samples are collected from the area.
6. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

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.

C. Collecting Samples Using Hand Tools

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:
   - 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.
   - 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. Affix labels after bottles have been closed; collect only one sample at a time to avoid mislabeling.
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.

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). Additionally, ensure that all decontaminated tools are wrapped in un-coated aluminum foil as needed.
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 and if equipment is wrapped in aluminum foil that un-coated aluminum foil is used.
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.

D. Equipment Decontamination

Whenever possible, use disposable equipment when collecting soil 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) or un-coated aluminum foil, and store away from potential PFAS sources.

IV. 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, 2020. *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/November 2020 Update.* November.

United States Navy, 2015. *Navy Drinking Water Sampling Policy for Perfluorochemicals: Perfluorooctane Sulfonate and Perfluorooctanoic Acid.* September

STANDARD OPERATING PROCEDURE

Soil Sampling

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoop, coring device, hand auger, or other appropriate hand tool
- Split-spoon samplers
- Thin-walled sampling tubes
- Drilling rig or soil-coring rig
- Stainless-steel pan/bowl or disposable sealable bags
- Sample bottles

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP *Decontamination of Drilling Rigs and Equipment*. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. A decontaminated sampling tool will be used to collect the sample when the desired sampling depth has been reached. Soil for semivolatile organic and inorganic analyses is placed in the bowl and mixed; soil for volatile organic analysis is not mixed or composited but is placed directly into the appropriate sample bottles. A stainless-steel trowel or disposable plastic scoop is used to transfer the sample from the bowl to the container.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

More details are provided in the SOP *Shallow Soil Sampling.*

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard. The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight ("hammer") dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless-steel tray or disposable sealable bag. The sample for semivolatile organic and inorganic analyses should be homogenized in the field by breaking the sample into small pieces and removing gravel. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

C. Thin-Walled Tube Sampling

Undisturbed fine grained samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) according to ASTM D 1587. Tubes will be 24- to 36 inches long and 3- to 4-inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends will be sealed with beeswax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample. Samples for geochemical analysis normally are not collected from thin-walled tube samples.

IV. Attachments

None

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.

VI. References

ASTM D1586 / D1586M-18, Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils, ASTM International, West Conshohocken, PA, 2018, www.astm.org

ASTM D1587 / D1587M-15, *Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes,* ASTM International, West Conshohocken, PA, 2015, www.astm.org

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 the most recent version of the Quality Systems Manual (QSM) for which the lab is certified at the time of analysis. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Materials and Equipment

A. 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 or tablet (see notes about tablet use below)

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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.

- Metal clipboard (if using loose leaf paper)
- 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

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.

B. 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
- Non-stick aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Contact your PFAS SME for an approved list of sunscreens and insect repellants.

The use of electronics (e.g., cell phones and tablets) should be avoided without the implementation of precautionary measures outlined below:

- All devices should be used with clean, ungloved hands and an approved stylus (if desired).

Following the use of a device, hands must be washed with soap and water and clean gloves should be used prior to contact with sampling equipment (bottleware, tubing, etc.).

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 to the middle of the bottle shoulder. Do not fill bottles completely. 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.

A. 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) or un-coated aluminum foil, 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.

IV. 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
NAVY CLEAN PROGRAM

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 the most recent version of the Quality Systems Manual (QSM) for which the lab is certified at the time of analysis. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

A. 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.

B. 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
- Non-Stick aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Contact your PFAS SME for an approved list of sunscreens and insect repellants.

The use of electronics (e.g., cell phones and tablets) should be avoided without the implementation of precautionary measures outlined below:

- All devices should be used with clean, ungloved hands and an approved stylus (if desired).

Following the use of a device, hands must be washed with soap and water and clean gloves should be used prior to contact with sampling equipment (bottleware, tubing, etc.).

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.
8. 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) or un-coated aluminum foil, and store away from potential PFAS sources.

IV. 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

Lysimeter Installation and Soil Moisture Sampling Procedures

I. Purpose and Scope

This SOP presents general guidelines for the methods and procedures for collecting water samples from the unsaturated zone for subsequent laboratory analysis through the installation and sampling of a pressure-vacuum soil water sampler, or lysimeter.

The lysimeter will remove water from the unsaturated zone by creating a vacuum inside the sampler slightly greater (approximately 1 bar) than the soil suction that holds the water in the capillary spaces. The resulting difference in pressure will result in a hydraulic gradient allowing the water to be extracted from the surrounding soil and containerized within the lysimeter's porous cup.

This SOP should be used in conjunction with the approved groundwater sampling for per- and polyfluoroalkyl substances (PFAS) SOP which provides guidelines for groundwater sample collection for samples that will be analyzed for PFAS as well as the soil logging SOP since it will be necessary to make note of the soil type and moisture observed during installation.

II. Equipment and Materials

- Single chamber stainless steel suction lysimeter and casing for shallow lysimeter installations (down to 10 feet bgs) installed by licensed drilling contractor.
- Dual chamber stainless steel suction lysimeter and casing for deeper lysimeter installations (depths greater than 10 feet bgs) installed by licensed drilling contractor.
- Silica flour, fine sand seal (No.1 sand), and grout
- Hollow stem auger or rotosonic drilling rig
- Vacuum pump (electric and hand pumps)
- Sample containers
- Shipping supplies (labels, coolers, and ice)
- PFAS-free field logbook and/or digital tablet

III. Procedures and Guidelines

A. Lysimeter Preinstallation Testing

The lysimeters should arrive preassembled by the manufacturer. Prior to installing, the samplers will be checked for leaks to ensure that the unit provides an adequate seal necessary for the subsequent pressurizing.

The access tubing will be colored coded so that following installation, the pressurizing/evacuating tubing can be differentiated from the sample recovery tubing. The tubing will also be cut to a sufficient length so that, following installation, it will be able to be attached to the sampling equipment located on the ground surface.

1. Test for leaks at the connections by submerging the unit in a deionized water bath and allow to soak according to the manufacturer's specification.
2. After soaking, apply positive pressure as determined in the manufacturer's specification to the submerged lysimeter. Any leaks will be evidenced by continuous bubble formation. Hand tighten the compression fittings and retest. If there are still leaks observed, this may warrant the repair and/or replacement of the unit. If no leaks are detected, the lysimeter is considered ready for installation.

B. Lysimeter Installation

The key component for the successful installation of the lysimeter is to ensure that the porous stainless steel cup is set and remains in firm contact with the surrounding soil so that soil water can move readily from the pores of the soil through the pores of the cup. This is obtained by employing careful installation processes that involve minimal disruption to the lysimeter while it is set in place during borehole backfilling and completion. Any disturbances to the unit, particularly the porous cup, may result in breaking the contact seal between the cup and surrounding soil.

1. The borehole for the lysimeter will be advanced using a drill rig. The borehole size will be based on the diameter of the porous stainless steel cup lysimeter. The borehole should allow for a thickness of 1.5 inches or greater of filter media on any one side of the porous stainless steel cup. Refer to the manufacturer's installation guide for further guidance. The boreholes will be drilled to a depth above the water table taking into account seasonal water table fluctuations and notable historical potentiometric trends.
2. At the final depth of each borehole, the augers will remain in place to prevent the borehole from collapsing while a silica flour slurry is prepared and poured into the borehole. The slurry will consist of silica flour that is mixed with water until it reaches the consistency of wet cement. Silica flour is mixed with distilled water using a ratio of one part water to three parts silica flour. A fifty-pound bag will require approximately 2 gallons of distilled water to make the slurry and will be sufficient for a single lysimeter installation in a 6-inch borehole. The volume of slurry poured will be enough so that it will completely submerge the porous stainless steel cup of the lysimeter. Pour part of

the slurry into the borehole to provide a bed beneath the lysimeter of at least 3-inches. Insert the lysimeter into the borehole making sure to keep the lysimeter centered within the borehole. With the lysimeter set in place in the slurry bed, pour the remaining silica slurry around the porous stainless steel cup to completely cover and surround the lysimeter body up to approx. 1.5 feet above the top of the porous cup. Once the porous stainless steel cup has been submerged in slurry, the drill tooling will be carefully lifted.

3. Place a 6-inch layer of No. 1 grade silica sand above the silica slurry. It is important to ensure minimal disruption to the lysimeter as the drill tooling is lifted.

4. A hydrated bentonite pellet seal will be emplaced immediately above the silica sand with a thickness of 2 feet. Polymer coated bentonite formulations will not be used.

5. The remainder of the annular space up to ground surface will be grouted with a Portland cement-bentonite mix (20:1) using a tremie pipe for deeper installations. Complete the well head with the appropriate at grade or above grade well manhole/riser.

6. Development will be completed following installation. The polyethylene tubing prelabeled for pressurizing/extraction will be securely fastened and clamped to the vacuum port of the pump. As the pump is turned on, it will initiate vacuum pressure to the lysimeter. If there is sufficient seal from the porous stainless steel cup and the surrounding soils, the manufacturer’s recommended vacuum should be obtainable. Development activities will continue until a minimum of one third of the water used to create the silica slurry is removed. Development water will be extracted by connecting the pressurizing/extraction tubing to a pressurized nitrogen cylinder or using a hand pump with a pressure gauge. Applying pressure will force the development water through the sample recovery tubing and into a collection bottle, which will be subsequently discarded.

7. Porewater sampling may begin 24 hours after lysimeter installation and development has been completed.

C. Field Sampling Procedures

The lysimeter will be operated by introducing a vacuum to the unit so the porous stainless steel cup is at a slightly greater suction pressure than the soil suction holding the water in the capillary spaces in the surrounding soil. This difference in pressure will result in the pulling of water from the soil pores and through the porous stainless steel cup for subsequent extraction. The pressurizing of the unit will be conducted by using a vacuum/pressure pump that has the operational capability to apply the manufacturer’s recommended vacuum/pressure Tension exceeding the range specified by the manufacturer may result in the breaking of meniscus in the pores resulting in a loss of vacuum pressure.

1. Vacuum Pump Setup
    a. To initiate the sampling process, the pressurizing/extraction tubing will be attached to the vacuum port, and vacuum pressure applied to the manufacturer's recommended vacuum/pressure.
2. Sample Collection
    a. Attach the vacuum pump to the pressurizing/extraction tubing. Apply a constant vacuum as recommended by the manufacturer to the lysimeter while keeping the fluid return line closed. Vacuum can be supplied with a battery powered vacuum pump. A powered vacuum pump is preferrable to a hand pump since the extraction time may take several hours.
    b. It will be trial and error for the first time sampling a lysimeter to determine the optimal vacuum time. Assumptions can be made on the characteristics of the soil observed during lysimeter installation. Sampling times can vary from less than 1 hour in wet soil, to more than 1 day in drier soil. When the sample is ready to be collected, open the fluid return line. The fluid collected in the porous stainless steel cup is brought to the surface by applying positive pressure to the vacuum/pressure line. The applied pressure forces the fluid up to the surface in the fluid return line and into a collection bottle.
    c. Sample volume, identification and analysis will be conducted in accordance with the methods and analyses listed in the approved Sampling and Analysis Plan.
    d. Based on the site-specific conditions and the presence or absence of impervious ground cover at the site, recharge of the soil moisture in the unsaturated zone can result in diminishing sample volumes as the sampling progresses at sites with impervious or semi-pervious surface cover. As a result, it may take up to 24 hours or more to obtain 150 to 250 mL of sample volume.
    e. Once the sample has been collected, secure the tubing and seal the ends before closing the manhole or protective casing.

D. Lysimeter Removal

Should the removal of a lysimeter be deemed necessary following sampling, it is not recommended to attempt to recover the unit intact if installed at depths greater than a few feet. With shallow installations, it may be possible to manually excavate the lysimeter for cleaning and reuse.

Deeper installations prove to be more challenging when attempting to recover the units for reuse. The PVC threaded connection to the top of the lysimeter will likely pull apart leaving the lysimeter in the ground if trying to loosen surrounding soils and pull the unit up. Stainless-steel self-tapping screws are recommended to be used at the threaded connection for extra support during extraction.

If recovery for reuse of the unit is not a concern, the riser and lysimeter assembly may be over drilled and extracted. Please refer to the Monitoring Well and Borehole Abandonment SOP for further details.

IV. Key Checks and Preventative Maintenance

- Ensure PFAS free drilling materials are used during installation.
- Use caution when mixing the silica flour slurry and keep the dust at a minimum (also, ensure management of airborne silica is incorporated into your health and safety plan).
- Ensure minimum disturbance to lysimeter during auger retrieval.
- Pre-wet the lysimeter and check for leaks prior to installation.
- Ensure the polyethylene tubing prelabeled for pressurizing/extraction is securely fastened and clamped to the vacuum port of the pump prior to initiating vacuum.
- Make sure to not pull water through the vacuum pump.
- Keep the working space clean with plastic sheeting and good housekeeping.
- Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:
  - ✓ Inspect vacuum pump regularly and replace as warranted
  - ✓ Inspect tubing fittings regularly and replace as warranted
  - ✓ Verify battery charge on vacuum pump and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

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:

General

- 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 __________

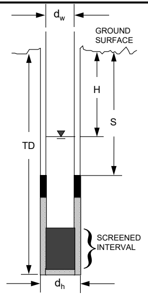
INITIAL WATER LEVEL __________
FINAL WATER LEVEL __________

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 $d_w ID$ =_____
Outside Diameter $d_w OD$ =_____
Depth to Water: H =_____
Depth to Base of Seal: S =_____
Depth to Base of Well: TD =_____
Estimated Filter Pack Porosity: P =_____



WELL VOLUME CALCULATION :

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

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

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

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

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

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

* = 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

Time Intervals

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 not 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

Office Procedures

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.

Equipment List

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).

4.0 REFERENCES

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Chirlin, G.R. 1989. A Critique of the Hvorslev Method for Slug Test Analysis: The Fully Penetrating Well. Ground Water Monitoring Review, Spring Issue, pp. 130—139.

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Lohman, S.W. 1982. Ground Water Hydraulics, U.S. Geological Survey Paper 708.

NFESC. 1999. Navy Installation Restoration Chemical Data Quality Manual (IR CDQM), NFESC Special Report SP-2056-ENV.

Papadopulos, S.S., J.D. Bredehoeft, and H.H. Cooper. 1973. On the Analysis of 'slug test' data, Water Resource Research Vol. 9, pp. 1087-1089.

SOP-I-A-7, *IDW Management*

SOP III-I, *Equipment Decontamination*

U.S. Department of Interior, Bureau of Reclamation. 1977. Ground Water Manual, (Stock Number 024-003-00106-6).

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

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).

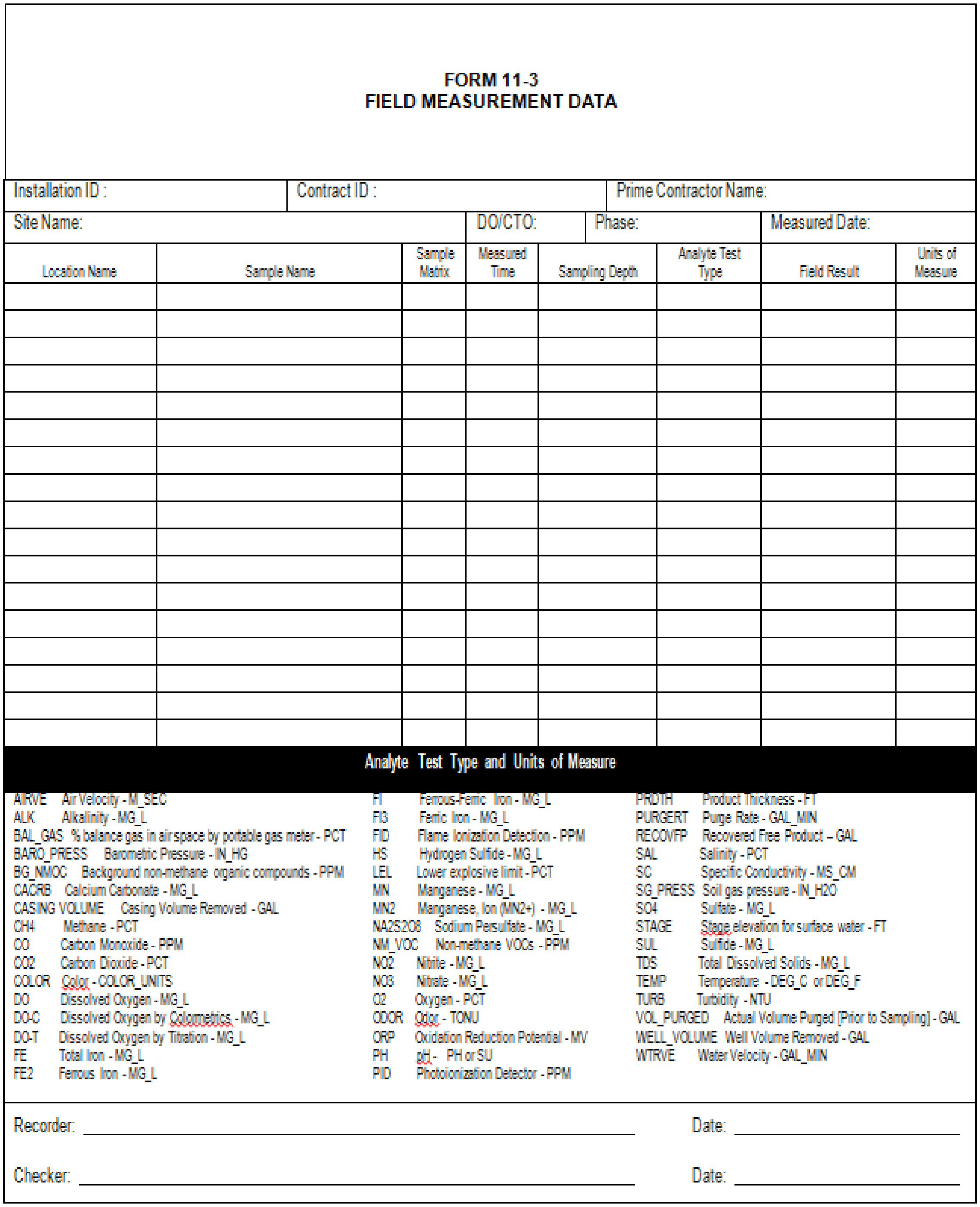
4.0 REFERENCES

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: ____________

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.

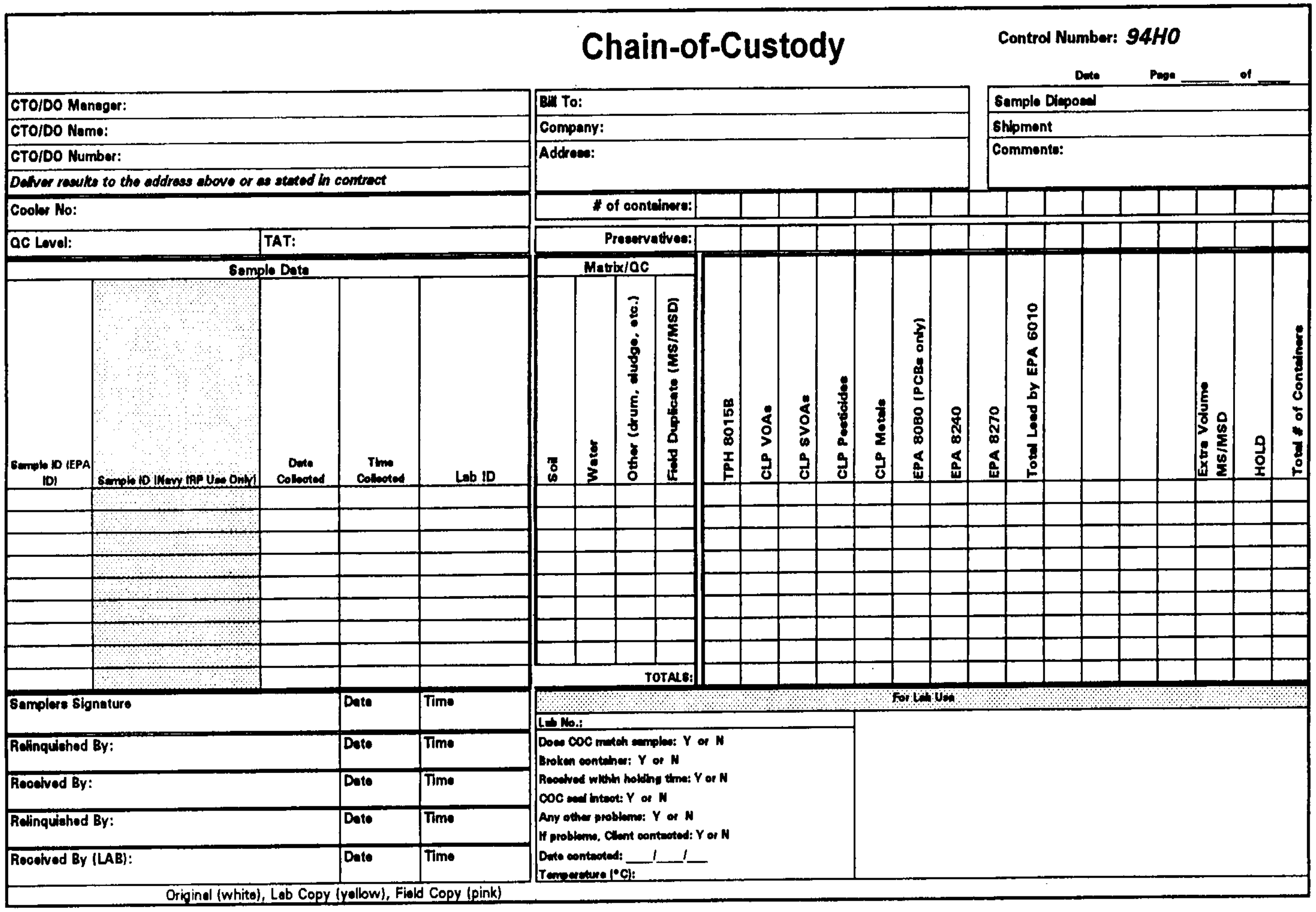
5.0 ATTACHMENTS

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:																

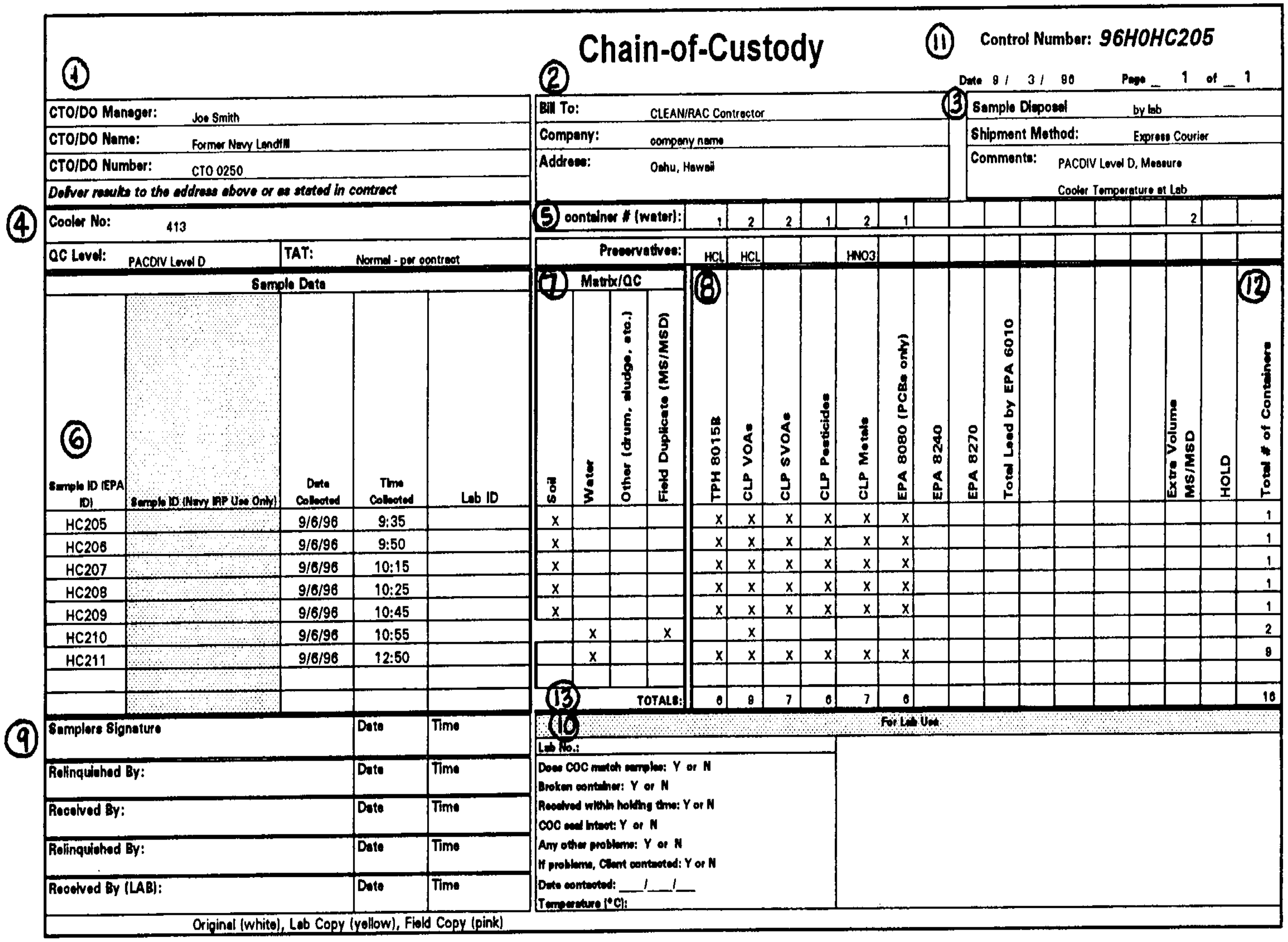
Samplers Signature	**Date**	**Time**
Relinquished By:	**Date**	**Time**
Received By:	**Date**	**Time**
Relinquished By:	**Date**	**Time**
Received By (LAB):	**Date**	**Time**

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

④ **Cooler No:** 413
QC Level: PACDIV Level D **TAT:** Normal - per 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

Sample Data ⑥ | ⑦ **Matrix/QC** | ⑧ ... ⑫

					⑤ container # (water):				1	2	2	1	2	1								2		
					Preservatives:				HCL	HCL			HNO3											
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										8
					⑬			TOTALS:	6	8	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:
Dated Occurred:	Matrix
Parameter (Test Code):	Method:
Analyst:	Supervisor:

Samples Affected (List by Accession AND Sample No.)

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

3. Results of Corrective Action

☐ Return to Control (indicated with)

☐ Corrective Actions Not Successful - DATA IS TO BE FLAGGED with _____________.

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

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 does 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

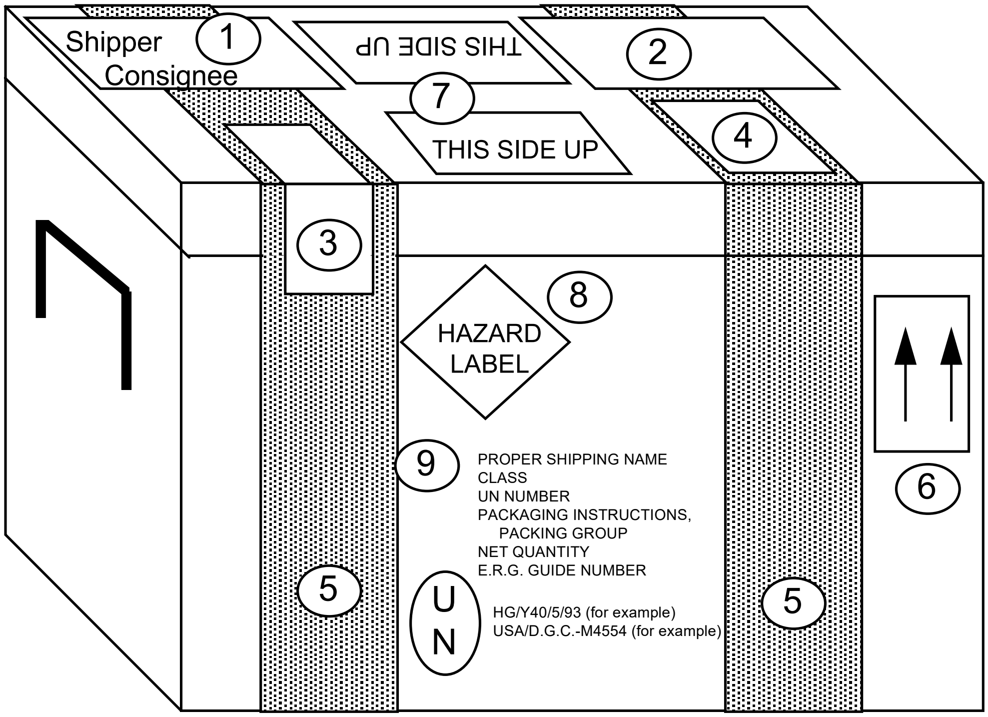
Attachment III-G-7 Commercial Invoice - Soil

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.

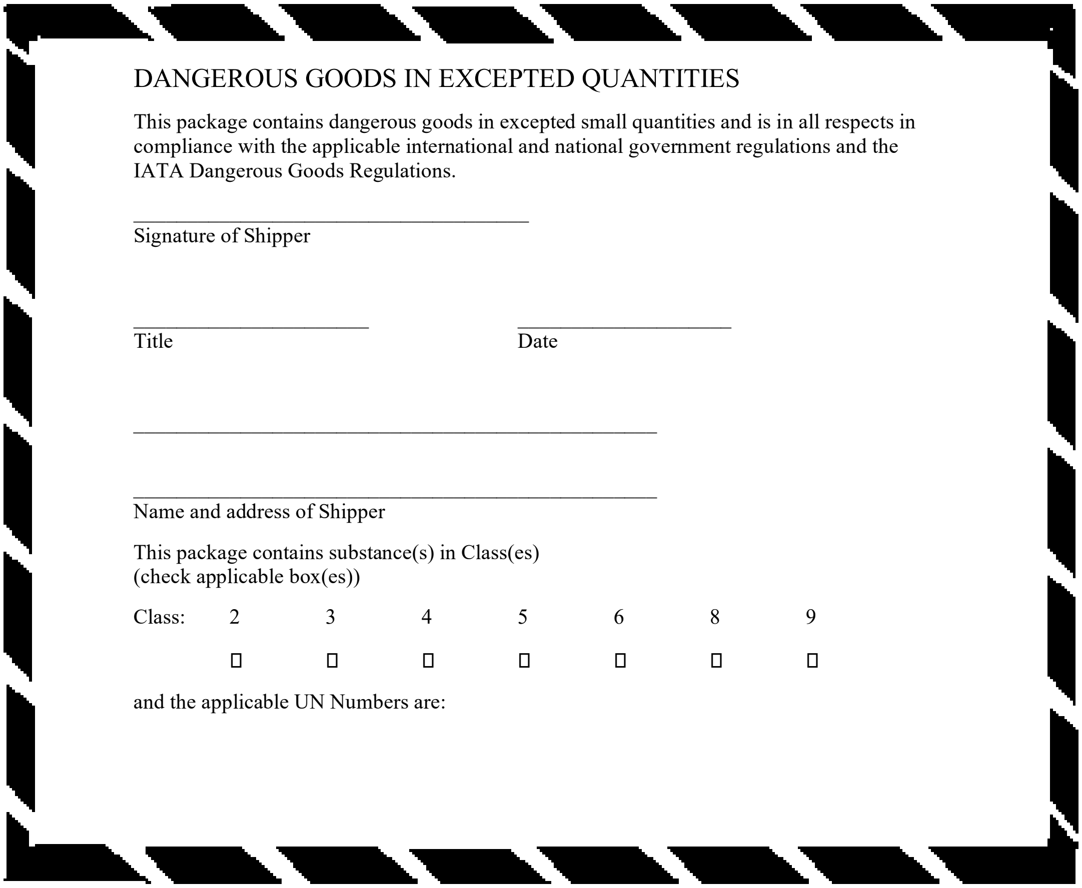
Note B: For inner packagings, the quantity contained in receptacle with a water capacity of 30 mL. For outer packagings, the sum of the water capacities of all the inner packagings contained must not exceed 1 L.

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
	☐	☐	☐	☐	☐	☐	☐

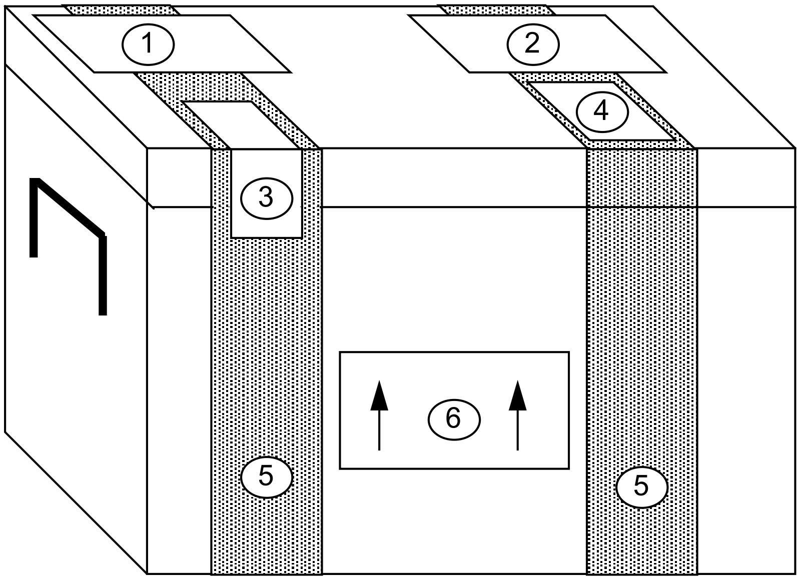
and the applicable UN Numbers are:

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

SPL11

FedEx USA Airbill FedEx Tracking Number 801704855619 0200 Form I.D. No. **Sender's Copy**

1 From (please print and press hard)

Account Number

Date ______ Sender's FedEx Account Number [redacted]

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 ☐ FedEx Box ☐ FedEx Tube ☐ Other Pkg.
Declared value limit $500.

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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Rev. Date 5/97
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)

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

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.

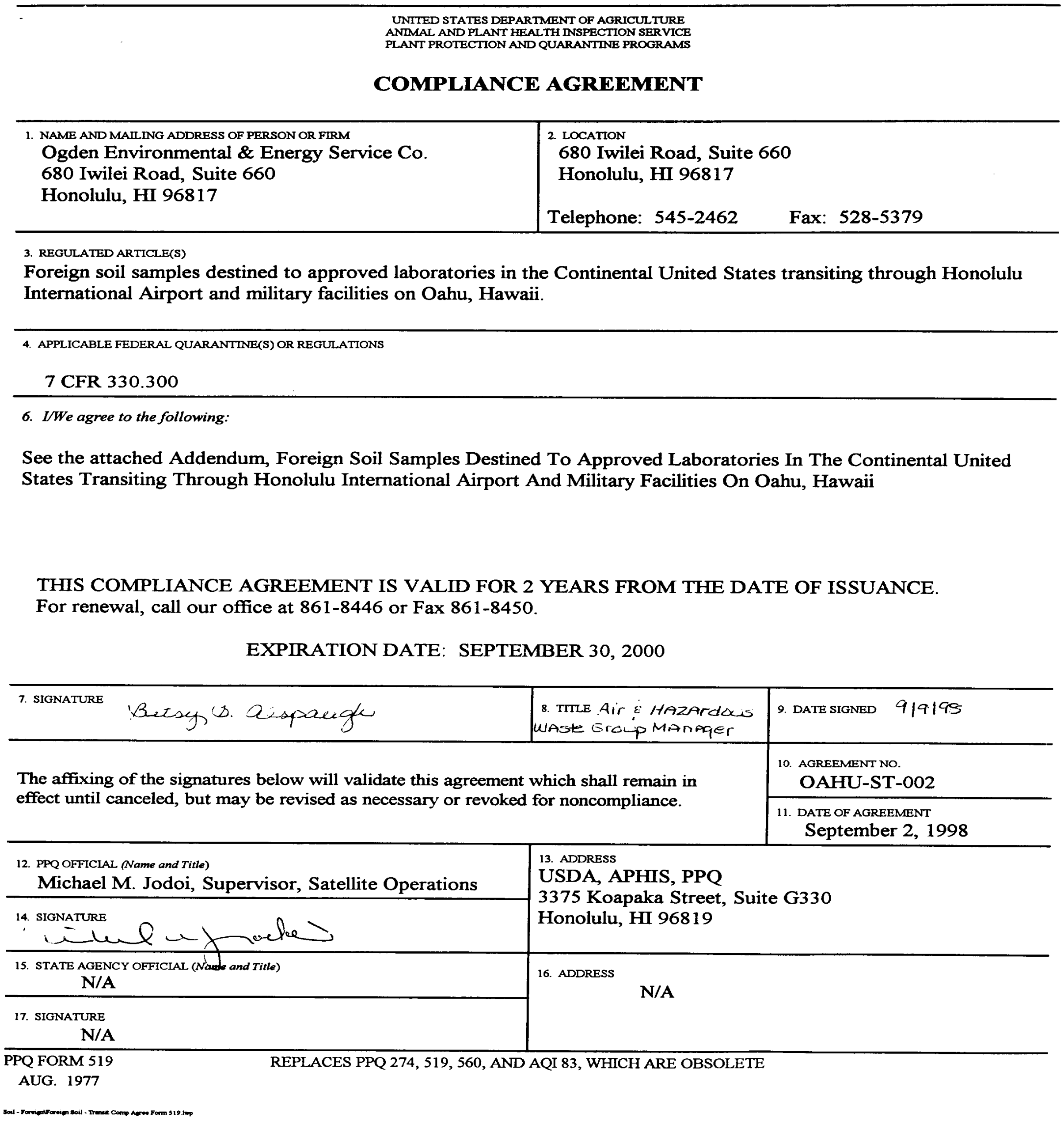
DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

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.twp

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.

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(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.

Appendix D
Department of Defense Environmental Laboratory Accreditation Program Accreditation Letters

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

VISTA ANALYTICAL LABORATORY
1104 Windfield Way
El Dorado Hills, CA 95762
Angelica Torres Phone: 916-673-1520

ENVIRONMENTAL

Valid To: September 30, 2023 Certificate Number: 3091.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with the 2009 TNI Environmental Testing Laboratory Standard, the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.3 of the DoD Quality Systems Manual for Environmental Laboratories), accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

High Resolution Gas Chromatography / Mass Spectrometry
Liquid Chromatography Mass Spectrometry / Mass Spectrometry

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
Dioxins/Furans			
Clean Up Method	EPA 3620C	EPA 3620C	EPA 3620C
1,2,3,4,6,7,8-Heptachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,4,7,8,9-Heptachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,4,7,8-Hexachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,6,7,8-Hexachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,7,8,9-Hexachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
2,3,4,6,7,8-Hexachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,7,8-Pentachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
2,3,4,7,8-Pentachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
2,3,7,8-Tetrachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
2,3,7,8-Tetrachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
Total Heptachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
Total Heptachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
Total Hexachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
Total Hexachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
Total Pentachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
Total Pentachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
Total Tetrachlorodibenzofuran	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
Total Tetrachlorodibenzo-p-dioxin	EPA 1613B EPA 8290	EPA 1613B EPA 8290	EPA 1613B EPA 8290
PCBs			
2-Chlorobiphenyl (1)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3-Chlorobiphenyl (2)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
4-Chlorobiphenyl (3)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2'-Dichlorobiphenyl (4)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3-Dichlorobiphenyl (5)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3'-Dichlorobiphenyl (6)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4-Dichlorobiphenyl (7)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4'-Dichlorobiphenyl (8)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,5-Dichlorobiphenyl (9)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,6-Dichlorobiphenyl (10)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3'-Dichlorobiphenyl (11)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4-Dichlorobiphenyl (12)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4'-Dichlorobiphenyl (13)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,5-Dichlorobiphenyl (14)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
4,4'-Dichlorobiphenyl (15)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,2',3-Trichlorobiphenyl (16)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4-Trichlorobiphenyl (17)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',5-Trichlorobiphenyl (18)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',6-Trichlorobiphenyl (19)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3'-Trichlorobiphenyl (20)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4-Trichlorobiphenyl (21)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4'-Trichlorobiphenyl (22)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,5-Trichlorobiphenyl (23)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,6-Trichlorobiphenyl (24)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4-Trichlorobiphenyl (25)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',5-Trichlorobiphenyl (26)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',6-Trichlorobiphenyl (27)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,4'-Trichlorobiphenyl (28)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,5-Trichlorobiphenyl (29)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,6-Trichlorobiphenyl (30)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4',5-Trichlorobiphenyl (31)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4',6-Trichlorobiphenyl (32)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4-Trichlorobiphenyl (33)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,5-Trichlorobiphenyl (34)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4-Trichlorobiphenyl (35)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',5-Trichlorobiphenyl (36)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4,4'-Trichlorobiphenyl (37)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4,5-Trichlorobiphenyl (38)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4',5-Trichlorobiphenyl (39)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3'-Tetrachlorobiphenyl (40)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4-Tetrachlorobiphenyl (41)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4'-Tetrachlorobiphenyl (42)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5-Tetrachlorobiphenyl (43)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5'-Tetrachlorobiphenyl (44)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,6-Tetrachlorobiphenyl (45)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,6'-Tetrachlorobiphenyl (46)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4'-Tetrachlorobiphenyl (47)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5-Tetrachlorobiphenyl (48)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5'-Tetrachlorobiphenyl (49)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,6-Tetrachlorobiphenyl (50)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,6'-Tetrachlorobiphenyl (51)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',5,5'-Tetrachlorobiphenyl (52)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',5,6'-Tetrachlorobiphenyl (53)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',6,6'-Tetrachlorobiphenyl (54)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4'-Tetrachlorobiphenyl (55)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4'-Tetrachlorobiphenyl (56)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5-Tetrachlorobiphenyl (57)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5'-Tetrachlorobiphenyl (58)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',6-Tetrachlorobiphenyl (59)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,4'-Tetrachlorobiphenyl (60)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,5-Tetrachlorobiphenyl (61)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,6-Tetrachlorobiphenyl (62)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,3,4',5-Tetrachlorobiphenyl (63)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4',6-Tetrachlorobiphenyl (64)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,5,6-Tetrachlorobiphenyl (65)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4'-Tetrachlorobiphenyl (66)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,5-Tetrachlorobiphenyl (67)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,5'-Tetrachlorobiphenyl (68)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,6-Tetrachlorobiphenyl (69)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4',5-Tetrachlorobiphenyl (70)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4',6-Tetrachlorobiphenyl (71)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',5,5'-Tetrachlorobiphenyl (72)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',5',6-Tetrachlorobiphenyl (73)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,4',5-Tetrachlorobiphenyl (74)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,4',6-Tetrachlorobiphenyl (75)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4,5-Tetrachlorobiphenyl (76)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,4'-Tetrachlorobiphenyl (77)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,5-Tetrachlorobiphenyl (78)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,5'-Tetrachlorobiphenyl (79)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',5,5'-Tetrachlorobiphenyl (80)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4,4',5-Tetrachlorobiphenyl (81)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4-Pentachlorobiphenyl (82)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5-Pentachlorobiphenyl (83)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',6-Pentachlorobiphenyl (84)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4'-Pentachlorobiphenyl (85)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5-Pentachlorobiphenyl (86)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5'-Pentachlorobiphenyl (87)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,6-Pentachlorobiphenyl (88)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,6'-Pentachlorobiphenyl (89)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5-Pentachlorobiphenyl (90)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',6-Pentachlorobiphenyl (91)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,5'-Pentachlorobiphenyl (92)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,6-Pentachlorobiphenyl (93)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,6'-Pentachlorobiphenyl (94)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5',6-Pentachlorobiphenyl (95)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,6,6'-Pentachlorobiphenyl (96)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3',4,5-Pentachlorobiphenyl (97)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3',4,6-Pentachlorobiphenyl (98)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',5-Pentachlorobiphenyl (99)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',6-Pentachlorobiphenyl (100)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5,5'-Pentachlorobiphenyl (101)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5,6'-Pentachlorobiphenyl (102)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5,'6-Pentachlorobiphenyl (103)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,6,6'-Pentachlorobiphenyl (104)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4'-Pentachlorobiphenyl (105)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5-Pentachlorobiphenyl (106)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5-Pentachlorobiphenyl (107)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5'-Pentachlorobiphenyl (108)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,6-Pentachlorobiphenyl (109)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,3,3',4',6-Pentachlorobiphenyl (110)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5,5'-Pentachlorobiphenyl (111)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5,6-Pentachlorobiphenyl (112)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5',6-Pentachlorobiphenyl (113)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,4',5-Pentachlorobiphenyl (114)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,4',6-Pentachlorobiphenyl (115)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,5,6-Pentachlorobiphenyl (116)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4',5,6-Pentachlorobiphenyl (117)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4',5-Pentachlorobiphenyl (118)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4',6-Pentachlorobiphenyl (119)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,5,5'-Pentachlorobiphenyl (120)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,5,'6-Pentachlorobiphenyl (121)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,3',4,5-Pentachlorobiphenyl (122)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4,4',5-Pentachlorobiphenyl (123)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4,5,5'-Pentachlorobiphenyl (124)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4,5,6'-Pentachlorobiphenyl (125)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,4',5-Pentachlorobiphenyl (126)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,5,5'-Pentachlorobiphenyl (127)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4'-Hexachlorobiphenyl (128)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5-Hexachlorobiphenyl (129)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5'-Hexachlorobiphenyl (130)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,6-Hexachlorobiphenyl (131)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,6'-Hexachlorobiphenyl (132)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,5'-Hexachlorobiphenyl (133)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,6-Hexachlorobiphenyl (134)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,6'-Hexachlorobiphenyl (135)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',6,6'-Hexachlorobiphenyl (136)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5-Hexachlorobiphenyl (137)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5'-Hexachlorobiphenyl (138)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',6-Hexachlorobiphenyl (139)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',6'-Hexachlorobiphenyl (140)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,5'-Hexachlorobiphenyl (141)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,6-Hexachlorobiphenyl (142)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,6'-Hexachlorobiphenyl (143)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5',6-Hexachlorobiphenyl (144)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,6,6'-Hexachlorobiphenyl (145)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5,5'-Hexachlorobiphenyl (146)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5,6-Hexachlorobiphenyl (147)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5,6'-Hexachlorobiphenyl (148)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5',6-Hexachlorobiphenyl (149)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',6,6'-Hexachlorobiphenyl (150)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,5',6-Hexachlorobiphenyl (151)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,6,6'-Hexachlorobiphenyl (152)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',5,5'-Hexachlorobiphenyl (153)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',5',6-Hexachlorobiphenyl (154)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',6,6'-Hexachlorobiphenyl (155)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5-Hexachlorobiphenyl (156)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',6-Hexachlorobiphenyl (158)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5,5'-Hexachlorobiphenyl (159)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5,6-Hexachlorobiphenyl (160)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5',6-Hexachlorobiphenyl (161)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5,5'-Hexachlorobiphenyl (162)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5,6-Hexachlorobiphenyl (163)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5',6-Hexachlorobiphenyl (164)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5,5',6-Hexachlorobiphenyl (165)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,4',5,6-Hexachlorobiphenyl (166)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4',5',6-Hexachlorobiphenyl (168)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5-Heptachlorobiphenyl (170)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2'3,3',4,4',6-Heptachlorobiphenyl (171)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,5'-Heptachlorobiphenyl (172)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,6-Heptachlorobiphenyl (173)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,6'-Heptachlorobiphenyl (174)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5',6-Heptachlorobiphenyl (175)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,6,6'-Heptachlorobiphenyl (176)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4',5,6-Heptachlorobiphenyl (177)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,5',6-Heptachlorobiphenyl (178)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,6,6'-Heptachlorobiphenyl (179)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5,5'-Heptachlorobiphenyl (180)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5,6-Heptachlorobiphenyl (181)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5,6'-Heptachlorobiphenyl (182)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5',6-Heptachlorobiphenyl (183)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',6,6'-Heptachlorobiphenyl (184)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,5',6-Heptachlorobiphenyl (185)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,6,6'-Heptachlorobiphenyl (186)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5,5',6-Heptachlorobiphenyl (187)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5,6,6'-Heptachlorobiphenyl (188)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5,6-Heptachlorobiphenyl (190)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5',6-Heptachlorobiphenyl (191)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5,5',6-Heptachlorobiphenyl (192)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5,5',6-Heptachlorobiphenyl (193)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5,5'-Octachlorobiphenyl (194)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5,6-Octachlorobiphenyl (195)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5,6'-Octachlorobiphenyl (196)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',6,6'-Octachlorobiphenyl (197)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,5',6-Octachlorobiphenyl (198)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,5',6'-Octachlorobiphenyl (199)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,6,6'-Octachlorobiphenyl (200)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5',6,6'-Octachlorobiphenyl (201)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,5',6,6'-Octachlorobiphenyl (202)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5,5',6-Octachlorobiphenyl (203)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,2',3,4,4',5,6,6'-Octachlorobiphenyl (204)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5,5',6-Octachlorobiphenyl (205)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (206)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl (207)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (208)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Decachlorobiphenyl (209)	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Decachlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Dichlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Heptachlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Hexachlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Monochlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Nonachlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Octachlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Pentachlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Tetrachlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Trichlorobiphenyl, Total	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Potable Water**	**Aqueous Film Forming Foams (AFFF)**	**Non Potable Water**	**Solid Hazardous Waste (Liquids and Solids)**	**Tissue**
Per-and Polyfluoroalkyl Substances (PFAS)					
6:2 Fluorotelomer sulfanate (6:2 FTS)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
8:2 Fluorotelomer sulfanate (8:2 FTS)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
N-ethyl perfluorooctanesulfonamidoacetic acid (N-EtFOSAA)	EPA 537.1 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15

Parameter/Analyte	**Potable Water**	**Aqueous Film Forming Foams (AFFF)**	**Non Potable Water**	**Solid Hazardous Waste (Liquids and Solids)**	**Tissue**
N-ethylperfluoro-1-octanesulfonamide (N-EtFOSA)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
N-ethylperfluoro-1-octanesulfonamido ethanol (N-EtFOSE)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
N-methyl perfluorooctanesulfonamidoacetic acid (N-MeFOSAA)	EPA 537.1 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
N-methylperfluoro-1-octanesulfonamide (N-MeFOSA)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
N-methylperfluoro-1-octanesulfonamido ethanol (N-MeFOSE)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorobutanesulfonic acid (PFBS)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorobutanoic acid (PFBA)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15

Parameter/Analyte	**Potable Water**	**Aqueous Film Forming Foams (AFFF)**	**Non Potable Water**	**Solid Hazardous Waste (Liquids and Solids)**	**Tissue**
Perfluorodecanesulfonate (PFDS)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorodecanoic acid (PFDA)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorododecanoic acid (PFDoA)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluoroheptanesulfonate (PFHpS)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluoroheptanonic acid (PFHpA)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorohexadecanoic acid (PFHxDA)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorohexanesulfononic acid (PFHxS)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15

Parameter/Analyte	**Potable Water**	**Aqueous Film Forming Foams (AFFF)**	**Non Potable Water**	**Solid Hazardous Waste (Liquids and Solids)**	**Tissue**
Perfluorohexanoic acid (PFHxA)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorononanoic acid (PFNA)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorooctane sulfonamide (PFOSA)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorooctanesulfonic acid (PFOS)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorooctanoic acid (PFOA)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluoropentanoic acid (PFPeA)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorotetradecanoic acid (PFTeDA)	EPA 537.1 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15

Parameter/Analyte	**Potable Water**	**Aqueous Film Forming Foams (AFFF)**	**Non Potable Water**	**Solid Hazardous Waste (Liquids and Solids)**	**Tissue**
Perfluorotridecanoic acid (PFTrDA)	EPA 537.1 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluoroundecanoic acid (PFUdA)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Hexafluoropropylene oxide dimer acid (HFPO-DA)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	EPA 537.1 EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluorononane sulfonic acid (PFNS)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15

Parameter/Analyte	**Potable Water**	**Aqueous Film Forming Foams (AFFF)**	**Non Potable Water**	**Solid Hazardous Waste (Liquids and Solids)**	**Tissue**
Perfluorooctadecanoic acid (PFODA)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluoropentane sulfonic acid (PFPeS)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
4,4,5,5,6,6,6-Heptafluorohexanoic acid (3:3 FTCA)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
2H,2H,3H,3H-Perfluorodecanoic acid (7:3 FTCA)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
2H,2H,3H,3H-Perfluorooctanoic acid (5:3 FTCA)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Potassium perfluoro-4-ethylcyclohexanesufonate (PFecHS)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15

Parameter/Analyte	**Potable Water**	**Aqueous Film Forming Foams (AFFF)**	**Non Potable Water**	**Solid Hazardous Waste (Liquids and Solids)**	**Tissue**
Sodium perfluoro-1-propanesulfonate (PFPrS)_	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Sodium perfluoro-1-dodecanesulfonate (PFDoS)	EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluoror(2-ethoxyethane)sulfonic acid (PFEESA)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluoro-3-methoxypropanoic acid (PFMPA)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Perfluoro-4-methoxybutanoic acid (PFMBA)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	EPA 533 EPA 537.1 mod	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15

Parameter/Analyte	**Air**
Dioxins/Furans	
1,2,3,4,7,8-HxCDD	EPA TO-9A
1,2,3,6,7,8-HxCDD	EPA TO-9A
1,2,3,7,8,9-HxCDD	EPA TO-9A
1,2,3,4,7,8-HxCDF	EPA TO-9A
1,2,3,6,7,8-HxCDF	EPA TO-9A
1,2,3,7,8,9-HxCDF	EPA TO-9A
2,3,4,6,7,8-HxCDF	EPA TO-9A
1,2,3,4,6,7,8-HpCDD	EPA TO-9A
1,2,3,4,6,7,8-HpCDF	EPA TO-9A
1,2,3,4,7,8,9-HpCDF	EPA TO-9A
OCDD	EPA TO-9A
OCDF	EPA TO-9A
1,2,3,7,8-PeCDD	EPA TO-9A
1,2,3,7,8-PeCDF	EPA TO-9A
2,3,4,7,8-PeCDF	EPA TO-9A
2,3,7,8-TCDD	EPA TO-9A
2,3,7,8-TCDF	EPA TO-9A
Total HPCDD	EPA TO-9A
Total HPCDF	EPA TO-9A
Total HxCDD	EPA TO-9A
Total HxCDF	EPA TO-9A
Total TCDD	EPA TO-9A
Total TCDF	EPA TO-9A
Total PCDF	EPA TO-9A
Total PCDD	EPA TO-9A

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El Dorado Hills, CA

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2017, the 2009 TNI Environmental Testing Laboratory Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.3 of the DoD Quality System Manual for Environmental Laboratories (QSM), accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated *April 2017*).

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Presented this 7th day of July 2021.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3091.01
Valid to September 30, 2023

For the tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

Appendix E

Laboratory Standard Operating Procedures

NAVFAC
Naval Facilities Engineering Systems Command

Sampling and Analysis Plan
Per- and Polyfluoroalkyl Substances Remedial Investigation Area 6
Naval Air Station Whidbey Island
Oak Harbor, Washington

NOTIFICATION: APPENDIX E CONTAINS SENSITIVE BUT UNCLASSIFIED INFORMATION WHICH IS PROTECTED BY THE FREEDOM OF INFORMATION ACT

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