Naval Facilities Engineering Systems Command Mid-Atlantic
Norfolk, Virginia

Final

Sampling and Analysis Plan
Remedial Investigation
Per- and Polyfluoroalkyl Substances
Site 111 Camp Davis Forward Arming and Refueling Point Activities South

Marine Corps Base Camp Lejeune
North Carolina

July 2022

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SAP Worksheet #1—Title and Approval Page

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North Carolina Licensed Geologist
Seal 2122
Daniel N. Hockett
Daniel Hockett
07-22-2022

Prepared for NAVFAC Mid-Atlantic
by CH2M HILL, Inc.
Charlotte, North Carolina
Contract N62470-16-D-9000
CTO N4008518F4978

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Signature Page

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Daniel Hockett
15 July 2022

Daniel Hockett Date
CH2M HILL, Inc. - Project Manager

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Jessica Skeean Date
CH2M HILL, Inc. - Quality Assurance Manager

Approval Signatures:

Naval Facilities Command Atlantic Date
Chemist/Quality Assurance Officer

Other Approval Signatures:

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Remedial Project Manager

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North Carolina Department of Environmental Quality
Remedial Project Manager

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Executive Summary

This Sampling and Analysis Plan (SAP) outlines the sampling activities in support of a Remedial Investigation (RI) specific to known or suspected releases of per- and polyfluoroalkyl substances (PFAS) to the environment at Site 111, Camp Davis Forward Arming and Refueling Point (FARP) Activities South, Marine Corps Base (MCB) Camp Lejeune in Onslow County, North Carolina. CH2M HILL, Inc. prepared this document under the Department of the Navy (Navy), Naval Facilities Engineering Command, Comprehensive Long-term Environmental Action—Navy 9000 Contract N62470-16-D-9000, Contract Task Order 4978, in accordance with the Navy's SAP policy guidance to help ensure that collected environmental data are scientifically sound, of known and documented quality, and suitable for intended uses.

Site 111, Camp Davis FARP Activities South area, is approximately 350 acres and consists of locations along the south runway where Marines staged P-19s (aircraft rescue and fire fighting vehicles), which contained aqueous film-forming foam (AFFF), for emergency response support during FARP operations. FARP activities have been documented in this area between 2013 and 2015; however, flight operations have been conducted at Camp Davis since 1943 and it is likely that emergency response support would have been staged during historical flight operations. The area was identified in the 2019 Preliminary Assessment (PA) for further investigation based on the potential for releases of AFFF during FARP operations (CH2M, 2019). Groundwater in the surficial aquifer and soil was investigated between July and November 2020 as part of the Basewide Site Inspection (SI) and two groundwater sample locations contained perfluorooctanoic acid (PFOA) and/or perfluorooctane sulfonate (PFOS) above screening levels (SLs) [1] used for the Basewide SI, including the United States Environmental Protection Agency (USEPA) lifetime health advisory (CH2M, 2022). Based on these results, a drinking water evaluation to identify drinking water wells within a 1-mile boundary of the site was initiated and expedited groundwater sampling in the Castle Hayne aquifer was conducted in March through September 2021. There were no exceedances of SLs for PFOA, PFOS, or perfluorobutanesulfonic acid (PFBS) in the off-Base drinking water samples or Castle Hayne aquifer groundwater samples. Additionally, during the drinking water evaluation, two supply wells (D-10 and D-11) operated by Onslow Water and Sewer Authority were discovered within 1 mile of the release area boundary. Although drinking water was tested and concentrations of PFOA and PFOS were below the USEPA lifetime health advisory, as a precautionary measure, pumping through these 2 wells was discontinued in January 2021.

Previous investigations have confirmed PFAS is present in the surficial aquifer above SLs. The nature and extent of, and resulting risks to human and ecological receptors from, PFAS within the surficial aquifer, source area soils, and additional transport pathways such as surface water and sediment present at Site 111 have not been fully investigated. If pumping from nearby off-Base drinking water wells is resumed, ongoing monitoring of sentinel wells is necessary to evaluate potential PFAS migration during continuous groundwater extraction under long-term pumping conditions.

The objectives and approach of the RI are to:

- **Objective:** Define the nature and extent of PFAS in the surficial aquifer groundwater, soil, surface water, and sediment in excess of PFAS project action limits [PALs], which are the current regional screening levels (RSLs), and assess potential risks to human health and ecological receptors. Results for the 29 PFAS included in the laboratory analysis will be provided in an appendix to the RI report. These will be retained for comparison to

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[1] SLs for PFOA, PFOS, and PFBS based on a hazard quotient (HQ) of 0.1.

appropriate screening values if they become available in the future for those compounds without a screening value and if screening values change for compounds with current screening values.

Approach: Install additional surficial aquifer monitoring wells and collect surficial, upper, and lower Castle Hayne aquifer groundwater, soil, surface water, and sediment samples for analysis of 29 PFAS listed in USEPA Unregulated Contaminant Monitoring Rule 5 (UCMR 5) via liquid chromatography tandem mass spectrometry compliant with Quality Systems Manual 5.3 Table B-15, in accordance with the laboratory's Environmental Laboratory Accreditation Program letters. 29 PFAS are proposed for the RI as the data will aid in determination of whether there are multiple releases at the site and in future management and remedial action decisions for the site. Two rounds of surficial aquifer groundwater and surface water and sediment samples will be collected to assess seasonal variability.

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 media. Initial ecological screening values, based on available documents in the literature are included in **Appendix A** 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.

- **Objective:** Refine the understanding of the groundwater flow direction and hydraulic properties and potential PFAS migration pathways.

  Approach: Collect synoptic groundwater levels to develop potentiometric surfaces and estimate groundwater flow and collect soil samples for geotechnical parameters (bulk density, total porosity, grain size, percent moisture, and total organic carbon) to be used in fate and transport modeling.

- **Objective:** If pumping from nearby off-Base public drinking water wells is resumed, evaluate potential changes in the hydraulic conditions and fate and transport of PFAS in groundwater due to continuous groundwater extraction under long-term pumping conditions.

  Approach: Collect samples from select monitoring wells located nearest the off-Base public drinking water wells and screened within the surficial, upper, and lower Castle Hayne aquifer for 29 PFAS compounds previously identified monthly for 1 quarter and quarterly for 9 months to evaluate potential migration from pumping activities.

This SAP consists of 37 worksheets specific to the scope of work for this RI. Tables are embedded within the worksheets. Figures are included at the end of the document. Additional SLs are provided in **Appendix A**. Field standard operating procedures are included in **Appendix B**. Laboratory Department of Defense Environmental Laboratory Accreditation Program Accreditation letters are included in **Appendix C.**

The laboratory information cited in this SAP is specific to Vista Analytical Laboratory in El Dorado Hills, California for PFAS analysis and Katahdin Analytical Services in Scarborough, Maine and Eurofins TestAmerica in South Burlington, Vermont for geotechnical parameters. If additional laboratory services are requested requiring modification to the existing SAP, revised SAP worksheets will be submitted to the Partnering Team for approval.

SAP Worksheets

Appendixes

Tables

Figures

Acronyms and Abbreviations

°C	degree(s) Celsius
>	greater than
≤	less than or equal to
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
%	percent
A	average ratio
AFFF	aqueous film-forming foam
AM	Activity Manager
ASD	Assistant Secretary of Defense
ASTM	ASTM International
amu	atomic mass unit
bgs	below ground surface
CA	corrective action
CAS	Chemical Abstracts Service
CCV	continuing calibration verification
CH2M	CH2M HILL, Inc.
CLEAN	Comprehensive Long-term Environmental Action—Navy
CSM	conceptual site model
DL	detection limit
DO	dissolved oxygen
DoD	Department of Defense
DQE	data quality evaluation
DQI	data quality indicator
DV	data validation
EDD	electronic data deliverable
EIS	extracted internal standard
ELAP	Environmental Laboratory Accreditation Program
EMD	Environmental Management Division
ERA	ecological risk assessment
ESV	ecological screening value
Eurofins	Eurofins TestAmerica
FARP	Forward Arming and Refueling Point
FCR	Field Change Request
FTL	Field Team Leader
GIS	geographic information system
g	gram
g/cm^3	gram per cubic centimeter
H&S	health and safety
HDPE	high-density polyethylene

HQ	hazard quotient
HSM	Health and Safety Manager
HSP	Health and Safety Plan
ICAL	initial calibration
ICV	initial calibration verification
ID	identification
IDW	investigation-derived waste
IR	Installation Restoration
ISC	instrument sensitivity check
Katahdin	Katahdin Analytical Services
LCH	lower Castle Hayne
LCL	lower control limit
LC-MS/MS	liquid chromatography tandem mass spectrometry
LCS	laboratory control sample
LDC	Laboratory Data Consultants
LOD	limit of detection
LOQ	limit of quantitation
MB	Method Blank
MCB	Marine Corps Base
mL	milliliter
MPC	Measurement Performance Criteria
MS	matrix spike
MSD	matrix spike duplicate
msl	mean sea level
N/A	not applicable
NAVFAC	Naval Facilities Engineering Systems Command
Navy	Department of the Navy
NCDEQ	North Carolina Department of Environmental Quality
ND	not detected
ng/g	nanogram(s) per gram
ng/L	nanogram(s) per liter
ONWASA	Onslow Water and Sewer Authority
ORP	oxidation-reduction potential
PA	Preliminary Assessment
PAL	project action limit
PDL	Project Delivery Lead
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PID	photoionization detector
PM	Project Manager
POC	point of contact
ppm	parts per million

PPRTV	Provisional Peer-Reviewed Toxicity Values
PVC	polyvinyl chloride
QA	quality assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	quality control
QSM	Quality Systems Manual
R^2	coefficient of determination
RI	Remedial Investigation
RPD	relative percent difference
RPM	Remedial Project Manager
RSL	regional screening level
RT	retention time
SAP	Sampling and Analysis Plan
SI	Site Inspection
SL	screening level
SOP	standard operating procedure
SPE	solid phase extraction
SSL	Site Safety Liaison
STC	Senior Technical Consultant
TAU	twin agent unit
TBD	to be determined
UCH	upper Castle Hayne
UCL	upper control limit
UFP	Uniform Federal Policy
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
Vista	Vista Analytical Laboratory
VOC	volatile organic compound
WQP	water quality parameter

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SAP Worksheet #2—SAP Identifying Information

(Uniform Federal Policy [UFP] Quality Assurance Project Plan [QAPP] Manual Section 2.2.4)

Site Name/Number:	Camp Davis Forward Arming and Refueling Point (FARP) Activities South, Site 111, Marine Corps Base (MCB) Camp Lejeune
Operable Unit:	Not established
Contractor Name:	CH2M HILL, Inc. (CH2M)
Contract Number:	N62470-16-D-9000
Contract Title:	Comprehensive Long-term Environmental Action—Navy (CLEAN) 9000 Program
Work Assignment Number (optional):	Contract Task Order 4978

1. **This Remedial Investigation (RI) Sampling and Analysis Plan (SAP) was prepared in accordance with the requirements of the following:**
   - *Guidance for Quality Assurance Project Plans* (USEPA, 2002)
   - *Uniform Federal Policy for Quality Assurance Project Plans* (USEPA, 2005)
   - *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)
   - *Interim Per-and Polyfluoroalkyl Substances (PFAS) Site Guidance for Naval Facilities Engineering Systems Command (NAVFAC) Remedial Project Managers (RPMs)/November 2020 Update* (Navy, 2020)
2. **Identify regulatory program:**
   - Comprehensive Environmental Response, Compensation, and Liability Act, as amended by Superfund Amendments and Reauthorization Act
3. **This document is a project-specific SAP.**
4. **List dates of scoping sessions that were held:**

Scoping Session	Date
MCB Camp Lejeune Partnering Team Meeting	July 15, 2021
MCB Camp Lejeune Partnering Team Meeting	September 28, 2021

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

Title	Date
Final *Sampling and Analysis Plan Basewide Per- and Polyfluoroalkyl Substances (PFAS) Site Inspection, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina* (CH2M, 2020)	May 2020
Field Change Request (FCR) 01 (CH2M, 2021b)	March 2021
FCR 02 (CH2M, 2021c)	May 2021

SAP Worksheet #2—SAP Identifying Information (continued)

6. **List organizational partners (stakeholders) and connection with lead organization:**
    - MCB Camp Lejeune – Base stakeholder
    - United States Environmental Protection Agency (USEPA) Region 4 – Regulatory Stakeholder
    - North Carolina Department of Environmental Quality (NCDEQ) – Regulatory Stakeholder
7. **Lead organization:**
    - Department of the Navy (Navy) – NAVFAC Mid-Atlantic
8. **If any required SAP elements or required information are not applicable (N/A) to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion as follows:**
    - No worksheets are excluded from this SAP.

SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number	Email Address or Mailing Address
David Cleland	RPM	NAVFAC Mid-Atlantic	(757) 341-0329	david.t.cleland.civ@us.navy.mil
Lindsey Mills	Environmental Engineer	NAVFAC Mid-Atlantic	(757) 341-0484	lindsey.e.mills5.civ@us.navy.mil
Thomas Richard	Installation Restoration (IR) Program Manager	MCB Camp Lejeune – Environmental Management Division (EMD)	(910) 451-9641	thomas.richard@usmc.mil
Laura Spung	IR Program Support Engineer	MCB Camp Lejeune - EMD	(910) 451-9610	laura.spung@usmc.mil
Jennifer Tufts	RPM	USEPA Region 4	(404) 562-8513	tufts.jennifer@epa.gov
Randy McElveen	RPM	NCDEQ	(919) 707-8341	randy.mcelveen@ncdenr.gov
Matt Louth	Activity Manager (AM)	CH2M	(757) 286-7629	matt.louth@ch2m.com
Kim Henderson	Deputy AM	CH2M	(757) 513-6632	kimberly.henderson@ch2m.com
Jessica Skeean	Project Delivery Lead (PDL)/Quality Assurance Manager (QAM)/SAP Reviewer	CH2M	(704) 544-4040	jessica.skeean@ch2m.com
Maggie Radford	Senior Technical Consultant (STC)	CH2M	(919) 749-9479	maggie.radford@ch2m.com
Daniel Hockett	Project Manager (PM)	CH2M	(704) 516-2665	daniel.hockett@ch2m.com
Anita Dodson	Program Chemist/SAP Reviewer/ Quality Assurance Officer (QAO)	CH2M	(757) 671-6218	anita.dodson@ch2m.com
Sonya Gordon	Project Chemist	CH2M	(615) 828-0406	sonya.gordon@jacobs.com
Martha Maier	Laboratory PM	Vista Analytical Laboratory (Vista)	(916) 673-1520	martha.maier@vista-analytical.com
Teresa Morrison	Laboratory QAO	Vista	(916) 673-1520	teresa.morrison@vista-analytical.com
Heather Manz	Laboratory PM	Katahdin Analytical Services (Katahdin)	(207) 874-2400	hmanz@katahdinlab.com

SAP Worksheet #3—Distribution List (continued)

Name of SAP Recipients	Title/Role	Organization	Telephone Number	Email Address or Mailing Address
Leslie Dimond	Laboratory QAO	Katahdin	(207) 874-2400	ldimond@katahdinlab.com
Kathryn Kelly	Laboratory PM	Eurofins TestAmerica (Eurofins)	(802) 660-1990	Kathryn.Kelly@Eurofins.com
Kristine Dusablon	Laboratory QAO	Eurofins	(802) 660-1990	Kristine.Dusablon@Eurofins.com
Pei Geng	Data Validator	Laboratory Data Consultants (LDC)	(760) 827-1100 x141	Pgeng@lab-data.com
To be determined (TBD)	Utility Locator	TBD	TBD	TBD
TBD	Driller	TBD	TBD	TBD
TBD	Surveyor	TBD	TBD	TBD
TBD	Investigation-derived waste (IDW) Transportation and Disposal Provider	TBD	TBD	TBD

SAP Worksheet #4—Project Personnel Sign-Off Sheet

Name	Organization/Title/Role	Telephone Number	Signature/Email receipt	SAP Section Reviewed	Date SAP Read
Matt Louth	CH2M/AM	(757) 286-7629			
Kim Henderson	CH2M/Deputy AM	(757) 513-6632			
Maggie Radford	CH2M/STC	(919) 749-9479			
Daniel Hockett	CH2M/PM	(704) 516-2665			
Anita Dodson	CH2M/Navy Program Chemist	(757) 671-6218			
Sonya Gordon	CH2M/Project Chemist	(615) 828-0406			
Martha Maier	Vista/Laboratory PM	(916) 673-1520			
Teresa Morrison	Vista/Laboratory QAO	(916) 673-1520			
Heather Manz	Katahdin/Laboratory PM	(207) 874-2400			
Leslie Dimond	Katahdin/Laboratory QAO	(207) 874-2400			
Kathryn Kelly	Eurofins/Laboratory PM	(802) 660-1990			
Kristine Dusablon	Eurofins /Laboratory QAO	(802) 660-1990			
Pei Geng	LDC/Data Validator	(760) 827-1100 x141			
TBD	Utility Locator	TBD			
TBD	Driller	TBD			
TBD	Surveyor	TBD			
TBD	IDW Transportation and Disposal Provider	TBD			

Any signed version of **Worksheet #4** will be kept on file at CH2M along with other project documents.

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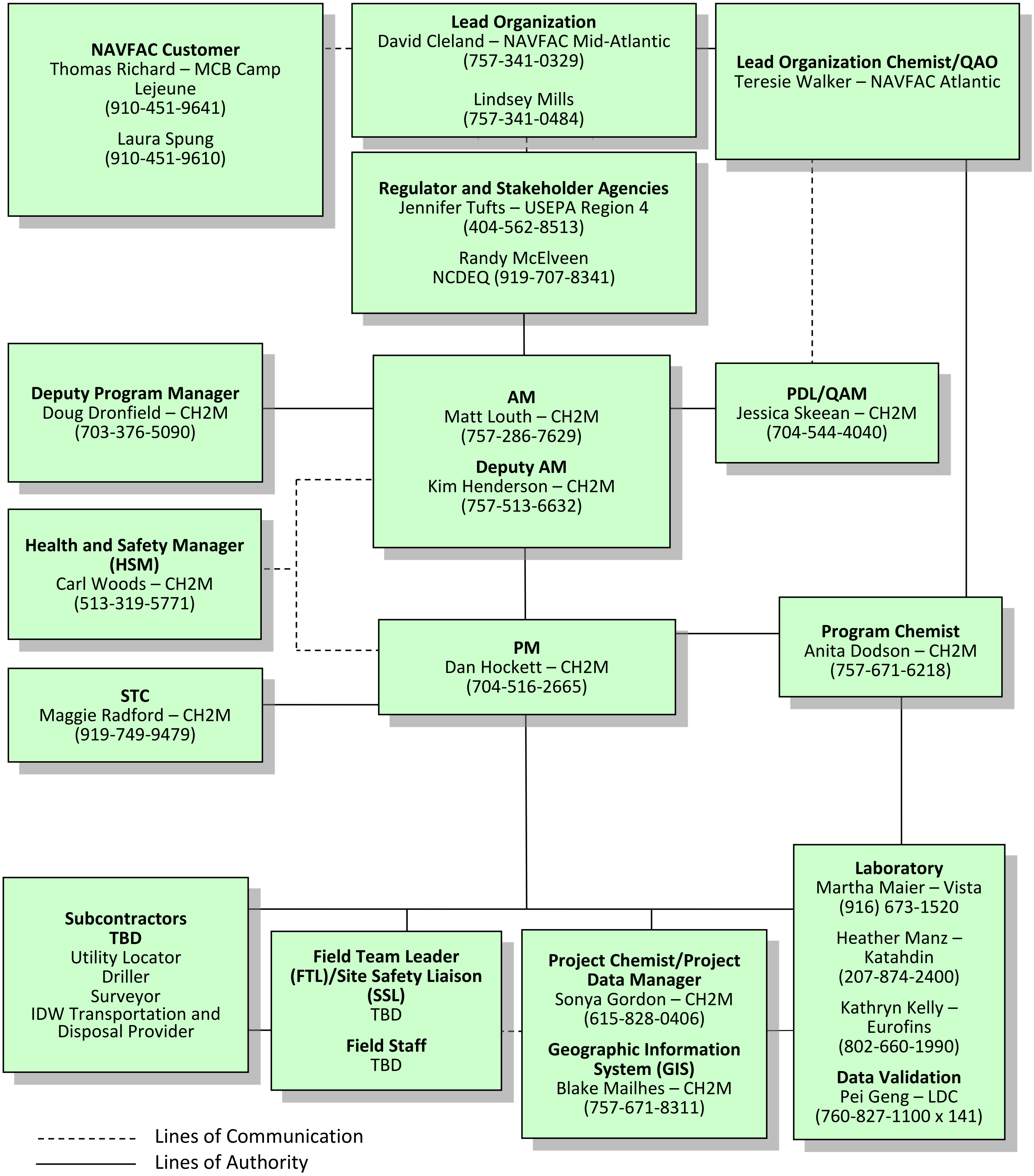
SAP Worksheet #5—Project Organizational Chart



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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or Email	Procedure, Pathway, and so forth.
Communication with NAVFAC (lead agency)	NAVFAC RPM	David Cleland	david.t.cleland@navy.mil (757) 341-0329	Primary point of contact (POC) for NAVFAC; can delegate communication to other internal or external POCs. NAVFAC RPM will notify USEPA and NCDEQ by email or telephone call for field changes affecting the scope or implementation. Data will be presented and discussed during partnering meetings.
Communication with MCB Camp Lejeune	MCB Camp Lejeune – EMD	Thomas Richard	thomas.richard@usmc.mil (910) 451-9641	Primary POC for MCB Camp Lejeune; can delegate communication to other internal or external POCs. EMD will notify NAVFAC RPM, USEPA, and NCDEQ by email or telephone call for field changes affecting the scope or implementation. Data will be presented and discussed during partnering meetings.
Communication with USEPA Region 4	USEPA Region 4 RPM	Jennifer Tufts	tufts.jennifer@epa.gov (404) 562-8513	Primary POC for USEPA; can delegate communication to other internal or external POCs. Upon notification of field changes, USEPA will approve or comment on the field changes. Data results will be presented and discussed during partnering meetings.
Communication with NCDEQ	NCDEQ RPM	Randy McElveen	randy.mcelveen@ncdenr.gov (919) 707-8341	Primary POC for NCDEQ; can delegate communication to other internal or external POCs. Upon notification of field changes, NCDEQ will approve or comment on the field. Data results will be presented and discussed during partnering meetings.
Quality Assurance (QA)/Quality control (QC) input	NAVFAC Chemist/QAO	Teresie Walker	teresie.r.walker.civ@us.navy.mil	Provides review comments to NAVFAC contractor on Pre-draft SAP via the Naval Installation Restoration Information System submittal. Provides overall NAVFAC guidance via direct communication with NAVFAC contractor chemist, as warranted.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or Email	Procedure, Pathway, and so forth.
Communication regarding overall project status and implementation and primary POC with NAVFAC RPM, USEPA, and NCDEQ	CH2M AM	Matt Louth	matt.louth@ch2m.com (757) 286-7629	Oversees project and will be informed of project status by the PM. If field changes occur, AM will work with the NAVFAC RPM to communicate in-field changes to the team by email. All data results will be communicated to the project team during the first partnering meeting following data receipt.
	CH2M Deputy AM	Kim Henderson	kimberly.henderson@ch2m.com (757) 513-6632	
Communication with CLEAN program	CH2M Deputy Program Manager	Doug Dronfield	doug.dronfield@ch2m.com (703) 376-5090	Oversees the CLEAN program for CH2M. Will be notified if field changes occur that require program support.
Quality issues during project implementation and data interpretation	CH2M QAM	Jessica Skeean	jessica.skeean@ch2m.com (704) 544-4040	Contact the QAM regarding quality issues during project implementation. The QAM will report to the AM.
Technical communications for project implementation and data interpretation	CH2M STC	Maggie Radford	maggie.radford@ch2m.com (919) 749-9479	Contact STC regarding questions/issues encountered in the field, input on data interpretation, as needed. STC will review the data as necessary prior to partnering team discussion and reporting review.
Communication for project delivery	CH2M PDL	Jessica Skeean	jessica.skeean@ch2m.com (704) 544-4040	Contact PDL as needed regarding questions/issues encountered in delivering the work.
Communications regarding the SAP	CH2M SAP Reviewer	Jessica Skeean	jessica.skeean@ch2m.com (704) 544-4040	Changes/revisions to the SAP will be reviewed by the SAP reviewer, as soon as possible, as necessary.
Communications regarding project management and implementation	PM	Daniel Hockett	daniel.hockett@ch2m.com (704) 516-2665	All information and materials about the project will be forwarded to the NAVFAC RPM, as necessary. POC for task manager, senior consultants, and sampling team.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or Email	Procedure, Pathway, and so forth.
Health and Safety (H&S)	CH2M HSM	Carl Woods	carl.woods@ch2m.com (513) 319-5771	Responsible for generation of the Health and Safety Plan (HSP) and approval of the activity hazard analyses prior to the start of fieldwork. The PM will contact the HSM as needed regarding questions/issues encountered in the field.
H&S	CH2M SSL	TBD	TBD	Responsible for the adherence of team members to the site safety requirements described in the HSP. Will report H&S incidents and near losses to PM as soon as possible.
QAPP field changes/ field progress reports	CH2M FTL	TBD	TBD	Documents field activities and work plan deviations (made with the approval of PM) in field logbooks; provide daily progress reports to PM.
Stop Work Order	CH2M AM	Matt Louth	matt.louth@ch2m.com (757) 286-7629	Any field member can immediately stop work if an unsafe condition that is immediately threatening to human health is observed. The field staff, FTL, or SSL should notify the CH2M PM and AM immediately, along with the NAVFAC RPM. Ultimately, the FTL, PM, and AM can stop work for a period of time. NAVFAC Mid-Atlantic can stop work at any time.
	CH2M PM	Daniel Hockett	daniel.hockett@ch2m.com (704) 516-2665	
	CH2M FTL/SSL	TBD	TBD	
	Field Team Members	TBD	TBD	
Work plan changes in field	FTL	TBD	TBD	Documentation of deviations from the work plan will be made in the field logbook, and the PM will be notified immediately. Deviations will be made only with approval from the PM.
Presentation of data	CH2M GIS	Blake Mailhes	blake.mailhes@ch2m.com (757) 671-6290	Provides support as needed for field activities and evaluation of data by generating figures using GIS.
Reporting laboratory quality issues	Vista PM	Martha Maier	martha.maier@vista-analytical.com (916) 673-1520	QA/QC issues with project field samples will be reported within 2 days to the Project Chemist by the laboratory.
	Katahdin PM	Heather Manz	hmanz@katahdinlab.com (207) 874-2400	
	Eurofins PM	Kathryn Kelly	Kathryn.Kelly@Eurofins.com (802) 660-1990	

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or Email	Procedure, Pathway, and so forth.
Field and analytical corrective actions (CAs)	Program Chemist/SAP Reviewer	Anita Dodson	anita.dodson@ch2m.com (757) 671-6218	CAs for field and analytical issues will be determined by the FTL and/or the Project Chemist and reported to the PM. If serious laboratory issues are discovered, the NAVFAC RPM will be notified.
Communications regarding SAP changes				Changes to the project that would prompt a SAP change that would require NAVFAC QAO approval include: the addition of an analytical suite not previously included in the SAP, the addition of an environmental matrix not previously included in the SAP, laboratory accreditation to a new Department of Defense (DoD) Quality Systems Manual (QSM) version, inclusion of a new laboratory in the SAP, 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 NAVFAC QAO approval unless those updates negatively impact the ability to meet project action levels.
Data tracking from field collection to database upload Release of analytical data	Project Chemist	Sonya Gordon	sonya.gordon@jacobs.com (615) 828-0406	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 Project Chemist. The Project Chemist will review analytical results for release to the project team. The Project Chemist will inform the CLEAN Program Chemist who will notify the NAVFAC QAO of any laboratory issues that would prevent the project from meeting project quality objectives or would cause significant delay in project schedule.
Reporting data quality issues	Data Validator	Pei Geng	Pgeng@lab-data.com (760) 827-1100 x141	The data validator reviews and qualifies analytical data as necessary. The data along with a validation narrative are returned to the Project Chemist within 14 calendar days. A 7-day expedited turn-around will be required for samples collected in response to resumption of public supply well pumping.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or Email	Procedure, Pathway, and so forth.
Field CAs	CH2M FTL	TBD	TBD	Field and analytical issues requiring CA will be determined by the FTL and/or PM on an as-needed basis; the PM will ensure QAPP requirements are met by field staff for the duration of the project. The FTL will notify the PM via phone of any need for CA. The PM/AM may notify the NAVFAC RPM of any field issues that would negatively affect schedule or the ability to meet project data quality objectives.
	CH2M PM	Daniel Hockett	daniel.hockett@ch2m.com (704) 516-2665	
Changes in the field	Utility Locator Driller Surveyor IDW Transportation and Disposal Provider	TBD	TBD	Documentation of deviations from planned field procedures during project work will discussed with PM prior to implementation. Deviations will only be made with approval from the PM.

Notes:

Stop Work Order: Any field member can immediately stop work if an unsafe condition, which is immediately threatening to human health, is observed. Ultimately, the FTL, PM, and AM can stop work for a period. NAVFAC Mid-Atlantic can stop work at any time.

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SAP Worksheet #7—Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities
David Cleland	RPM	NAVFAC Mid-Atlantic	Oversees project.
Thomas Richard	IR Program Manager	MCB Camp Lejeune	Oversees project.
Teresie Walker	Chemist/QAO	NAVFAC Atlantic	NAVFAC Review of SAP and QA input.
Jennifer Tufts	RPM	USEPA Region 4	USEPA POC.
Randy McElveen	RPM	NCDEQ	NCDEQ POC.
Matt Louth	AM	CH2M	Oversees project activities.
Kim Henderson	Deputy AM	CH2M	Oversees project activities and provides senior technical support for project approach and execution.
Doug Dronfield	Deputy Program Manager	CH2M	Oversees program.
Daniel Hockett	PM	CH2M	Manages project.
Jessica Skeean	PDL/QAM/SAP Reviewer	CH2M	Provides support for project delivery. Provides QA oversight. Reviews and approves changes or revisions to the SAP.
Maggie Radford	STC	CH2M	Provides senior technical support for project approach and execution.
Carl Woods	HSM	CH2M	Prepares HSP and manages H&S for all field activities.
Anita Dodson	Program Chemist	CH2M	Provides SAP project delivery support, reviews and approves SAPs, and performs final data evaluation and QA oversight.
Sonya Gordon	Project Chemist	CH2M	Data management: Performs data evaluation and QA oversight, is the POC with laboratory and validator for analytical issues.
Blake Mailhes	GIS	CH2M	Manages the generation of maps and figures using GIS.
TBD	FTL	CH2M	Coordinates all field activities and sampling.
TBD	Field Staff	CH2M	Conducts field activities.

SAP Worksheet #7—Personnel Responsibilities Table (continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
Martha Maier	Laboratory PM	Vista	Manages samples tracking and maintains good communication with Project Chemist.
Heather Manz	Laboratory PM	Katahdin	Manages samples tracking and maintains good communication with Project Chemist.
Kathryn Kelly	Laboratory PM	Eurofins	Manages samples tracking and maintains good communication with Project Chemist.
Teresa Morrison	Laboratory QAO	Vista	Responsible for audits, CA, and checks of QA performance within the laboratory.
Leslie Dimond	Laboratory QAO	Katahdin	Responsible for audits, CA, and checks of QA performance within the laboratory.
Kristine Dusablon	Laboratory QAO	Eurofins	Responsible for audits, CA, and checks of QA performance within the laboratory.
Pei Geng	Data Validator	LDC	Validate laboratory data from an analytical standpoint prior to data use.
TBD	Utility Locator	TBD	Locate underground utilities before intrusive work begins.
TBD	Driller	TBD	Installs monitoring wells.
TBD	Surveyor	TBD	Collects data positions of environmental sample locations.
TBD	IDW Transportation and Disposal Provider	TBD	Responsible for manifesting, transporting and disposing of IDW generated during field activities.

SAP Worksheet #8—Special Personnel Training Requirements Table

Project Function	Specialized Training by Title or Description of Course	Training Provider	Training Date	Personnel / Groups Receiving Training	Personnel Titles / Organizational Affiliation	Location of Training Records / Certificates
There are no special personnel training requirements for this work.						

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

Project Name: Site 111 Camp Davis FARP Activities South PFAS Sampling Activities **Projected Date(s) of Sampling:** To start if/when public supply well pumping is resumed **PM:** Daniel Hockett			**Site Name**: Site 111 **Site Location:** MCB Camp Lejeune, North Carolina	
Date of Session: July 15, 2021 (Virtual Meeting) **Scoping Session Purpose:** IR Program Partnering Team Meeting to discuss and approve initial and continuing monitoring groundwater for PFAS pending resumption of public utility supply wells operation.				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
David Cleland	RPM	NAVFAC Mid-Atlantic	(757) 341-0329	david.t.cleland@navy.mil
Lindsey Mills	Environmental Engineer	NAVFAC Mid-Atlantic	(757) 341-0484	lindsey.e.mills@navy.mil
Thomas Richard	IR Program Manager	MCB Camp Lejeune—EMD	(910) 451-9641	thomas.richard@usmc.mil
Jennifer Tufts	RPM	USEPA Region 4	(404) 562-8513	tufts.jennifer@epa.gov
Randy McElveen	RPM	NCDEQ	(919) 707-8341	randy.mcelveen@ncdenr.gov
Beth Hartzell	RPM	NCDEQ	(919) 707-8335	beth.hartzell@ncdenr.gov
Matt Louth	AM	CH2M	(757) 286-7629	matt.louth@ch2m.com
Monica Fulkerson	IR Lead	CH2M	(704) 544-5177	monica.fulkerson@ch2m.com
Daniel Hockett	PM	CH2M	(704) 516-2665	daniel.hockett@ch2m.com

A presentation was reviewed by CH2M. The initial Site Inspection (SI) perfluorooctanoic acid (PFOA)/ perfluorooctane sulfonate (PFOS) results at Camp Davis FARP Activities South indicated no detections in soil and 2 out of 14 surficial aquifer groundwater sample locations exceeded the USEPA lifetime health advisory for PFAS/PFOA. Initial results of additional investigations into the Castle Hayne aquifer were also discussed.

Two off-Base public supply wells (D-10 and D-11, owned by Onslow Water and Sewer Authority [ONWASA]), located to the west of the site and identified in a drinking water evaluation initiated upon receipt of the SI data, are currently offline after operating from November 2020 to January 2021. If the public utility supply wells resume operation, the team discussed a groundwater monitoring approach to evaluate PFAS in select on-Base monitoring wells to evaluate the influence of off-Base supply well pumping on the PFAS distribution at Camp Davis.

The approach includes groundwater sampling for PFAS analysis at 2 lower Castle Hayne (LCH) aquifer monitoring wells (located within the same limestone and nearest to D-10 and D-11), 1 surficial aquifer monitoring well (where concentrations were above screening levels (SLs)[2], and its paired (1) upper Castle Hayne (UCH) aquifer monitoring well to evaluate potential downgradient migration. The proposed sampling frequency is monthly for 3 months and quarterly for 9 months. An LCH monitoring well to the northeast will be included in the quarterly events after the

3 monthly events. The monthly results will be evaluated and the monitoring well network re-evaluated based on the results. Based on the results, additional sampling requirements will be evaluated and adjusted as needed.

Consensus – The Team agreed to the approach for the proposed monitoring activities at Camp Davis as discussed. Expedited turn-around-time (at least 7 days) will be requested from the laboratory and data validator.

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[2] SLs for PFOA, PFOS, and PFBS are based on a hazard quotient (HQ) of 0.1.

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

Project Name: Site 111 Camp Davis FARP Activities South PFAS RI SAP **Projected Date(s) of Sampling:** Spring/Summer 2022 **PM:** Daniel Hockett			**Site Name**: Site 111 **Site Location:** MCB Camp Lejeune, North Carolina	
Date of Session: September 28, 2021 **Scoping Session Purpose:** IR Program Partnering Team Meeting to discuss and approve the Site 111 RI approach.				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
David Cleland	Lead RPM	NAVFAC Mid-Atlantic	(757) 341-0329	david.t.cleland@navy.mil
Lindsey Mills	Environmental Engineer	NAVFAC Mid-Atlantic	(757) 341-0484	lindsey.e.mills@navy.mil
Thomas Richard	IR Program Manager	MCB Camp Lejeune—EMD	(910) 451-9641	thomas.richard@usmc.mil
Jennifer Tufts	RPM	USEPA Region 4	(404) 562-8513	tufts.jennifer@epa.gov
Randy McElveen	RPM	NCDEQ	(919) 707-8341	randy.mcelveen@ncdenr.gov
Beth Hartzell	RPM	NCDEQ	(919) 707-8335	beth.hartzell@ncdenr.gov
Matt Louth	AM	CH2M	(757) 286-7629	matt.louth@ch2m.com
Monica Fulkerson	IR Lead	CH2M	(704) 544-5177	monica.fulkerson@ch2m.com
Maggie Radford	STC	CH2M	(919) 749-9479	maggie.radford@ch2m.com
Daniel Hockett	PM	CH2M	(704) 516-2665	daniel.hockett@ch2m.com

Comments

The team reviewed and discussed the Site 111 (Camp Davis FARP Activities South) CSM, data needs, and approach for the PFAS RI, obtained team consensus for the SAP, and reviewed the schedule. The RI data needs and approach for groundwater and soil were discussed as follows:

- **Data Needs**
  - Downgradient delineation in surficial aquifer from BW-FARP-S-MW03
  - Horizontal and vertical delineation in surficial aquifer around BW-FARP-S-MW07
  - Additional soil data surrounding presumed release area (BW-FARP-S-MW07)
- **Approach**
  - Install 18 new surficial aquifer monitoring wells bracketing water table
  - Install 3 new monitoring well screened immediately above the clay unit (approximately 40 feet below ground surface [bgs])
  - Collect groundwater samples from:
    - 11 existing and 21 new surficial aquifer wells
    - 4 existing UCH aquifer wells
    - 6 existing LCH aquifer wells
  - Collect co-located surface (0-1 foot) and subsurface (immediately above the water table) soil samples from 7 new well locations
  - Analyze samples for 18 PFAS listed in USEPA Method 537.1

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

Discussion:

The team discussed what happens if there are detections in the deeper surficial aquifer. CH2M indicated that a FCR would be prepared; however, aqueous film-forming foam (AFFF) is totally miscible in water and not expected to stratify within the water column. Additionally, the highest concentrations are typically detected at the interface of groundwater and unsaturated soil. The intent of the deeper aquifer well was to refine the vertical delineation of PFAS to evaluate the volume of impacts more accurately.

USEPA asked if direct-push technology sampling was considered to evaluate conditions prior to installing permanent wells. CH2M indicated that direct-push technology may yield unrepresentative results and that the preference is to install permanent wells.

NCDEQ asked if wells would be cased. CH2M explained that the wells will be installed above the clay and that isolation casings are not required. NCDEQ asked if rotosonic drilling methods would be used. CH2M indicated that the drilling method likely would be rotosonic because of ease of implementation. NCDEQ indicated that care needs to be taken to avoid pulling impacts down through the water column and to choose methods that protect the aquifer. CH2M indicated that rotosonic drilling methods would be used so that a temporary isolation casing could be utilized.

The RI data needs and approach for surface water and sediment was reviewed as follows:

- **Data Needs:**
  - Drainage ditches surrounding the site have not been investigated but contain flowing surface water that potentially originates from groundwater discharge
- **Approach**
  - Collect 14 co-located surface water and sediment samples at locations within drainage ditches
    - 2 rounds during base flow conditions, one at estimated high water table and one at low water table conditions
    - Collect groundwater samples from all surficial aquifer monitoring wells during the same events as surface water and sediment sampling
  - Based on data, evaluate possible areas of groundwater discharge through temperature study or other groundwater-to-surface water assessment techniques

The RI data will be used to refine the CSM through:

- Delineating the nature and extent of PFAS with SLs (PFOA, PFOS, perfluorobutanesulfonic acid [PFBS])
- Evaluating groundwater migration and potential PFAS transport
- Refining potential exposure pathways
- Modeling groundwater to evaluate the potential for off-Base PFAS migration - Incorporate data collected during pumping test conducted in cooperation with ONWASA
- Conducting a human health risk assessment for 3 PFAS with SLs
- Conduct an ecological risk assessment (ERA) to include PFAS with Navy-vetted literature comparison criteria

Consensus

The Team agreed to the general approach for the Site 111 PFAS RI for the SAP.

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SAP Worksheet #10—Conceptual Site Model

The site location is shown on **Figure 10-1**. The CSM for Site 111, Camp Davis FARP Activities South, is presented in **Table 10-1** and depicted graphically on **Figure 10-2**.

Table 10-1. Site 111 Conceptual Site Model

<table>
<tr><td>Site Name</td><td>Site 111 – Camp Davis FARP Activities South</td></tr>
<tr><td>Site Location</td><td>Within the Greater Sandy Run Area (Figure 10-1)</td></tr>
<tr><td>Site Description and Operational History</td><td>The Camp Davis FARP Activities South area is approximately 350 acres and consists of locations along the south runway where Marines staged P-19s (aircraft rescue and fire fighting vehicles) for emergency response support during FARP operations. FARP activities have been documented in this area between 2013 and 2015; however, flight operations have been conducted at Camp Davis since 1943 and it is likely that emergency response support would have been staged during historical flight operations.</td></tr>
<tr><td>Land Use</td><td>The area is currently used for military training. The approximately 30 acre paved air strip is surrounded by approximately 300 acres of mowed grassland intersected by paved roads and drainage ditches. The areas beyond the maintained grass are pine forests intersected with paved roadways built in the 1940’s.</td></tr>
<tr><td>Investigation History</td><td>
<p>The following is a summary of investigations conducted at Site 111 (identified in the Preliminary Assessment [PA] and SI as the Camp Davis FARP Activities South area).</p>
<p>PA – 2019</p>
<p>The Site 111 area was evaluated in the Basewide PA for PFAS. During FARP operations, P-19s and mobile fire extinguishing systems known as twin agent units (TAUs) supported the training operations by providing emergency response capability. AFFF tanks are present on P-19s and TAUs. FARPs where P-19s or TAUs were used were identified as potential PFAS release areas based on the potential for inadvertent deployment of AFFF during wet checks and/or spills from the P-19 tanks. Although no documentation or institutional knowledge of an AFFF release was identified during the PA, further evaluation was recommended because P-19s were used between 2013 and 2015 during FARP activities within this area (CH2M, 2019).</p>
<p>SI Sampling – 2020</p>
<p>The SI fieldwork was conducted between July and November 2020. Seven surface soil samples (0-1 feet bgs), 7 subsurface soil samples (ranging from 3-4 to 5-6 feet bgs), and 8 surficial aquifer groundwater samples from permanent monitoring wells screened from 4-14 feet bgs to 8-18 feet bgs were collected for analysis of PFAS (method liquid chromatography tandem mass spectrometry [LC-MS/MS] compliant with QSM 5.3 Table B-15).</p>
<p>The analytical results for soil and groundwater were compared to residential scenario risk-based SLs. Results for PFOA, PFOS, and PFBS are as follows:</p>
<table>
<tr><th rowspan="2">Analyte</th><th colspan="3">Surface Soil</th><th colspan="3">Subsurface Soil</th><th colspan="3">Groundwater (surficial)</th></tr>
<tr><th>Frequency of Detection</th><th>Frequency of Exceedance</th><th>Maximum Concentration (ng/g)</th><th>Frequency of Detection</th><th>Frequency of Exceedance</th><th>Maximum Concentration (ng/g)</th><th>Frequency of Detection</th><th>Frequency of Exceedance</th><th>Maximum Concentration (ng/L)</th></tr>
<tr><td>PFOA</td><td>1/7</td><td>0/7</td><td>0.99 J</td><td>0/7</td><td>--</td><td>ND</td><td>5/8</td><td>1/8</td><td>808.31</td></tr>
<tr><td>PFOS</td><td>0/7</td><td>--</td><td>ND</td><td>0/7</td><td>--</td><td>ND</td><td>6/8</td><td>2/8</td><td>13,344.23</td></tr>
<tr><td>PFBS</td><td>0/7</td><td>--</td><td>ND</td><td>0/7</td><td>--</td><td>ND</td><td>8/8</td><td>0/8</td><td>436.46</td></tr>
</table>
<p>ng/L = nanogram(s) per liter
ng/g = nanogram(s) per gram
ND = not detected</p>
</td></tr>
</table>

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site 111 Conceptual Site Model

Investigation History (continued)	**SI Sampling – 2020 (Continued)** The human health risk screening identified potential unacceptable risks associated with exposure to PFOA and PFOS in groundwater (CH2M, 2022). Because the SI data confirmed a release based on the PFOA and PFOS exceedances of SLs and potential unacceptable human health risks, an RI was recommended to delineate the nature and extent of PFAS impacts and further evaluate potential human health risks from exposure to PFAS. **Post-SI Sampling** Based on the preliminary results of the SI, two expedited investigations, summarized in the following paragraphs, were conducted to assess potential impacts to off-Base receptors and to further investigate the hydrogeologic properties of the UCH and LCH aquifers. ***Drinking water evaluation – March – September 2021:*** Public outreach efforts were initiated to identify drinking water wells within 1 mile of the Site 111 boundary because concentrations of PFOA and PFOS in groundwater samples collected from the surficial aquifer exceed the lifetime health advisory (70 ng/L) and off-Base drinking water wells could be located within 1 mile downgradient of the site based on inferred UCH and LCH aquifer groundwater flow direction. Based on the public outreach efforts through June 2021, 12 off-Base drinking water wells screened in the Castle Hayne aquifer have been identified. Samples were collected from these drinking water wells in March, April, June, and September 2021. All results were below the USEPA lifetime health advisory level for PFOS and/or PFOA (CH2M, 2022). A summary of the drinking water results will be included in the RI. ***Groundwater Investigation – June 2021:*** During the public outreach efforts, two public supply wells, drawing groundwater from unscreend boreholes in the limestone of the LCH aquifer (106 to 166 feet bgs and 112 to 172 feet bgs) operated by ONWASA were identified within a 1 mile radius of the site to the west/northwest. Water from both wells had previously been tested and concentrations of PFOA and PFOS were below the USEPA Lifetime Health Advisory but they were voluntarily taken offline in January 2021 while further PFAS investigation on the Base was underway. The Navy also collected samples from these off-Base water supply wells in June 2021 for PFAS analysis and the PFOA and PFOS were not detected above the laboratory reporting limits of 1.09 ng/L. In addition, two ONWASA supply wells are located to the northeast greater than 1 mile from the site. An investigation was initiated in June 2021 to further assess PFAS in the surficial, UCH, and LCH aquifers and the hydrogeology of the deeper aquifers. Monitoring wells were installed as follows: • Clusters of wells consisting of surficial/UCH aquifer (screened from 70-80 feet bgs)/LCH (screened from 150-160 and 155-165 feet bgs) were installed at three locations between the site and the Town of Holly Ridge, in the inferred downgradient direction from the site within the UCH/LCH aquifers. • LCH aquifer monitoring wells were installed between the site boundary and ONWASA supply wells (one to the northeast and one to the west). • One UCH aquifer well was installed in the presumed release area adjacent to the surficial well from which groundwater sample with the highest PFOA and PFOS concentrations was collected. All existing and newly installed monitoring wells were sampled for PFAS in June 2021. Results are shown on **Figures 10-3** through **10-5**. PFAS concentrations in the surficial aquifer were similar to the September 2020 data and there were no exceedances of the SLs in the newly installed wells in all aquifer zones. Hydrogeologic information obtained during this investigation is presented in the **Geology and Hydrogeology** section of this table. A full presentation of the groundwater investigation and results will be incorporated into the RI.	
Site Conditions	**Surface Features, Topography and Hydrology**	The ground surface at Site 111 consists of a paved runway surrounded by maintained grass and wetland to the west/northwest and east/northeast. The ground surface elevation ranges from approximately 50 feet above mean sea level (msl) in the wetland areas northeast of the site to 65 feet msl in the runway area (**Figure 10-1**). There are drainage ditches surrounding the runway area that appear to flow to the northeast along the site boundary. Stormwater runoff likely flows radially outward to the drainage ditches. There are natural channels originating along the northwestern boundary of the site that appear to connect to the Big Shakey Swamp to the north/northwest. Surface water may ultimately discharge into the Big Shakey Swamp and Juniper Swamp (to the northeast).

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site 111 Conceptual Site Model

Site Conditions (continued)	**Geology and Hydrogeology**	Site-specific lithology and hydrogeology is based on the SI and post-SI investigations of the surficial, UCH, and LCH aquifers. A generalized cross section is depicted on **Figure 10-2**. The most shallow, unconsolidated formation (surficial aquifer) consists of sands and silty-sands, with variable layers of clay from ground surface to approximately 40 feet bgs. A clay semi-confining unit ranging in thickness from 10 feet to 30 feet was encountered in borings throughout the site at approximately 40 feet bgs. Below the clay, the UCH aquifer consists of fine sands to a depth of approximately 110 to 120 feet bgs where limestone is encountered (LCH aquifer). Groundwater in the surficial aquifer generally flows to the north and northwest and is encountered approximately 3 to 5 feet bgs (elevation ranging from 64.76 feet msl to the southeast to 51.05 feet msl to the northwest, **Figure 10-3**). Because of the shallow groundwater table and the consistent presence of flowing water, it is possible that surficial aquifer groundwater is discharging into the drainage ditches surrounding the site (**Figure 10-2**). Groundwater in the Castle Hayne (both UCH and LCH) aquifer flows to the southeast. Potentiometric elevations range from 28.24 to 26.73 feet msl in the UCH aquifer (**Figure 10-4**) and 30.85 to 26.75 feet msl in the LCH aquifer (**Figure 10-5**) indicating a downward potential.
Chemicals of Potential Concern	29 PFAS (listed in **Worksheet #15**)	
Nature and Extent	**Soil** There were no PFOA, PFOS, or PFBS exceedances of SLs in surface and subsurface soil samples collected during the SI field activities. However, the samples were limited to the 7 monitoring well locations installed within the suspected release areas and locations were spaced greater than 500 feet apart. There is the potential for additional releases to have occurred in unpaved areas at the site. **Groundwater** PFOA and/or PFOS exceedances of SLs are limited to groundwater in the surficial aquifer at two sample locations (**Figure 10-3**): • BW-FARP-S-MW07 located near the 2014 P-19 staging area (PFOA and PFOS) • BW-FARP-S-MW03 located hydraulically downgradient from BW-FARP-S-MW07 (PFOS only) The horizontal extent of PFOA and/or PFOS is not fully defined in the surficial aquifer as there are no downgradient wells from BW-FARP-S-MW03 and the distance between surficial aquifer wells is greater than 600 feet. Further, the vertical extent of PFAS in the source area is not defined above the clay semi-confining unit as only the shallow portion of the surficial aquifer has been sampled. There were no exceedances of SLs in the UCH/LCH aquifer samples and the monitoring well network in the Castle Hayne aquifer is adequate to vertically define the extent of PFOA, PFOS, and PFBS in the source area (adjacent to BW-FARP-S-MW07) and downgradient.	
Migration Pathways	PFAS have been released to the environment at Site 111. PFAS are a large family of compounds with varying properties. Research into defining the properties of individual PFAS and the impact on their migration in the environment is ongoing. Some PFAS, such as PFOS, PFOA, and PFBS are not known to degrade under typical environmental conditions (ITRC, 2020); because of this, they persist in the environment. PFAS present in unsaturated soils are subject to downward leaching during precipitation or irrigation events (ITRC, 2020). In general, PFAS are mobile in groundwater but also tend to associate with the organic carbon fraction of soil or sediment (ITRC, 2020). Many PFAS exhibit surfactant properties and preferentially accumulate at interfaces such as the air-water interface, which may contribute to enhanced retention of PFAS in the vadose zone and capillary fringe where unsaturated conditions provide significant air-water interfacial area (ITRC, 2020). Potential PFAS migration pathways to be evaluated in this RI include the following: • Direct release of PFAS to surface soil • Soil transport via soil erosion, construction, or other ground-disturbing activities • Leaching of PFAS from surface soil to subsurface soil and/or surficial aquifer groundwater • Transport via advection in groundwater • Overland flow of media containing PFAS to downgradient surface water bodies • Transport to surface water via groundwater discharge • Transport via vertical migration from the surficial aquifer into the Castle Hayne aquifer	

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site 111 Conceptual Site Model

Human Health Receptors and Exposure Scenarios	**Soil** Workers (including current military personnel), visitors, trespassers, and residents within 1 mile of PFAS release areas could potentially be exposed to PFAS in soil through incidental ingestion of and dermal contact with surface and subsurface soil. Construction or other ground-disturbing activities, including landscaping, could result in potential exposure to soil. **Groundwater** Groundwater within the Castle Hayne aquifer is the primary drinking water source on-Base and off-Base in the surrounding area. If PFAS migrates into the Castle Hayne aquifer near an existing or future water supply well, including the two nearby public supply wells, current and/or future workers and residents could be exposed to PFAS in groundwater through ingestion and dermal contact. Since groundwater is within the potential depth of construction activities (within about 10 to 12 feet of ground surface), construction workers could be exposed to PFAS in groundwater through dermal contact during excavation activities. **Surface Water and Sediment** Workers, visitors, or trespassers could potentially be exposed to PFAS through incidental ingestion of and dermal contact with surface water and sediment in the drainage ditches. Current military personnel may be exposed to PFAS through ingestion and dermal contact with surface water and incidental ingestion and dermal contact with sediment in the drainage ditches during training exercises. **Biota** Because there is some evidence that PFAS may bioaccumulate in terrestrial food items (such as plants), upper trophic level receptors (such as birds and mammals) could potentially be indirectly exposed to PFAS in soil through the consumption of terrestrial organisms. Potential recreational hunters could ingest game that had been exposed to PFAS in soil.
Ecological Receptors and Exposure Scenarios	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 media. Initial ecological screening values, based on available documents in the literature are included in **Appendix A** 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.. **Soil** Site 111 consists of an asphalt runway and mowed maintained vegetation with some wetlands along the borders of the site. Consequently, terrestrial habitat within the site is of limited quality. However, 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 in this area. Because there is evidence that PFAS bioaccumulate in terrestrial food items (such as plants), there is the potential that upper trophic level receptors (such as birds and mammals) could be exposed to these substances via the food web, as well as through incidental ingestion of soil.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site 111 Conceptual Site Model

Ecological Receptors and Exposure Scenarios (continued)	**Groundwater** While ecological receptors generally do not have direct exposure to groundwater, shallow groundwater at Site 111 may be hydraulically connected to the drainage ditches along the site boundary presenting a potential exposure pathway for aquatic biota in the drainage ditches. This pathway is discussed further below. **Surface Water and Sediment** Lower trophic level ecological receptors (such as plants; aquatic, benthic, or terrestrial invertebrates; and reptiles or amphibians) could be exposed to PFAS released to surface water (if present), or sediment (either directly or indirectly via surface runoff and drainage from onsite terrestrial areas or through groundwater discharge), through root uptake, direct contact, or direct ingestion. Because there is evidence that PFAS bioaccumulate in food items, there is the potential that upper trophic level receptors (such as birds and mammals) could be exposed to these compounds via the food web, as well as through incidental ingestion of ditch surface soil or sediment and, if the pathway is complete, offsite sediment, and direct ingestion of fresh surface water (if present).
Data Needs	The following data needs were identified for this investigation: • The extent of PFAS has not been fully defined horizontally or vertically within the surficial aquifer in the release area. Additional groundwater data are needed to define the vertical and horizontal extent of PFAS in the surficial aquifer near the assumed release area at BW-FARP-S-MW07 and in the downgradient direction. • Soil sample locations from the SI were widely spaced, resulting in low resolution of the characterization of the source and surrounding area. Additional soil data are needed to define the extent of the assumed release area in unpaved areas where P-19s may have been staged during training. • Transport pathways such as groundwater to surface water and overland flow to and through onsite ditches have not been evaluated but are potentially present at the site. Surface water and sediment data are needed to evaluate potential transport from overland flow or through groundwater discharge into the drainage ditches surrounding the site. • Geotechnical data has not been collected at this site to support hydrologic modeling to evaluate the fate and transport of PFAS in groundwater. • If pumping from nearby off-Base public drinking water wells is resumed, potential changes in the hydraulic conditions and fate and transport of PFAS in groundwater could occur due to continuous groundwater extraction under long-term pumping conditions.

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

The problem definition, objectives, environmental questions, investigation approach, and Project Quality Objectives are presented in **Table 11-1**.

Table 11-1. Problem Definitions/Objectives, Environmental Questions, and Project Quality Objectives

Problem Definition/ Objectives	Environmental Questions	General Investigation Approach	Project Quality Objectives
Previous investigations have confirmed PFAS is present in the surficial aquifer above SLs. The nature and extent of, and resulting risks to human and ecological receptors from, PFAS within the surficial aquifer, source area soils, and additional transport pathways such as surface water and sediment present at Site 111 have not been fully investigated. The objectives of the RI are to: • Define the nature and extent of PFAS in the surficial aquifer groundwater, soil, surface water, and sediment (in excess of PFAS project action limits [PALs]) and assess potential risks to human health and ecological receptors. • Refine the understanding of the groundwater flow direction and hydraulic properties and potential PFAS migration pathways. • If pumping from nearby off-Base public drinking water wells is resumed, evaluate potential changes in the hydraulic conditions and fate and transport of PFAS in groundwater due to continuous groundwater extraction under long-term pumping conditions.	What is the nature and extent of PFAS in surficial aquifer groundwater, soil, surface water, and sediment and, if present, the resulting potential risk to human and ecological receptors?	Proposed sample locations are shown on **Figure 11-1**. Groundwater: • Install 18 new surficial aquifer monitoring wells bracketing the water table • Install 1 new surficial aquifer monitoring well immediately above the clay semi-confining unit adjacent to BW-FARP-S-MW07, and 2 new surficial aquifer monitoring wells immediately above the clay semi-confining unit downgradient of BW-FARP-S-MW03 • Collect groundwater samples from 11 existing and 21 new surficial aquifer monitoring wells, 4 existing UCH aquifer monitoring wells, and 6 existing LCH aquifer monitoring wells • Collect groundwater samples from the surficial aquifer monitoring wells during the same event as the sediment and surface water samples, resulting in 2 rounds of groundwater sampling for surficial aquifer monitoring wells Soil: • Collect surface (0-1 foot bgs) and subsurface (immediately above the water table) soil samples at 7 new monitoring well locations Surface Water/Sediment: • Collect 2 rounds of co-located surface water and sediment samples from 14 locations within drainage ditches surrounding the site during seasonally high and low groundwater table conditions Samples will be analyzed for the 29 PFAS listed in USEPA UCMR 5 via LC-MS/MS compliant with QSM 5.3 Table B-15, in accordance with the laboratory's Environmental Laboratory Accreditation Program Accreditation letters. Sediment samples will also be sampled for grain size and total organic carbon to support the ERA.	Groundwater, soil, surface water, and sediment data will be evaluated in accordance with **Figure 11-2**. If PFAS are detected above PALs in boundary samples (that is farthest upstream or downstream surface water or sediment, and deepest, farthest downgradient, upgradient, and/or cross-gradient groundwater samples) then additional sampling may be required to define the extent of PFAS in site media. While not identified as PALs, ecological screening values will be considered when evaluating the nature and extent of soil, surface water, and sediment. If the extent of PFOS, PFOA, and/or PFBS extends to down-gradient off-Base surface water features that are impacted, additional consideration will be warranted and an addendum or field change request to this SAP will be prepared. If PFAS are detected above PALs in site media, then human health and ecological risks will be evaluated. If unacceptable risks are identified then the RI report will recommend an evaluation of remedial alternatives for media with unacceptable risks as part of a Feasibility Study. If PFAS are not detected above PALs in site media, then no additional action is needed to address PFAS in that medium.
(continued from previous page)	What are the hydraulic and geotechnical properties of the surficial aquifer that may affect transport of PFAS?	Synoptic groundwater levels will be collected during each groundwater sampling event to develop potentiometric surfaces and estimate groundwater flow. Up to 12 soil samples will be collected and analyzed for geotechnical parameters (bulk density, total porosity, fraction organic carbon) to help quantify the fate and transport properties of the surficial aquifer and to provide site-specific input data for fate and transport modeling. The exact locations of the geotechnical samples will be chosen to obtain fate and transport characteristics for the range of lithologies that comprise the aquifer system at Site 111 while advancing the various borings. Two to three samples will be collected from the various types of soils encountered within the surficial aquifer, as determined by the field geologist/engineer using the Unified Soil Classification System (USCS).	Groundwater elevation data will be used to evaluate fate and transport through the aquifer system. The soil data will be used to provide quantification of the transport properties of the range of lithologies that comprise the aquifer system at Site 111.
	Have multiple releases of PFAS occurred over time which could have affected the nature and extent of PFAS?	Samples will be analyzed for the 29 PFAS listed in USEPA UCMR 5 via LC-MS/MS compliant with QSM 5.3 Table B-15, in accordance with the laboratory's Environmental Laboratory Accreditation Program Accreditation letters. The ratio of detected PFAS for each location will be evaluated to identify unique PFAS fingerprints indicative of multiple releases at differing times.	The ratio of detected carboxylate and sulfonate PFAS will be used to evaluate whether multiple releases of different types of PFAS have occurred within the investigation area and will be used as a line of evidence to determine whether each release is fully delineated.
(continued from previous page)	If continuous groundwater extraction from the water supply wells is resumed, does it affect the transport of PFAS from the surficial aquifer to the Castle Hayne Aquifer?	Proposed sample locations are shown on **Figure 11-1**. Groundwater samples will be collected monthly for 1 quarter upon the initiation of groundwater pumping from adjacent off-Base water supply wells, quarterly for 9 months from the following wells: • Surficial aquifer: BW-FARP-S-MW07 • UCH aquifer: BW-FARP-S-MW18 • LCH aquifer: BW-FARP-S-MW20 and BW-FARP-S-MW21 Samples will be analyzed on an expedited 7-day turn for the 29 PFAS listed in USEPA UCMR 5 via LC-MS/MS compliant with QSM 5.3 Table B-15, in accordance with the laboratory's Environmental Laboratory Accreditation Program Accreditation letters. Synoptic groundwater levels will be collected during each groundwater sampling event to develop potentiometric surfaces and estimate groundwater flow changes resulting from pumping.	Data will be used to update the CSM. If PFAS appears to be migrating toward public supply wells, as evidenced by new detections and/or increasing concentrations, then this information will be included in the CSM and an interim action may be necessary to mitigate the impacts of the PFAS migration.

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

What are the PALs?

Human Health

- **Groundwater and Surface Water:** Groundwater and surface water data for PFOA, PFOS, PFBS, hexafluoropropylene oxide dimer acid and its ammonium salt [HFPO-DA], perfluorononanoic acid [PFNA], and perfluorohexanesulfonic acid [PFHxS] will be compared to tap water RSLs based on an HQ of 0.1 from the May 2022 RSL table (USEPA, 2022). PFAS results for constituents without an SL 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 for PFOA, PFOS, PFBS, HFPO-DA, PFNA, and PFHxS will be compared to residential soil RSLs based on an HQ of 0.1 from the May 2022 RSL table (USEPA, 2022). PFAS results for constituents without an SL will be provided in an appendix to the RI report for comparison to appropriate screening values if they are available in the future.

What are additional screening levels that may be considered in the RI data evaluation?

The following additional screening levels will be considered as part of the data evaluation in the RI; however, they are not considered cleanup levels or intended for sole use in the risk assessments or for remedial actions. Promulgated state cleanup values will be evaluated as ARARs, if needed.

Human Health

- **Groundwater:** The groundwater sample results will also be compared to the North Carolina Interim Maximum Allowable Concentration for PFOA presented in **Appendix A**.
- **Groundwater used as drinking water:** Groundwater that may be used as drinking water will be compared to the USEPA Lifetime Health Advisory for PFOA and PFOS of 70 ng/L or 0.07 micrograms per liter (µg/L) for the sum of the two chemicals as presented in **Appendix A.**
- **Soil:** The soil sample results will also be compared to the North Carolina Preliminary Soil Remediation Goals for protection of groundwater available for PFBS as presented in **Appendix A**. Soil data will also be evaluated for leaching potential based on a multiple lines of evidence approach including 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 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

- **Soil, Surface Water, and Sediment:** PFAS compounds will be evaluated for potentially unacceptable risk to ecological receptors for pathways confirmed to be complete during the RI. Ecological screening values (ESVs) are included in **Appendix A** to ensure that data collected during the RI are suitable to meet needs for ERA; however, ESVs applied at the time of ERA will be based on state of the science data at the time of the evaluation.

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

What types of data are needed (matrix, target analytes, analytical groups, field screening, onsite analytical or offsite laboratory techniques, sampling techniques)?

The data to be collected during this investigation will include the following:

- Soil boring logs that describe lithology will be generated during the monitoring well installations.
- Laboratory analytical results for PFAS in groundwater, soil, surface water, and sediment samples.
  - The specific target analytes and PALs are included in **Worksheet #15**.
- Water quality parameters (WQPs), including pH, conductivity, oxidation-reduction potential (ORP), dissolved oxygen (DO), temperature, and turbidity will be collected during groundwater sample collection. With the exception of turbidity, these WQPs will also be collected during surface water sampling.
- Parameters to support hydrogeologic modeling including total organic carbon, bulk density, total porosity, moisture content, and grain size distribution. Total organic carbon will be used to adjust ESVs.
- Surveyed coordinates for soil sample locations and new groundwater monitoring well locations will be collected by a North Carolina-registered land surveyor.
- Groundwater elevation data will be collected prior to groundwater sample collection.

Are there any 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 DLs will be suitable to detect PFOA, PFOS, and PFBS 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 #12, #24,** and **#28** for laboratory QC samples. These MPC are consistent with the latest version of the DoD QSM, as applicable, and method specific or laboratory in-house limits where the QSM does not apply.

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

- All sampling locations are shown on **Figure 11-1** and are based on the rationale presented in **Worksheet #17** and in accordance with the project schedule outlined in **Worksheet #16**.
- The data will be collected following the methodologies in **Worksheet #14** and the standard operating procedures (SOPs) presented in **Worksheet #21**.

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

Matrix: Groundwater, Surface water

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

QC Sample[a]	Analytical Group	Frequency	Data Quality Indicators (DQIs)	MPC
Field Duplicate	PFAS	1 per 10 field samples of similar matrix	Precision	Relative Percent Difference (RPD) less than or equal to (≤) 30 percent (%)
Equipment Rinsate Blank		One per day of field sampling for decontaminated equipment One per lot for disposable equipment	Bias/Contamination	No target analytes detected greater than (>) ½ LOQ or > 1/10 sample concentration, whichever is greater
Field Blank[b]		One per sampling event	Bias/Contamination	No target analytes detected > ½ LOQ or > 1/10 sample concentration, whichever is greater
Cooler Temperature Indicator		1 per cooler to the laboratory	Accuracy/Representativeness	≤ 10 degrees Celsius (°C) at laboratory receipt, storage in the laboratory ≤ 6°C, but 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 #12-2—Measurement Performance Criteria Table for Field QC Samples

Matrix: Soil, Sediment

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

QC Sample[a]	Analytical Group	Frequency	DQIs	MPC
Field Duplicate	PFAS	1 per 10 field samples of similar matrix	Precision	RPD ≤ 35%
Equipment Rinsate Blank		One per day of field sampling for decontaminated equipment One per lot for disposable equipment	Bias/Contamination	No target analytes detected > 1/2 LOQ or greater than 1/10 sample concentration, whichever is greater
Field Blank[b]		One per sampling event	Bias/Contamination	No target analytes detected > ½ LOQ or >1/10 sample concentration, whichever is greater
Cooler Temperature Indicator		1 per cooler to the laboratory	Accuracy/Representativeness	≤ 10°C at laboratory receipt, storage in the laboratory ≤ 6°C, but 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 QC Samples

Matrix: Soil, Sediment

Analytical Group: Geotechnical Parameters

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

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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
Analytical PFAS results from groundwater and soil samples	CH2M. 2022. Draft *Basewide Per- and Polyfluoroalkyl Substances Site Inspection, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* January.	CH2M, analytical laboratory data from groundwater samples, 2020	Data will be used for risk assessment in the RI report and to select sample locations.	None. All data has been validated and is deemed usable.
	CH2M, results from additional SI activities.	CH2M, analytical laboratory data from groundwater samples, 2021		

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SAP Worksheet #14—Summary of Project Tasks

The technical approach for the proposed field activities is detailed herein. The SOPs tabulated on **Worksheet #21** and provided in **Appendix B** address the protocols to be used for the RI. Any modification to the work approach will be documented in the field notes.

Pre-sampling Tasks

- Subcontractor procurement
  - Analytical laboratory
  - Data Validator
  - Utility locator
  - Driller
  - Surveyor
  - IDW transportation and disposal contractor
- Fieldwork scheduling

Sampling Tasks

- Mobilization
- Utility clearance
- Monitoring well installation
- Well development
- Groundwater sampling
- Soil sampling
- Surface water and sediment sampling
- Decontamination
- Surveying
- IDW management
- Sample shipping
- Demobilization

Mobilization

Mobilization for the field effort includes procurement of necessary field equipment and initial transport to the investigation area. Equipment and supplies will be brought to the field when the CH2M field team mobilizes for field activities. Field notes will be captured on loose leaf notebook paper and forms each day or on tablets in accordance with SOPs in **Appendix B**. A concrete paved and curbed location for the placement of IDW will be determined before field activities. Before beginning any phase of work, CH2M and its subcontractors will have field meetings to discuss the work items and worker responsibilities, and to familiarize workers with the HSP.

In general, work will be performed in Level D personal protective equipment, consisting of a hard hat, safety glasses, safety-toed boots, and hearing protection. Field activities will take place during normal daylight working hours. Weekend work might be necessary to accommodate flight operations schedules.

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

Utility Clearance

Utilities will be cleared before beginning intrusive activities in accordance with the SOP listed in **Worksheet #21** and provided in **Appendix B**. CH2M will coordinate utility clearance. A third-party utility clearance subcontractor will be procured by CH2M to clearly mark subsurface utilities near the proposed monitoring well and soil sample locations. Any proposed monitoring well locations within 5 feet of utility locations will be relocated to avoid impact to utilities. The FTL will consult with the PM and STC to confirm that the new location will meet the PQO.

Monitoring Well Installation

New monitoring wells will be installed using sonic drilling method. Continuous soil cores will be collected in plastic sleeves and logged. The wells will be constructed using 2-inch-inner-diameter Schedule 40 polyvinyl chloride (PVC) and 0.010-inch PVC screens. Each monitoring well will be constructed with a 10-foot-long screen at depths specified in **Table 14-1**. The annular space around the well screens will be backfilled with a well-graded, fine to medium silica sand filter pack consisting of a thoroughly washed, round, durable, siliceous material containing less than 5 percent calcareous particles. The filter pack will extend from the bottom of the boring to 2 feet above the top of screen. A minimum 2-foot-thick bentonite layer will be placed above the sand pack. After the bentonite has been hydrated, a cement-bentonite grout will be placed in the remaining annular space.

Spill prevention will include guidelines for fuel and waste transfer operations as well as provisions for secondary containment/ground surface protection, good housekeeping, and preventative maintenance. The following practices will be implemented to minimize the possibilities of spills during chemical transfer (fueling) operations:

- The number of containers used in any chemical transfer operation should be optimized to allow for the safest handling possible with the minimum number of containers.
- The proper equipment will be used for moving chemical containers into storage areas and transferring them to the work areas. Equipment safety procedures are specified in the HASP.
- Secondary containment will be used at the transfer points for all chemical transfer operations.
- Transfer operations (including fueling) will never be left unattended.
- Liquid material will not be stored in the back of trucks or equipment unless it is secured and in secondary containment. Material containers will be inspected for dents, excessive rusting, cracks or leaks.
- Stormwater drains and conveyances in close proximity to the operations area will be completely covered during the transfer to prevent any spills from entering them. If the work is occurring in sloping areas, berms or other devices will be proactively placed around the work area to slow or prevent migration should a spill occur.

Preventive maintenance involves the regular inspection and testing of equipment and operational systems. Breakdowns and failures can often be avoided by adjustment, repair, or replacement of equipment. The following practices will be adhered to as part of preventive maintenance:

- All equipment will be inspected prior to entering the site and then on a daily basis. Inspections will focus on active or potential leaks as well as any faulty hoses and fittings. Inspections will be documented in the daily logs. Equipment requiring maintenance or repair will not be placed into service.

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

- Any equipment used will be maintained in accordance with the manufacturer's specifications. This maintenance will occur offsite if possible.
- Prior to using or moving any vehicle or piece of equipment, perform a 360-degree walk around. Checking for the presence of any leaks both on the ground, under the vehicle or equipment, and in any secondary containment associated with the vehicle or equipment.

Adequate spill control materials will be maintained at the local work areas where chemical products are being used. Spill response kits will be kept in close proximity to locations where hazardous materials are being used so that they can be easily accessed in the event of an incident. Smaller kits will be maintained in construction support vehicles, if needed.

Well Development

Upon completion of the well installation, each monitoring well will be developed using a combination of surging and pumping throughout the well screen. During monitoring well development, the CH2M field crew will measure WQPs, including pH, temperature, conductivity, and turbidity. Development will continue for approximately 1 hour and until the turbidity of the water removed from the well is as clear as practicable, using professional judgment. Surge blocks and pumps with Teflon parts will be avoided during development.

Newly installed monitoring wells will be developed in accordance with the SOP listed in **Worksheet #21** and provided in **Appendix B**.

Groundwater Sampling

Groundwater Level Measurements

Before groundwater sampling, and at least 24 hours after well installation and development has been completed, the depth to groundwater, to the nearest 0.01 foot, will be measured from all monitoring wells in accordance with the SOP listed in **Worksheet #21** and provided in **Appendix B**. Measurements will be made from the top of the PVC riser, which will be marked. If during removal of the locking well cap, the well demonstrates signs of being under pressure (escaping air sounds or cap being pushed off by pressure), then the depth to water in that monitoring well will be measured repeatedly over a period of several minutes to determine whether the water level is still changing. If over several minutes the water level continues to change, the water level in that well will not be measured for a period of 1 hour to allow the water level to equilibrate. Depth to water and time measured will be recorded in the field notes.

Collection of Groundwater Samples

Groundwater samples will be collected from the newly installed monitoring wells (**Table 14-1**) and existing monitoring wells (**Table 14-2**), in accordance with **Worksheet #17** and with the SOPs listed in **Worksheet #21** and provided in **Appendix B.** For groundwater samples collected under low flow/low stress conditions, the peristaltic pump intake will be placed at the middle of the wetted well screen interval.

Depth to water readings and WQPs will be measured and recorded (approximately every 5 minutes) before sampling using a depth-to-water meter and water quality meter, calibrated daily (at a minimum). Sampling will begin when three well volumes have been purged or when minimal water level drawdown requirements are met and WQPs have stabilized for three consecutive readings in accordance with the Low Flow Groundwater Sampling

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

SOP listed in **Worksheet #21** and located in **Appendix B**. If excessive drawdown occurs at very low flow rates, then the well will be purged by removing three well volumes or until groundwater can no longer be removed from the well, and then sampled once the groundwater level has recovered to the extent where a sample can be obtained in accordance with the Groundwater Sampling SOP listed in **Worksheet #21** and located in **Appendix B**. Depth-to-water, total depth, and WQPs will be recorded on Groundwater Sampling Data Sheets. Groundwater will be collected into laboratory-supplied high-density polyethylene (HDPE) bottles and placed into coolers containing enough ice to keep the samples 0 to 6°C (but not frozen) until they are received by the laboratory. Following completion of the PFAS sampling, each area will be restored to its original condition.

Soil Sampling

Soil samples will be collected at the surface (0 to 6 inches bgs) and top of the capillary fringe in the unsaturated soil (to be determined in the field) at select new monitoring well boring locations located within or near potential release areas (**Table 14-1**) in accordance with **Worksheet #18** and with the SOPs listed in **Worksheet #21** and provided in **Appendix B**. Locations for collection of soil samples were selected in areas likely to contain PFAS releases to the surface based on the CSM provided in **Worksheet #10**.

Soil samples will be collected in accordance with the soil sampling SOPs listed in **Worksheet #21** and located in **Appendix B** using a sampling tool advanced to the desired sampling depth. Soil will be collected in the laboratory-supplied HDPE jars using reusable decontaminated equipment or single-use dedicated equipment. Soil samples will be placed into coolers containing enough ice to keep the samples 0 to 6°C (but not frozen) until they are received by the laboratory. Soil samples for geotechnical parameters will be selected to represent the range of lithologies present in the surficial aquifer within the screened interval. Two to three samples will be collected from the various types of soils encountered within the surficial aquifer, as determined by the field geologist/engineer using the USCS. Soil will be collected in the laboratory supplied containers and shipped to the geotechnical laboratory. Soil samples will also be tested for pH by a field pH probe. Samples will be selected from borings across the site in the saturated zone, representing the soil types encountered in the surficial aquifer including fine sands and mixtures of sand, silt, and clay in varying percentages.

Following completion of the PFAS and geotechnical sampling, each area will be restored to its original condition.

Surface Water and Sediment Sampling

Surface water and sediment samples are planned along the drainage ditches surrounding the site and entering the adjacent wetlands (**Figure 11-1**). Although estimated surface water flow direction is depicted on **Figure 11-1**, the surface water flow direction will be confirmed before collecting any samples. If surface water is not present at a location identified for sampling, then the sample will be moved to a location with surface water present and the FTL will consult with the PM and STC to confirm that the new location will meet the PQO. Samples will not be collected within 24 hours of a rain event with more than 0.5 inches of accumulation.

Surface water samples will be collected from downstream to upstream using PFAS-free sampling equipment in accordance with applicable SOPs in **Worksheet #21** and located in **Appendix B**. Surface water will be collected within the water column, from approximately 2 inches above the sediment surface, into laboratory-supplied HDPE bottles and placed into coolers containing enough ice to keep the samples 0 to 6°C (but not frozen) until they are received by the laboratory. After the surface water sample is collected, the depth of the water will be measured using a PFAS-free water-level indicator and WQPs, including conductivity, temperature, pH, DO, turbidity, and ORP, will be collected using a hand-held water quality meter. The water quality meter will be calibrated daily (at a minimum) and the calibration documented in the field notes. Appropriate QA/QC samples will be collected as specified in **Worksheet #20**.

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

Sediment samples will be collected following surface water sample collection using PFAS-free sampling equipment in accordance with applicable SOPs in **Worksheet #21**. Sediment samples will be collected from 0 to 6 inches bgs and analyzed for the site-specific laboratory analytical parameters listed in **Worksheet #17**. Sediment will be collected into laboratory-supplied HDPE jars and placed into coolers containing enough ice to keep the samples 0 to 6°C until they are received by the laboratory. Sediment samples will also be tested for pH by a field pH probe.

Decontamination

All nondisposable sampling equipment will be decontaminated immediately after each use in accordance with the SOP listed in **Worksheet #21** and provided in **Appendix B**. Decontamination fluids will be contained in a tank or 55-gallon drum and disposed of offsite as described in the IDW management section below.

Surveying

Newly installed permanent monitoring well locations will be horizontally and vertically located by a North Carolina-licensed surveyor in accordance with SOP listed in **Worksheet #21** and provided in **Appendix B**. The surveyor will provide coordinates of all horizontal points X, Y, to the nearest 0.5 foot and vertical point Z (top of casing) to the nearest 0.01 foot. The ground surface elevations will be surveyed to the nearest 0.01 foot for asphalt and concrete surfaces and to 0.1 foot for unpaved ground surfaces.

Investigation-derived Waste Management

IDW is expected to consist of drill cuttings from the soil borings generated during monitoring well installations, purge water from well development and groundwater sampling, and decontamination fluids. Aqueous IDW and solid IDW will be stored in separate 55-gallon drums. IDW will be managed in accordance with the MCB Camp Lejeune and Marine Corps Air Station New River *Investigation and Remediation Waste Management Plan* (CH2M, 2021a) and the SOP referenced in **Worksheet #21** and included in **Appendix B**. Disposal requirements will follow the *Interim Per-and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers* (Navy, 2020) from November 2020; however, if Navy guidance is updated before IDW management is initiated, the new guidance will be followed upon direction by the NAVFAC RPM. Disposable equipment, including personal protective equipment, will be disposed of in an opaque trash bag in an on-Base dumpster.

Sample Shipment

Analytical samples and equipment will be shipped by overnight courier in accordance with the SOP referenced in **Worksheet #21** and included in **Appendix B**.

Demobilization

Full demobilization will occur when the project is complete, 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.
- Restoration of the area to an appropriate level (for example, repair of deep ruts) will be verified by the CH2M FTL.
- All equipment will be inspected, packaged, and shipped to the appropriate location.

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

Sample Analysis

The laboratory will maintain, test, inspect, and calibrate analytical instruments (**Worksheets #24** and **#25**). The laboratory will analyze aqueous and solid samples for PFAS as shown on **Worksheets #15** and **#18**. QC samples are described on **Worksheet #28**. SOPs for all laboratory analytical tasks are tabulated on **Worksheet #23** and will be provided upon request.

Analyses will be conducted by Vista, Katahdin, and Eurofins as listed in **Worksheet #30**.

Data Validation, Review, and Management Tasks

Data from all media samples (groundwater, soil, surface water, and sediment) obtained from the analytical laboratory will be validated. The project chemist is responsible for data tracking and storage. Definitive analytical laboratory data will be reported as a Stage 4 data package including certificates of analysis for traceability and 10 percent of the data will undergo Stage 4 validation before use by the Navy. All WQP data will be checked by the project chemist before use. The FTL is responsible for ensuring the photoionization detector (PID) and WQP meter are calibrated prior to sample collection. See **Worksheet #36** for more information. All analytical data (from groundwater, soil, surface water, and sediment samples) will be loaded into the Naval Installation Restoration Information Solution database.

Procedures for Recording and Correcting Data

- Field data will be recorded on loose leaf notebook paper and on tablets
- Project Assessment/Audit: **Worksheets #31** and **#32**
- Data Validation: **Worksheets #35** and **#36**
- Data Usability Assessment: **Worksheet #37**

Analytical and Validation Tasks

The analytical laboratory will process and prepare samples for analyses and will analyze all samples per **Worksheets #19** and **#23**. QC samples are described on **Worksheet #28**. SOPs for all laboratory analytical tasks are tabulated on **Worksheet #23**.

- The laboratory will maintain, test, inspect, and calibrate analytical instruments. See **Worksheets #24** and **#25**.
- The laboratory will process and prepare samples for analysis.
- All analytical data to be used for chemical characterization of the investigated areas will be validated. See **Worksheet #36** for more details.
- A data usability assessment will be performed on the RI data. See **Worksheet #37** for more details.

Reporting

A summary of the field activities, nature and extent, human health and ecological risk assessments, fate and transport, conclusions, and recommendations will be presented in an RI Report, according to the anticipated schedule outlined in **Worksheet #16**. Deviations from this SAP will be discussed in a dedicated section of the RI report.

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

Table 14-1. New Monitoring Well Details

Potential Well Identification (ID)	**Proposed Screened Interval (feet bgs)[1]**	**Well Diameter (inches)**	**Well Completion[2]**
BW-FARP-S-MW22	30 to 40	2	Flush Mount
BW-FARP-S-MW23	10 to 20	2	Flush Mount
BW-FARP-S-MW24	10 to 20	2	Flush Mount
BW-FARP-S-MW25	10 to 20	2	Flush Mount
BW-FARP-S-MW26	10 to 20	2	Flush Mount
BW-FARP-S-MW27	10 to 20	2	Flush Mount
BW-FARP-S-MW28	10 to 20	2	Flush Mount
BW-FARP-S-MW29	10 to 20	2	Flush Mount
BW-FARP-S-MW30	10 to 20	2	Flush Mount
BW-FARP-S-MW31	10 to 20	2	Flush Mount
BW-FARP-S-MW32	10 to 20	2	Flush Mount
BW-FARP-S-MW33	10 to 20	2	Flush Mount
BW-FARP-S-MW34	10 to 20	2	Flush Mount
BW-FARP-S-MW35	10 to 20	2	Flush Mount
BW-FARP-S-MW36	10 to 20	2	Flush Mount
BW-FARP-S-MW37	10 to 20	2	Flush Mount
BW-FARP-S-MW38	10 to 20	2	Flush Mount
BW-FARP-S-MW39	10 to 20	2	Flush Mount
BW-FARP-S-MW40	10 to 20	2	Flush Mount
BW-FARP-S-MW41	30 to 40	2	Flush Mount
BW-FARP-S-MW42	30 to 40	2	Flush Mount

Note:

Bold indicates soil sampling location for PFAS, geotechnical soil samples may be collected from any well location that is representative of aquifer conditions.

[1] Actual screened intervals to target the surficial aquifer will be determined in the field based on soil boring logs

[2] Well completions may change based on field conditions and base operations

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

Table 14-2. Existing Well Details

Well ID	Screened Interval (feet bgs)	Well Diameter (inches)
BW-FARP-S-MW01	5 to 15	2
BW-FARP-S-MW02	4 to 14	2
BW-FARP-S-MW03	5 to 15	2
BW-FARP-S-MW04	8 to 18	2
BW-FARP-S-MW05	5 to 15	2
BW-FARP-S-MW06	8 to 18	2
BW-FARP-S-MW07	4 to 14	2
BW-FARP-S-MW08	7 to 17	2
BW-FARP-S-MW09	5 to 15	2
BW-FARP-S-MW10	70 to 80	2
BW-FARP-S-MW11	150 to 160	2
BW-FARP-S-MW12	7 to 17	2
BW-FARP-S-MW13	70 to 80	2
BW-FARP-S-MW14	155 to 165	2
BW-FARP-S-MW15	8 to 18	2
BW-FARP-S-MW16	70 to 80	2
BW-FARP-S-MW17	155 to 165	2
BW-FARP-S-MW18	70 to 80	2
BW-FARP-S-MW19	160 to 170	2
BW-FARP-S-MW20	125 to 145	2
BW-FARP-S-MW21	130 to 150	2

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

Matrix: Groundwater, Surface Water

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

Analyte	CAS Number	PAL (ng/L)	PAL Reference	Laboratory Limits (Vista)			LCS and MS/MSD Recovery Limits and RPD[1] (%)		
				LOQs (ng/L)	LODs (ng/L)	DLs (ng/L)	LCL	UCL	RPD
Perfluorooctanoic acid (PFOA)	335-67-1	6	Tapwater RSL	8.0	4.0	2.0	71	133	30
Perfluorooctane Sulfonate (PFOS)	1763-23-1	4	Tapwater RSL	8.0	4.0	2.0	65	140	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	600	Tapwater RSL	8.0	4.0	2.0	72	130	30
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	No Criterion	8.0	4.0	2.0	**65**	**135**	30
1H, 1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2 FTS)	39108-34-4	--	No Criterion	8.0	4.0	2.0	67	138	30
1H, 1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2 FTS)	757124-72-4	--	No Criterion	8.0	4.0	2.0	63	143	30
1H, 1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2 FTS)	27619-97-2	--	No Criterion	8.0	4.0	2.0	64	140	30
4,8-dioxa-3H-perfluoronanoic acid (ADONA)	919005-14-4	--	No Criterion	8.0	4.0	2.0	**65**	**135**	30
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	--	No Criterion	8.0	4.0	2.0	**65**	**135**	30

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

Analyte	CAS Number	PAL (ng/L)	PAL Reference	Laboratory Limits (Vista)			LCS and MS/MSD Recovery Limits and RPD[1] (%)		
				LOQs (ng/L)	LODs (ng/L)	DLs (ng/L)	LCL	UCL	RPD
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	6	Tapwater RSL	8.0	4.0	2.0	**65**	**135**	30
N-Ethylperfluoro-1-octanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	No Criterion	8.0	4.0	2.0	61	135	30
N-Methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	No Criterion	8.0	4.0	2.0	65	136	30
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	--	No Criterion	8.0	4.0	2.0	**65**	**135**	30
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	--	No Criterion	8.0	4.0	2.0	**65**	**135**	30
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	--	No Criterion	8.0	4.0	2.0	**65**	**135**	30
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	--	No Criterion	8.0	4.0	2.0	**65**	**135**	30
Perfluorobutanoic acid (PFBA)	375-22-4	--	No Criterion	8.0	4.0	2.0	73	129	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	No Criterion	8.0	4.0	2.0	71	129	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	No Criterion	8.0	4.0	2.0	72	134	30
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	--	No Criterion	8.0	4.0	2.0	69	134	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	No Criterion	8.0	4.0	2.0	72	130	30
Perfluorohexane sulfonate (PFHxS)	355-46-4	39	Tapwater RSL	8.0	4.0	2.0	68	131	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	No Criterion	8.0	4.0	2.0	72	129	30
Perfluorononanoic acid (PFNA)	375-95-1	5.9	Tapwater RSL	8.0	4.0	2.0	69	130	30

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

Analyte	**CAS Number**	**PAL (ng/L)**	**PAL Reference**	**Laboratory Limits (Vista)**			**LCS and MS/MSD Recovery Limits and RPD[1] (%)**		
				LOQs (ng/L)	**LODs (ng/L)**	**DLs (ng/L)**	**LCL**	**UCL**	**RPD**
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	--	No Criterion	8.0	4.0	2.0	71	127	30
Perfluoropentanoic acid (PFPeA)	2706-90-3	--	No Criterion	8.0	4.0	2.0	72	129	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	No Criterion	8.0	4.0	2.0	71	132	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	No Criterion	8.0	4.0	2.0	65	144	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	No Criterion	8.0	4.0	2.0	69	133	30

Notes:

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

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

RSL Tap water values based on HQ of 0.1 are from the USEPA RSLs Table (May 2022).

CAS = Chemical Abstracts Service

LCL = lower control limit

LCS = laboratory control sample

MS = matrix spike

MSD = matrix spike duplicate

PPRTV = Provisional Peer-Reviewed Toxicity Value

UCL = upper control limit

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

Matrix: Soil, Sediment

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

Analyte	CAS Number	PAL (µg/kg)	PAL Reference	Laboratory Limits[1] (Vista)			LCS and MS/MSD Recovery Limits and RPD (%)[2]		
				LOQs (µg/kg)	**LODs (µg/kg)**	**DLs (µg/kg)**	**LCL**	**UCL**	**RPD**
Perfluorooctane Sulfonate (PFOS)	1763-23-1	13	Residential Soil RSL	2.0	1.0	0.50	68	136	30
Perfluorooctanoic acid (PFOA)	335-67-1	19	Residential Soil RSL	2.0	1.0	0.50	69	133	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1,900	Residential Soil RSL	2.0	1.0	0.50	72	128	30
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	No Criterion	2.0	1.0	0.50	**65**	**135**	30
1H, 1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2 FTS)	39108-34-4	--	No Criterion	2.0	1.0	0.50	65	137	30
1H, 1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2 FTS)	757124-72-4	--	No Criterion	2.0	1.0	0.50	62	145	30
1H, 1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2 FTS)	27619-97-2	--	No Criterion	2.0	1.0	0.50	64	140	30
4,8-dioxa-3H-perfluoronanoic acid (ADONA)	919005-14-4	--	No Criterion	2.0	1.0	0.50	**65**	**135**	30
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	--	No Criterion	2.0	1.0	0.50	**65**	**135**	30
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	223	Residential Soil RSL	2.0	1.0	0.50	**65**	**135**	30

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

Analyte	**CAS Number**	**PAL (µg/kg)**	**PAL Reference**	**Laboratory Limits[1] (Vista)**			**LCS and MS/MSD Recovery Limits and RPD (%)[2]**		
				LOQs (µg/kg)	**LODs (µg/kg)**	**DLs (µg/kg)**	**LCL**	**UCL**	**RPD**
N-Ethylperfluoro-1-octancesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	No Criterion	2.0	1.0	0.50	61	139	30
N-Methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	No Criterion	2.0	1.0	0.50	63	144	30
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	--	No Criterion	2.0	1.0	0.50	**65**	**135**	30
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	--	No Criterion	2.0	1.0	0.50	**65**	**135**	30
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	--	No Criterion	2.0	1.0	0.50	**65**	**135**	30
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	--	No Criterion	2.0	1.0	0.50	**65**	**135**	30
Perfluorobutanoic acid (PFBA)	375-22-4	--	No Criterion	2.0	1.0	0.50	71	135	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	No Criterion	2.0	1.0	0.50	69	133	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	No Criterion	2.0	1.0	0.50	69	135	30
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	--	No Criterion	2.0	1.0	0.50	70	132	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	No Criterion	2.0	1.0	0.50	71	131	30
Perfluorohexane sulfonate (PFHxS)	355-46-4	130	Residential Soil RSL	2.0	1.0	0.50	67	130	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	No Criterion	2.0	1.0	0.50	70	132	30

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

Analyte	CAS Number	PAL (µg/kg)	PAL Reference	Laboratory Limits[1] (Vista)			LCS and MS/MSD Recovery Limits and RPD (%)[2]		
				LOQs (µg/kg)	LODs (µg/kg)	DLs (µg/kg)	LCL	UCL	RPD
Perfluorononanoic acid (PFNA)	375-95-1	19	Residential Soil RSL	2.0	1.0	0.50	72	129	30
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	--	No Criterion	2.0	1.0	0.50	73	123	30
Perfluoropentanoic acid (PFPeA)	2706-90-3	--	No Criterion	2.0	1.0	0.50	69	132	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	No Criterion	2.0	1.0	0.50	69	133	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	No Criterion	2.0	1.0	0.50	66	139	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	No Criterion	2.0	1.0	0.50	64	136	30

Notes:

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

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

Residential Soil RSL values based on HQ of 0.1 are from the USEPA RSLs Table (May 2022).

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.

µg/kg = micrograms per kilogram

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

Matrix: Soil, Sediment

Analytical Group: Geotechnical Parameters

Analyte[1]	Method[2]	CAS Number [3]	Units
Grain Size (Sieve and Hydrometer)			
Gravel (%)	ASTM D422	GRAVEL	%
Sand (%)	ASTM D422	14808-60-7	%
Coarse Sand (%)	ASTM D422	COARSE SAND	%
Very Coarse Sand (%)	ASTM D422	VERYCOARSESAND	%
Medium Sand (%)	ASTM D422	MEDIUM SAND	%
Fine Sand (%)	ASTM D422	FINESAND	%
Fines (%)	ASTM D422	FINES	%
Very Fine Sand (%)	ASTM D422	VERYFINESAND	%
Silt (%)	ASTM D422	SILT	%
Clay (%)	ASTM D422	1318-74-7	%
Sieve No. 004 (4.75 millimeters)	ASTM D422	SIEVE4.75	%
Sieve No. 010 (2 millimeters)	ASTM D422	SIEVE2.0	%
Sieve No. 020 (850 micrometers)	ASTM D422	SIEVE850	%
Sieve No. 040 (425 micrometers)	ASTM D422	SIEVE425	%
Sieve No. 060 (250 micrometers)	ASTM D422	SIEVE250	%
Sieve No. 080 (180 micrometers)	ASTM D422	SIEVE180	%
Sieve No. 100 (150 micrometers)	ASTM D422	SIEVE150	%
Sieve No. 200 (75 micrometers)	ASTM D422	SIEVE75	%
Bulk Density [4]	ASTM D2937	DENSITY	grams per cubic meter (g/cm^3)
Porosity [4]	American Petroleum Institute RP40	-3080	%
Total Organic Carbon	Walkley Black	%TOC	%
Solids, Percent Moisture [4]	SM 2540G	%MOIST	%

Notes:

[1] There are no action limits, laboratory reporting limits, or LCS recovery limits for geotechnical parameters.

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

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

[4] Soil only, all other analytes will be run on both soil and sediment.

ASTM = ASTM International

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SAP Worksheet #16—Project Schedule / Timeline Table

Activities	**Organization**	**Dates (MM/YYYY)**	
		Anticipated Date(s) of Initiation	**Anticipated Date of Completion**
SAP			
Draft SAP preparation	CH2M	9/2021	12/2021
NAVFAC QAO/LANT / Base SAP Review	NAVFAC, MCB Camp Lejeune	12/2021	4/2022
USEPA/NCDEQ SAP review	NAVFAC, MCB Camp Lejeune, NCDEQ, USEPA Region 4	5/2022	6/2022
Final SAP acceptance	NAVFAC, MCB Camp Lejeune, NCDEQ, USEPA Region 4	6/2022	7/2022
Field Implementation			
Utility locating	CH2M, subcontractor	8/2022	8/2022
Monitoring well installation, Round 1 groundwater, soil, surface water, and sediment sampling	CH2M, subcontractor	8/2022	9/2022
Laboratory analyses, data validation (DV), and data management	CH2M, subcontractor	9/2022	1/2023
Round 2 groundwater, surface water, and sediment sampling	CH2M	3/2023	4/2023
Monitoring well survey	CH2M	1/2023	1/2023
Laboratory analyses, DV, and data management	CH2M, subcontractor	4/2023	7/2023
RI Report			
Draft report preparation	CH2M	6/2023	11/2023
NAVFAC/Base Review	NAVFAC, MCB Camp Lejeune	11/2023	1/2024
USEPA/NCDEQ report review	NAVFAC, MCB Camp Lejeune, NCDEQ, USEPA Region 4	2/2024	4/2024
Final report acceptance	NAVFAC, MCB Camp Lejeune, NCDEQ, USEPA Region 4	5/2024	6/2024

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SAP Worksheet #17—Sampling Design and Rationale

Groundwater, soil, surface water, and sediment samples will be collected as detailed in **Table 17-1**. The sample depth information is provided in the Sampling Strategy and Rationale column. Samples will be analyzed for PFAS by LC-MS/MS Compliant with QSM v5.3 Table B-15. Actual sample locations may vary from the proposed sample locations presented on **Figures 11-1** due to field conditions or conflicts with Base operations.

Table 17-1. Sampling Design and Rationale for Site 111 Sampling

Matrix	Number of Samples	Sampling Locations	Analysis	Laboratory Method	Sampling Strategy and Rationale
Groundwater	Round 1: 32 Surficial, 4 UCH, 6 LCH Round 2: 32 Surficial	Refer to **Figure 11-1**	PFAS	LC-MS/MS Compliant with DoD QSM 5.3, Table B-15 / SOP 5-369-08	Groundwater samples will be collected from 21 proposed surficial aquifer monitoring well locations, 11 existing surficial aquifer monitoring well locations, 4 existing UCH aquifer monitoring well locations, and 6 existing LCH aquifer monitoring well locations. New monitoring well locations were selected as follows: • BW-FARP-S-MW22 – screened above the clay layer (approximately 30 to 40 feet bgs) adjacent to BW-FARP-S-MW07 where PFOA and PFOS exceeds SLs in surficial aquifer groundwater to delineate vertical stratification within the surficial aquifer • BW-FARP-S-MW41 and BW-FARP-S-MW42 – screened above the clay layer (approximately 30 to 40 feet bgs) downgradientof BW-FARP-S-MW03 where PFOA and PFOS exceeds SLs in surficial aquifer groundwater to delineate vertical extent within the surficial aquifer • BW-FARP-S-MW23 through -MW28 – screened from approximately 10 to 20 feet bgs to bracket the water table, located along the drainage ditch running to the northwest of the site and downgradient (-MW23 through -MW26) and sidegradient (-MW27 and -MW28) from BW-FARP-S-MW03 where PFOS exceeds SLs in surficial aquifer groundwater to delineate the downgradient impacts in surficial aquifer groundwater • BW-FARP-S-MW29 through -MW32 – screened from approximately 10 to 20 feet bgs to bracket the water table, located sidegradient to BW-FARP-S-MW03 and downgradient (-MW29 and -MW30)/sidegradient (-MW31 and -MW32) from BW-FARP-S-MW07, located along the runway to evaluated whether there are additional releases from historical activities • BW-FARP-S-MW33 – screened from approximately 10 to 20 feet bgs to bracket the water table, located adjacent to runway and downgradient from BW-FARP-S-MW07 to delineate impacted groundwater in the assumed release area • BW-FARP-S-MW34 through -MW40 – screened from approximately 10 to 20 feet bgs to bracket the water table, located in a grid pattern around the assumed release area (BW-FARP-S-MW07) to the drainage ditch to define the extents of PFAS impacts within the surficial aquifer. Existing surficial, UCH, and LCH aquifer monitoring wells will be sampled to confirm initial results and evaluate potential temporal variability. Two rounds of samples will be collected during high and low water table conditions from surficial aquifer monitoring wells during surface water and sediment sampling to assess seasonal variability and changes in water table on surface water concentrations.
	6 events: 1 Surficial, 1 UCH, 2 LCH	Refer to **Figure 11-1**	PFAS	LC-MS/MS Compliant with DoD QSM 5.3, Table B-15 / SOP 5-369-08	If pumping is resumed at ONWASA supply wells D-10 and/or D-11, groundwater monitoring will be initiated monthly for 1 quarter and quarterly for 9 months. The frequency and monitoring well network may be modified based on the groundwater data as it is collected and evaluated. Initially the monitoring well network will consist of: • BW-FARP-S-MW20 and -MW21 – screened in the same LCH aquifer zone as the supply wells and located closest to the supply wells and between the release area and supply wells • BW-FARP-S-MW18 – Screened in the UCH aquifer adjacent to the impacted surficial aquifer monitoring well to identify downward migration of PFAS • BW-FARP-S-MW07 – Impacted surficial aquifer well, to monitor changes in the surficial aquifer concentrations that may be resulting from pumping
Soil	Round 1: Surface Soil: 7 Subsurface Soil: 7	Refer to **Figure 11-1**	PFAS	LC-MS/MS Compliant with DoD QSM 5.3, Table B-15 / SOP 5-369-08	Soil samples will be collected from two depths (one sample collected at the surface [0-1 foot bgs] and the second at the top of the capillary fringe in the unsaturated soil) at seven of the proposed surficial aquifer monitoring well locations (BW-FARP-S-MW34 through -MW40) to evaluate potential soil impacts in the area surrounding BW-FARP-S-MW07.
	Round 1: Subsurface Soil: 12	TBD	Bulk Density Porosity Total Organic Carbon Grain Size (sieve and hydrometer) Solids, Percent Moisture	ASTM D2937-04 ASTM D854-06 Walkley Black ASTM D422 SM 2540G	Soil samples will be collected for laboratory analysis of geotechnical parameters (total porosity, dry bulk density, fraction organic carbon, and grain size analysis). Sample locations will be selected in the field to provide representative horizontal coverage across Site 111 to account for spatial variability in geotechnical parameters. Soil sample depths will be selected in the field to cover the range of lithologies through which PFAS may be transported (typically clay/silt, silty sand, sand, and organic rich material, if present). The results will be used to refine the site CSM and to parameterize the groundwater flow and solute transport model.

SAP Worksheet #17—Sampling Design and Rationale (continued)

Table 17-1. Sampling Design and Rationale for Site 111 Sampling

Matrix	Number of Samples	Sampling Locations	Analysis	Laboratory Method	Sampling Strategy and Rationale
Surface Water	Round 1: 14 Round 2: 14	Refer to Figure 11-1	PFAS	LC-MS/MS Compliant with DoD QSM 5.3, Table B-15 / SOP 5-369-08	Surface water and sediment samples (BW-FARP-S-SW01/SD01 through -SW14/SD14) will be collected within drainage ditches and features surrounding the site to assess whether PFAS has migrated into these media either through overland flow or groundwater infiltration. Sample locations were selected at locations likely to have received surface runoff or groundwater discharge from the release area and downstream of the site. Surface water samples will be collected approximately 2 inches from the sediment surface and sediment samples will be collected from approximately 0-6 inches below sediment surface to capture the biologically active zones of each medium. Samples BW-FARP-S-SW06/SD06, -SW07/SD07, -SW08/SD08, and -SW09/SD09 are upstream of the site to accurately evaluate site contributions to measured concentrations. Two rounds of samples will be collected during high and low water table conditions from surface water and sediment locations to assess seasonal variability and changes in water table on surface water concentrations.
Sediment	Round 1: 14 Round 2: 14	Refer to Figure 11-1	PFAS	LC-MS/MS Compliant with DoD QSM 5.3, Table B-15 / SOP 5-369-08	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table

(UFP-QAPP Manual Section 3.1.1)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
Round 1					
BW-FARP-S-MW01	BW-FARP-S-GW01-YYQ	Groundwater – Surficial	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	2 (Duplicate)	**Worksheet #21**
BW-FARP-S-MW02	BW-FARP-S-GW02-YYQ	Groundwater – Surficial		3 (MS/MSD)	
BW-FARP-S-MW03	BW-FARP-S-GW03-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW04	BW-FARP-S-GW04-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW05	BW-FARP-S-GW05-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW06	BW-FARP-S-GW06-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW07	BW-FARP-S-GW07-YYQ	Groundwater – Surficial		2 (Duplicate)	
BW-FARP-S-MW08	BW-FARP-S-GW08-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW09	BW-FARP-S-GW09-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW10	BW-FARP-S-GW10-YYQ	Groundwater – UCH		1	
BW-FARP-S-MW11	BW-FARP-S-GW11-YYQ	Groundwater – LCH		1	
BW-FARP-S-MW12	BW-FARP-S-GW12-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW13	BW-FARP-S-GW13-YYQ	Groundwater – UCH		1	
BW-FARP-S-MW14	BW-FARP-S-GW14-YYQ	Groundwater – LCH		1	
BW-FARP-S-MW15	BW-FARP-S-GW15-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW16	BW-FARP-S-GW16-YYQ	Groundwater – UCH		1	
BW-FARP-S-MW17	BW-FARP-S-GW17-YYQ	Groundwater – LCH		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (Continued)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
BW-FARP-S-MW18	BW-FARP-S-GW18-YYQ	Groundwater – UCH	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	1	**Worksheet #21**
BW-FARP-S-MW19	BW-FARP-S-GW19-YYQ	Groundwater – LCH		1	
BW-FARP-S-MW20	BW-FARP-S-GW20-YYQ	Groundwater – LCH		1	
BW-FARP-S-MW21	BW-FARP-S-GW21-YYQ	Groundwater – LCH		2 (Duplicate)	
BW-FARP-S-MW22	BW-FARP-S-GW22-YYQ	Groundwater – Surficial (deep)		3 (MS/MSD)	
BW-FARP-S-MW23	BW-FARP-S-GW23-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW24	BW-FARP-S-GW24-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW25	BW-FARP-S-GW25-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW26	BW-FARP-S-GW26-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW27	BW-FARP-S-GW27-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW28	BW-FARP-S-GW28-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW29	BW-FARP-S-GW29-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW30	BW-FARP-S-GW30-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW31	BW-FARP-S-GW31-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW32	BW-FARP-S-GW32-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW33	BW-FARP-S-GW33-YYQ	Groundwater – Surficial		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (Continued)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
BW-FARP-S-MW34	BW-FARP-S-GW34-YYQ	Groundwater – Surficial	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	2 (Duplicate)	**Worksheet #21**
	BW-FARP-S-SS34-YYQ	Surface Soil		2 (Duplicate)	
	BW-FARP-S-SB34-xx-yy-YYQ	Subsurface Soil		2 (Duplicate)	
BW-FARP-S-MW35	BW-FARP-S-GW35-YYQ	Groundwater – Surficial		1	
	BW-FARP-S-SS35-YYQ	Surface Soil		3 (MS/MSD)	
	BW-FARP-S-SB35-xx-yy-YYQ	Subsurface Soil		3 (MS/MSD)	
BW-FARP-S-MW36	BW-FARP-S-GW36-YYQ	Groundwater – Surficial		1	
	BW-FARP-S-SS36-YYQ	Surface Soil		1	
	BW-FARP-S-SB36-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MW37	BW-FARP-S-GW37-YYQ	Groundwater – Surficial		1	
	BW-FARP-S-SS37-YYQ	Surface Soil		1	
	BW-FARP-S-SB37-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MW38	BW-FARP-S-GW38-YYQ	Groundwater – Surficial		1	
	BW-FARP-S-SS38-YYQ	Surface Soil		1	
	BW-FARP-S-SB38-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MW39	BW-FARP-S-GW39-YYQ	Groundwater – Surficial		1	
	BW-FARP-S-SS39-YYQ	Surface Soil		1	
	BW-FARP-S-SB39-xx-yy-YYQ	Subsurface Soil		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (Continued)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
BW-FARP-S-MW40	BW-FARP-S-GW40-YYQ	Groundwater – Surficial	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	1	**Worksheet #21**
	BW-FARP-S-SS40-YYQ	Surface Soil		1	
	BW-FARP-S-SB40-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MW41	BW-FARP-S-SS41-YYQ	Groundwater – Surficial (deep)		1	
BW-FARP-S-MW42	BW-FARP-S-SS42-YYQ	Groundwater – Surficial (deep)		1	
BW-FARP-S-SW01	BW-FARP-S-SW01-YYQ	Surface Water		2 (Duplicate)	
BW-FARP-S-SW02	BW-FARP-S-SW02-YYQ	Surface Water		3 (MS/MSD)	
BW-FARP-S-SW03	BW-FARP-S-SW03-YYQ	Surface Water		1	
BW-FARP-S-SW04	BW-FARP-S-SW04-YYQ	Surface Water		1	
BW-FARP-S-SW05	BW-FARP-S-SW05-YYQ	Surface Water		1	
BW-FARP-S-SW06	BW-FARP-S-SW06-YYQ	Surface Water		1	
BW-FARP-S-SW07	BW-FARP-S-SW07-YYQ	Surface Water		1	
BW-FARP-S-SW08	BW-FARP-S-SW08-YYQ	Surface Water		1	
BW-FARP-S-SW09	BW-FARP-S-SW09-YYQ	Surface Water		1	
BW-FARP-S-SW10	BW-FARP-S-SW10-YYQ	Surface Water		2 (Duplicate)	
BW-FARP-S-SW11	BW-FARP-S-SW11-YYQ	Surface Water		1	
BW-FARP-S-SW12	BW-FARP-S-SW12-YYQ	Surface Water		1	
BW-FARP-S-SW13	BW-FARP-S-SW13-YYQ	Surface Water		1	
BW-FARP-S-SW14	BW-FARP-S-SW14-YYQ	Surface Water		1	
BW-FARP-S-SD01	BW-FARP-S-SD01-YYQ	Sediment		2 (Duplicate)	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (Continued)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
BW-FARP-S-SD02	BW-FARP-S-SD02-YYQ	Sediment	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	3 (MS/MSD)	**Worksheet #21**
BW-FARP-S-SD03	BW-FARP-S-SD03-YYQ	Sediment		1	
BW-FARP-S-SD04	BW-FARP-S-SD04-YYQ	Sediment		1	
BW-FARP-S-SD05	BW-FARP-S-SD05-YYQ	Sediment		1	
BW-FARP-S-SD06	BW-FARP-S-SD06-YYQ	Sediment		1	
BW-FARP-S-SD07	BW-FARP-S-SD07-YYQ	Sediment		1	
BW-FARP-S-SD08	BW-FARP-S-SD08-YYQ	Sediment		1	
BW-FARP-S-SD09	BW-FARP-S-SD09-YYQ	Sediment		1	
BW-FARP-S-SD10	BW-FARP-S-SD10-YYQ	Sediment		2 (Duplicate)	
BW-FARP-S-SD11	BW-FARP-S-SD11-YYQ	Sediment		1	
BW-FARP-S-SD12	BW-FARP-S-SD12-YYQ	Sediment		1	
BW-FARP-S-SD13	BW-FARP-S-SD13-YYQ	Sediment		1	
BW-FARP-S-SD14	BW-FARP-S-SD14-YYQ	Sediment		1	
Geotechnical Samples					
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil	Bulk Density, Porosity, Total Organic Carbon, Grain Size (sieve and hydrometer), Solids, Percent Moisture	1	**Worksheet #21**
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (Continued)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil	Bulk Density, Porosity, Total Organic Carbon, Grain Size (sieve and hydrometer), Solids, Percent Moisture	1	**Worksheet #21**
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	
BW-FARP-S-MWXX	BW-FARP-S-SBXX-xx-yy-YYQ	Subsurface Soil		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (Continued)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
Round 2					
BW-FARP-S-MW01	BW-FARP-S-GW01-YYQ	Groundwater – Surficial	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	2 (Duplicate)	**Worksheet #21**
BW-FARP-S-MW02	BW-FARP-S-GW02-YYQ	Groundwater – Surficial		3 (MS/MSD)	
BW-FARP-S-MW03	BW-FARP-S-GW03-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW04	BW-FARP-S-GW04-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW05	BW-FARP-S-GW05-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW06	BW-FARP-S-GW06-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW07	BW-FARP-S-GW07-YYQ	Groundwater – Surficial		2 (Duplicate)	
BW-FARP-S-MW08	BW-FARP-S-GW08-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW09	BW-FARP-S-GW09-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW12	BW-FARP-S-GW12-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW15	BW-FARP-S-GW15-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW22	BW-FARP-S-GW22-YYQ	Groundwater – Surficial (deep)		1	
BW-FARP-S-MW23	BW-FARP-S-GW23-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW24	BW-FARP-S-GW24-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW25	BW-FARP-S-GW25-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW26	BW-FARP-S-GW26-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW27	BW-FARP-S-GW27-YYQ	Groundwater – Surficial		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (Continued)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
BW-FARP-S-MW28	BW-FARP-S-GW28-YYQ	Groundwater – Surficial	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	1	**Worksheet #21**
BW-FARP-S-MW29	BW-FARP-S-GW29-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW30	BW-FARP-S-GW30-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW31	BW-FARP-S-GW31-YYQ	Groundwater – Surficial		2 (Duplicate)	
BW-FARP-S-MW32	BW-FARP-S-GW32-YYQ	Groundwater – Surficial		3 (MS/MSD)	
BW-FARP-S-MW33	BW-FARP-S-GW33-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW34	BW-FARP-S-GW34-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW35	BW-FARP-S-GW35-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW36	BW-FARP-S-GW36-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW37	BW-FARP-S-GW37-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW38	BW-FARP-S-GW38-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW39	BW-FARP-S-GW39-YYQ	Groundwater – Surficial		1	
BW-FARP-S-MW40	BW-FARP-S-GW40-YYQ	Groundwater – Surficial		1	
BW-FARP-S-SW01	BW-FARP-S-SW01-YYQ	Surface Water		2 (Duplicate)	
BW-FARP-S-SW02	BW-FARP-S-SW02-YYQ	Surface Water		3 (MS/MSD)	
BW-FARP-S-SW03	BW-FARP-S-SW03-YYQ	Surface Water		1	
BW-FARP-S-SW04	BW-FARP-S-SW04-YYQ	Surface Water		1	
BW-FARP-S-SW05	BW-FARP-S-SW05-YYQ	Surface Water		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (Continued)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
BW-FARP-S-SW06	BW-FARP-S-SW06-YYQ	Surface Water	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	1	**Worksheet #21**
BW-FARP-S-SW07	BW-FARP-S-SW07-YYQ	Surface Water		1	
BW-FARP-S-SW08	BW-FARP-S-SW08-YYQ	Surface Water		1	
BW-FARP-S-SW09	BW-FARP-S-SW09-YYQ	Surface Water		1	
BW-FARP-S-SW10	BW-FARP-S-SW10-YYQ	Surface Water		2 (Duplicate)	
BW-FARP-S-SW11	BW-FARP-S-SW11-YYQ	Surface Water		1	
BW-FARP-S-SW12	BW-FARP-S-SW12-YYQ	Surface Water		1	
BW-FARP-S-SW13	BW-FARP-S-SW13-YYQ	Surface Water		1	
BW-FARP-S-SW14	BW-FARP-S-SW14-YYQ	Surface Water		1	
BW-FARP-S-SD01	BW-FARP-S-SD01-YYQ	Sediment		2 (Duplicate)	
BW-FARP-S-SD02	BW-FARP-S-SD02-YYQ	Sediment		3 (MS/MSD)	
BW-FARP-S-SD03	BW-FARP-S-SD03-YYQ	Sediment		1	
BW-FARP-S-SD04	BW-FARP-S-SD04-YYQ	Sediment		1	
BW-FARP-S-SD05	BW-FARP-S-SD05-YYQ	Sediment		1	
BW-FARP-S-SD06	BW-FARP-S-SD06-YYQ	Sediment		1	
BW-FARP-S-SD07	BW-FARP-S-SD07-YYQ	Sediment		1	
BW-FARP-S-SD08	BW-FARP-S-SD08-YYQ	Sediment		1	
BW-FARP-S-SD09	BW-FARP-S-SD09-YYQ	Sediment		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (Continued)

Sample Location	Sample ID	Matrix	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
BW-FARP-S-SD10	BW-FARP-S-SD10-YYQ	Sediment	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	2 (Duplicate)	**Worksheet #21**
BW-FARP-S-SD11	BW-FARP-S-SD11-YYQ	Sediment		1	
BW-FARP-S-SD12	BW-FARP-S-SD12-YYQ	Sediment		1	
BW-FARP-S-SD13	BW-FARP-S-SD13-YYQ	Sediment		1	
BW-FARP-S-SD14	BW-FARP-S-SD14-YYQ	Sediment		1	
Ongoing Monitoring [a]					
BW-FARP-S-MW07	BW-FARP-S-GW07-YYQ	Groundwater – Surficial	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	2 (Duplicate)	**Worksheet #21**
BW-FARP-S-MW18	BW-FARP-S-GW18-YYQ	Groundwater – UCH		3 (MS/MSD)	
BW-FARP-S-MW20	BW-FARP-S-GW20-YYQ	Groundwater – LCH		1	
BW-FARP-S-MW21	BW-FARP-S-GW21-YYQ	Groundwater – LCH		1	

[a] Ongoing monitoring samples will be collected if the public supply wells D10 and D11 resume pumping and will be conducted monthly for one quarter and quarterly for the following 9 months on an expedited 7-day turn.

YYQ – two-digit year, quarter [quarter to be designated as A, B, C, or D]

xx-yy – top depth, bottom depth (in feet)

XX – monitoring well number

SAP Worksheet #19—Analytical SOP Requirements Table

Matrix	Analytical Group	Analytical Method / SOP Reference	Containers	Minimum Sample Amount Required for Analysis	Preservation Requirements	Maximum Holding Time[a] (Preparation/Analysis)
Soil, Sediment	PFAS	PFAS by LC-MS/MS Compliant with QSM v. 5.3 Table B-15[b] / SOP 49	1 x 6-ounce HDPE w/polypropylene screw cap jar	20 grams (g)	Samples are stored at or below 6°C, but not frozen, until extraction.	28 days to extraction; 30 days after extraction to analysis
Groundwater, Surface water	PFAS	PFAS by LC-MS/MS Compliant with QSM v. 5.3 Table B-15[b] / SOP 49	2 x 250 mL HDPE w/polypropylene screw cap jars	2 x 250 mL	Samples are stored at or below 6°C, but not frozen, until extraction	28 days to extraction; 30 days after extraction to analysis
Soil	Bulk Density	ASTM D2937-04 / BR-GT-018	1 × 2-inch diameter × 6-inch-long sleeve	500 g	Samples are stored at or below 6°C, but not frozen	Holding times are not applicable
Soil	Porosity	ASTM D854-06 / BR-GT-004	1 x 4 ounce glass jar	200 g	Samples are stored at or below 6°C, but not frozen	Holding times are not applicable
Soil, Sediment	Total Organic Carbon	Walkley Black / CA-777	1 x 4 ounce glass jar	20 g	Samples are stored at or below 6°C, but not frozen	28 days to analysis
Soil, Sediment	Grain Size (sieve and hydrometer)	ASTM D422 / CA-551	1 x 16 ounce glass jar	50 g	Samples are stored at or below 6°C, but not frozen	Holding times are not applicable
Soil	Solids, Percent Moisture	SM 2540G / CA-717	1 x 4 ounce glass jar	20 g	Samples are stored at or below 6°C, but not frozen	7 days to analysis

Notes:

[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 QSM v. 5.3 Table B-15 or the most recent version of the QSM for which Vista has DoD Environmental Laboratory Accreditation Program (ELAP) certification.

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SAP Worksheet #20—Field Quality Control Sample Summary Table

Matrix	Analytical Group	Number of Sampling Locations	Number of Field Duplicates	Number of MS/MSDs	Number of Equipment Blanks	Number of Field Blanks	Total Number of Samples to Lab
Rounds 1 and 2 RI Sampling							
Round 1							
Groundwater	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	40	4	2/2	2	2	52
Surface water		14	2	1/1	1	1	20
Sediment		14	2	1/1	1	1	20
Soil		14	2	2/2	1	1	22
Soil	Bulk Density	12	N/A	N/A	N/A	N/A	12
Soil	Porosity	12	N/A	N/A	N/A	N/A	12
Soil	Total Organic Carbon	12	N/A	N/A	N/A	N/A	12
Soil	Grain Size (sieve and hydrometer)	12	N/A	N/A	N/A	N/A	12
Soil	Solids, Percent Moisture	2	N/A	N/A	N/A	N/A	12
Round 2							
Groundwater	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	30	3	2/2	2	2	41
Surface water		14	2	1/1	1	1	20
Sediment		14	2	1/1	1	1	20
Ongoing Monitoring[a]							
Round 1							
Groundwater	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	4	1	1/1	1	1	9

SAP Worksheet #20—Field Quality Control Sample Summary Table (continued)

Matrix	Analytical Group	Number of Sampling Locations	Number of Field Duplicates	Number of MS/MSDs	Number of Equipment Blanks	Number of Field Blanks	Total Number of Samples to Lab
Round 2							
Groundwater	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	4	1	1/1	1	1	9
Round 3							
Groundwater	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	4	1	1/1	1	1	9
Round 4							
Groundwater	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	4	1	1/1	1	1	9
Round 5							
Groundwater	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	4	1	1/1	1	1	9
Round 6							
Groundwater	PFAS (LC-MS/MS Compliant with QSM v5.3 Table B-15)	4	1	1/1	1	1	9

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

[a] Ongoing monitoring samples will be collected if the public supply wells D10 and D11 resume pumping and will be conducted monthly for one quarter and quarterly for the following 9 months on an expedited 7-day turn.

SAP Worksheet #21—Project Sampling SOP References Table

Reference Number	Title, Revision Date and / or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SOP-001	Preparing Field Log Books, rev. 02/2022	CH2M	Loose leaf paper or tablet for electronic data capture	Yes	Loose leaf paper substituted for standard field log books.
SOP-002	Decontamination of Personnel and Equipment, rev. 02/2022	CH2M	For cleansing reusable samplers	No	
SOP-003	Decontamination of Drill Rigs and Equipment, rev. 02/2022	CH2M	Steam cleaner, potable water, phosphate-free, detergent, brushes, personal protective equipment	No	
SOP-004	Disposal of Waste Fluids and Solids, rev. 02/2022	CH2M	United States Department of Transportation 55-gallon drums or tank	No	
SOP-005	Locating and Clearing Underground Utilities, rev. 02/2022	CH2M	EM-31, Ground Penetrating Radar systems, Magnetic and Optical field methods	No	
SOP-006	Low-Flow Groundwater Sampling from Monitoring Wells - USEPA Region 4, MCB Camp Lejeune, rev. 02/2022	CH2M	Pump, HDPE tubing	Yes	Reflects most recent Base and USEPA Region 4 low-flow sampling guidance
SOP-007	Groundwater Sampling from Monitoring Wells - USEPA Region 4, rev. 02/2022	CH2M	Pump, HDPE tubing	No	For volumetric purge.
SOP-008	Field Measurement of pH, Specific Conductance, DO, ORP, and Temperature Using a WQP Meter with Flow-through Cell, rev. 02/2022	CH2M	Water quality meter with flow-through cell	No	
SOP-009	Water Level Measurements, rev. 02/2022	CH2M	Electronic water-level meter, Interface probe	No	

SAP Worksheet #21—Project Sampling SOP 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-010	Equipment Blank and Field Blank Preparation, rev. 02/2022	CH2M	Laboratory provided blank liquid and sample bottles	No	
SOP-011	Chain-of-Custody, rev. 02/2022	CH2M	Chain-of-custody form	No	
SOP-012	Packaging and Shipping Procedures for Low-Concentration Samples, rev. 02/2022	CH2M	Laboratory-supplied coolers, plastic bags, ice, tape	No	No Teflon supplies, Samples will be kept on ice and shipped to laboratory via FedEx.
SOP-013	Global Positioning System, rev. 02/2022	CH2M	Hand-held global positioning system unit	No	
SOP-014	MultiRAE PID, rev. 02/2022	CH2M	PID	No	
SOP-015	Shallow Soil Sampling, rev. 02/2022	CH2M	Stainless steel trowel, sample jars, pin flags	No	
SOP-016	Logging of Soil Borings, rev. 02/2022	CH2M	Indelible pen, ruler, logbook, spatula, soil color chart, grain size chart, hand lens, USCS index charts	No	
SOP-017	Sampling Contents of Tanks and Drums, rev. 02/2022	CH2M	Rubber mallet, socket wrench, laboratory-supplied sample bottles	No	
SOP-018	Installation of Monitoring wells by Sonic Drilling, rev. 02/2022	CH2M	Sonic drill rig, well materials	No	

SAP Worksheet #21—Project Sampling SOP 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-019	Surface Water Sampling for Per- and Polyfluoroalkyl Substances, rev. 12/2021	CH2M	PFAS-free sampler (open tube sampler, dip sampler, weighted bottle sampler [no glass], hand pump without Teflon components, Van Dorn sampler, depth-integrating sampler, peristaltic pump and PFAS-free tubing), sampling containers (HDPE with HDPE screw cap), loose leaf paper without waterproof coating or tablet, metal clip board if using paper, pen (not Sharpie), nitrile or latex gloves, meters for specific conductance, temperature, pH, and DO.	No	No Teflon components, PFAS-free shipping materials
SOP-020	Sediment Sampling for Per- and Polyfluoroalkyl Substances, rev. 12/2021	CH2M	PFAS-free sample collection device (hand corer, scoop, dredge, or grab sampler), measuring tape, sample jars, loose leaf paper without waterproof coating or tablet, metal clip board if using paper, pen (not Sharpie), nitrile or latex gloves, meters for specific conductance, temperature, pH, and DO.	No	No Teflon components, PFAS-free shipping materials
SOP-021	Groundwater Sampling for Per- and Polyfluoroalkyl Substances, rev. 12/2021	CH2M	Teflon-free tubing, Teflon-free bailer (if using bailer), PFAS-free pump, sample bottles (HDPE bottle with HDPE screw cap), laboratory prepared deionized, certified PFAS-free water for field blank collection, loose leaf paper without waterproof coating or tablet, metal clip board, pen (not Sharpie), nitrile or latex gloves	No	No Teflon components, PFAS-free shipping materials

SAP Worksheet #21—Project Sampling SOP 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-022	Soil Sampling for Per- and Polyfluoroalkyl Substances, rev. 12/2021	CH2M	Sample jars (HDPE bottle with HDPE screw cap), laboratory prepared deionized, certified PFAS-free water for field blank collection, loose leaf paper without waterproof coating or tablet, clip board, pen (not Sharpie), nitrile or latex gloves	No	No Teflon components, PFAS-free shipping materials
SOP-023	Civil Surveying, rev. 02/2022	CH2M		No	

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

Field Equipment	Activity[a]	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference[b]	Comments
Water Quality Meter	Calibrate probes using Auto-Calibration Standard Solution	Daily and as needed	To properly calibrate the water quality meter, immerse the instrument in the premixed standard solutions. Each solution has a standard solution value on the container. Enter the standard solution value from the container into the YSI. Observe the reading on the water quality meter for each parameter (specific conductance, DO, pH, and ORP). When the reading shows no significant change for approximately 30 seconds, press enter. The screen will indicate the calibration has been accepted. pH will be calibrated using a minimum of 2-point calibration. Typical standard solution values are: conductivity – 1.413 milliSiemens/ centimeter; DO – 100 %; pH – 4.0, 7.0, and 10.0 standard unit; ORP – 240 millivolts.	Manufacturer technical support for calibration errors	FTL	SOP-008	**Appendix B**
Hand-held global positioning system unit	Self-calibration	When unit is turned on	The unit antenna will receive signal from satellites (a minimum of 3 satellites is necessary for signal and data collection/operation).	Manufacturer technical support for calibration errors	FTL	SOP-013	**Appendix B**
PID	Calibrate using ambient air and isobutylene 100 parts per million (ppm) calibration gas	Daily and as Needed	Parameter-specific, as defined in SOP-013, Section 4A. PID calibration acceptance criteria: 1) Fresh air calibration using a Zero Air bottle (HAZCO Services Part Number SGZA or RAE Systems Part Number 600-0024) to zero out carbon monoxide, volatile organic compounds (VOCs), lower explosive limit, oxygen, and hydrogen sulfide. If no Zero Air is available, perform the fresh air calibration in an area free from any detectable vapors. 2) Multiple sensor calibration using a mixed gas bottle (HAZCO Services Part Number R-SGRAE4 or RAE Systems Part Number 008-3002) to calibrate carbon monoxide to 50 ppm, lower explosive limit to 50 %, oxygen to 20.9 %, and hydrogen sulfide to 25 ppm. 3) Single sensor calibration using VOC gas isobutylene (HAZCO Services Part number r-SGISO or RAE Part Number 600-0002) to calibrate VOCs to 100 ppm.	Manufacturer technical support for calibration errors	FTL	SOP-014	**Appendix B**

Notes:

[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**).

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SAP Worksheet #23—Labs Analytical SOP References Table

Lab SOP Number	Title, Revision Date, and Number	Date reviewed if not revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Laboratory Performing Analysis	Variance to QSM	Modified for Project Work?
SOP 49	*Preparation and Analysis for the Determination of Per- and Polyfluorinated Compounds, 12/17/2020, Revision 24*	01/06/2022	Definitive	Soil/Sediment/Groundwater/Surface water / PFAS	LC/MS/MS	Vista	No	No
CHP	Chemical Hygiene Plan, 03/15/2021, Revision 3	N/A	N/A	N/A	N/A	Vista	N/A	No
SOP 12	*Sample Receiving and Sample Control Procedures, 12/10/2021, Revision 21*	N/A	N/A	N/A	N/A	Vista	N/A	No
CA-777	Titrimetric Determination of Organic Carbon Using the Walkley-Black Method, 05/2013, Revision 0	01/2021	Screening	Soil / Geotech	Titration	Katahdin	No	No
CA-551	Grain Size Analysis, 06/2020, Revision 3	N/A	Screening	Soil / Geotech	Sieve/Hydrometer	Katahdin	No	No
CA-717	Total Solids/ Total Volatile Solids Determination in Solid Matrices, 02/2019, Revision 11	01/2021	Screening	Soil / Geotech	Gravimetric	Katahdin	No	No
SD-902	Sample Receipt and Internal Control, 05/20, Revision 14	06/2021	N/A	N/A	N/A	Katahdin	No	No
SD-903	Sample Disposal, 09/17, Revision 6.	01/2021	N/A	N/A	N/A	Katahdin	No	No
BR-GT-018	Density in Soils by Drive Cylinder Method (ASTM D2937-04), 08/2021, Revision 9	N/A	Screening	Soil / Geotech	Gravimetric	Eurofins	No	No
BR-GT-004	Specific Gravity of Soil Solids by Water Pycnometer (ASTM D854-06 – Method B), 08/2020, Revision 10	N/A	Screening	Soil / Geotech	Gravimetric	Eurofins	No	No

Notes:

DoD ELAP certification is required for analyses that will generate definitive data. Vista’s DoD ELAP certification expires September 30, 2023.

SPE = solid phase extraction

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SAP Worksheet #24—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
LC/MS/MS (PFAS)	Initial calibration (ICAL) for all analytes	At instrument set-up and after ICV or CCV failure, prior to sample analysis. External Calibration is not allowed. Calibration can be linear (minimum of 5 standards) or quadratic (minimum of 6 standards); weighting is allowed.	The isotopically labeled analog of an analyte (Extracted Internal Standard Analyte) must be used for quantitation if commercially available (Isotope Dilution Quantitation). Commercial PFAS standards available as salts are acceptable providing the measured mass is corrected to the neutral acid concentration. Results shall be reported as the neutral acid with appropriate CAS number. If a labeled analog is not commercially available, the Extracted Internal Standard Analyte with the closest retention time or chemical similarity to the analyte must be used for quantitation. (Internal Standard Quantitation). Analytes must be within 70-130% of their true value for each calibration standard. ICAL must meet one of the two options below: Option 1: The relative standard deviation of the response factors for all analytes must be ≤ 20%. Option 2: Linear or non-linear calibrations must have coefficient of determination (R^2) ≥ 0.99 for each analyte.	If these requirements are not met for the ICAL, CA is performed, and the calibration is repeated. No samples shall be analyzed until ICAL has passed. Flagging is not appropriate.	Analyst / Laboratory Project Manager	SOP 49
	Initial Calibration Verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis.	Analyte concentrations must be within ±30% of their true value.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL. No samples shall be analyzed until ICV has passed. Flagging is not appropriate.		
	Continuing Calibration Verification (CCV)	Prior to sample analysis (if not preceded by and ICAL and ICV), after every 10 field samples, and at the end of the analytical sequence. All samples must be bracketed by the analysis of a standard. Instrument sensitivity check (ISC) can serve as a bracketing CCV.	Concentration of analytes must range from the LOQ to the mid-level calibration concentration. Analyte concentrations must be within ±30% of their true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, or if two consecutive CCV's cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternatively, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Qualify all results for the specific analyte(s) in all samples since the last acceptable calibration verification. Results may not be reported without valid CCVs.		
	Retention Time (RT) window position establishment	Once per ICAL and at the beginning of the analytical sequence. Calculated for each analyte and extracted internal standard (EIS)	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A		
	RT window width	Every field sample, standard, blank, and QC sample. Calculated for each analyte and EIS.	RT of each analyte and EIS analyte must fall within 0.4 minutes of the predicted retention times from the daily calibration verification or, on days when ICAL is performed, from the midpoint standard of the ICAL. Analytes must elute within 0.1 minutes of the associated EIS. This criterion applies only to analyte and labeled analog pairs.	Correct problem and reanalyze samples.		

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
LC/MS/MS (PFAS) (continued)	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. 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).	Calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. Mass calibration range must bracket the ion masses of interest. The most recent mass calibration must be used for every acquisition in an analytical run. Mass calibration must be verified to be ±0.5 amu of the true value, by acquiring a full scan continuum mass spectrum of a PFAS stock standard.	If the mass calibration fails, then recalibrate. If it fails again, consult manufacturer instructions on corrective maintenance. Flagging is not appropriate. Problem must be corrected. No samples may be analyzed under a failing mass calibration.	Analyst / Laboratory Project Manager	SOP 49
	Mass Spectral Acquisition Rate	Each analyte, EIS analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	N/A. Flagging is not appropriate.		
	Calibration, Calibration Verification, and Spiking Standards	All analytes.	Standards containing both branched and linear isomers must be used when commercially available. PFAS method analytes may consist of both branched and linear isomers, but quantitative standards that contain the linear and branched isomers do not exist for all method analytes. For PFAS that do not have a quantitative branched and linear standard, identify the branched isomers by analyzing a qualitative standard that includes both linear and branched isomers and determine retention times, transitions and transition ion ratios. Quantitate samples by integrating the total response (i.e., accounting for peaks that are identified as linear and branched isomers) and relying on the 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.	N/A. Flagging is not appropriate.		
	Instrument Sensitivity Check (ISC)	Prior to analysis and at least once every 12 hours.	Analyte concentrations must be at LOQ; concentrations must be within ±30% of their true values.	Correct problem rerun ISC. If problem persists, repeat ICAL. No samples shall be analyzed until ISC has met acceptance criteria. ISC can serve as the initial daily CCV. Flagging is not appropriate.		

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 (e.g., alternate transition was used due to observed interferences).	N/A. Flagging is not appropriate.	Analyst / Laboratory Project Manager	SOP 49
	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 (perfluorobutanoic acid and perfluoropentanoic acid). Documentation of the primary and confirmation transitions and the ion ratio is required. In-house acceptance criteria for evaluation of ion ratios must be used and must not exceed 50-150%. Signal to Noise Ratio must be ≥ 10 for all ions used for quantification and must be ≥ 3 for all ions used for confirmation. Quant ion and confirmation ion must be present and must maximize simultaneously (±2 seconds).	N/A 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 using the ICAL standards. An acceptance range of ratio could be within A ±3 standard deviation for confirmation of detection.		
	Instrument Blank	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. Successful analysis following the highest standard analyzed determines the highest concentration that carryover 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 is met. If sample concentrations exceed the highest allowed standard and the sample(s) following exceed this acceptance criteria (>1/2 LOQ), they must be reanalyzed. 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. 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.		

Notes:

[1] Refer to **Worksheet #23** for a complete reference to relevant analytical SOPs.

amu = atomic mass unit

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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	CA	Responsible Person	SOP Reference
TQS-MICRO	Source cleaning	LC-MS/MS	Visual inspection sample/gas cone cleaning	As Needed	N/A	N/A	Analyst/supervisor	SOP 49
Aquity UPLC	Needle replacement		Visual inspection contamination Bent needle	As Needed	Leak test in software	Repeat if leak test fails		
TQS-Micro	Source heater		Source not at 150 degrees	As Needed	Source maintains 150 degrees	Repeat with new heater if sources do not heat		
Sciex 4000 QTrap	Cleaning Q0		Visual inspection curtain plate cleaning	As Needed	N/A	N/A		

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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 B** of this SAP.
Sample Packaging (Personnel/Organization): Project Field Team, FTL/CH2M. Field SOPs are in **Appendix B** of this SAP.
Coordination of Shipment (Personnel/Organization): FTL/CH2M
Type of Shipment/Carrier: FedEx Priority Overnight
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Receipt Personnel/Vista, Katahdin, Eurofins
Sample Custody and Storage (Personnel/Organization): Sample Receipt Personnel/ Vista, Katahdin, Eurofins
Sample Preparation (Personnel/Organization): Extractions Personnel/ Vista, Katahdin, Eurofins
Sample Determinative Analysis (Personnel/Organization): Analysts/ Vista, Katahdin, Eurofins
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 45 days
Sample Extract/Digestate Storage (No. of days from extraction/digestion): 90 days
Biological Sample Storage (No. of days from sample collection): N/A
SAMPLE DISPOSAL
Personnel/Organization): Sample Disposal/ Vista, Katahdin, Eurofins
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 Table

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory): Samples will be collected by field team members under the supervision of the FTL. As samples are collected, they will be placed into containers and labeled. 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 537.1/5-371-04 are less than 10ºC 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 custody seals will be placed on the outside of each sample cooler, so that the seals must be broken to open. Coolers will be shipped to the laboratories via FedEx overnight, with the airbill number indicated on the chain of custody (to relinquish custody). Upon delivery, the laboratory will log each cooler and report the status of the samples to CH2M. See **Worksheet #21** for SOPs containing sample custody guidance. The CH2M field team will ship all PFAS samples to Vista in El Dorado, California. Geotech samples will be shipped to Katahdin in Scarborough, Maine and Eurofins in South Burlington, Vermont.
Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal): Laboratory custody procedures can be found in the laboratory SOPs, which are provided in **Appendix D**.
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 project chemist 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 QC Sample Table

Matrix: Soil, Sediment, Groundwater, Surface water
Analytical Group: PFAS
Analytical Method/SOP Reference: PFAS by LC/MS/MS Compliant with QSM 5.3 Table B-15/SOP 49

QC Sample	Frequency/Number	Method/ SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	Data Quality Indicator	MPC
Aqueous Sample Preparation	Each sample and associated batch QC sample.	SPE must be used unless samples are known to contain high PFAS concentrations (e.g., AFFF formulations). Inline SPE is acceptable. Entire sample plus bottle rinsate must be extracted using SPE. Samples with > 1% solids may require centrifugation prior to SPE extraction. 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. Pre-screening of separate aliquots of aqueous samples is recommended.	N/A	Analyst/ Laboratory Project Manager	N/A	Same as Method/ SOP QC Acceptance Limits
Soil and Sediment Sample Preparation	Each sample and associated batch QC sample.	Entire sample received by the laboratory must be homogenized prior to subsampling.	N/A		N/A	
Sample Cleanup Procedure	Each sample and associated batch QC sample.	ENVI-Carb or equivalent must be used on each sample and batch QC sample. Removal of interferences from matrix. Cleanup should reduce bias from matrix background.	N/A		Bias/ Contamination	

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

QC Sample	Frequency/Number	Method/ SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	Data Quality Indicator	MPC
Method Blank (MB)	One per prep batch of 20 or fewer samples of similar matrix	No analytes detected > 1/2 LOQ or >1/10 the amount measured in any sample or >1/10 regulatory limit, whichever is greater.	Correct problem. Reprep and reanalyze MB and all QC samples and field samples processed with the contaminated blank. Results may not be reported without a valid MB. Samples may be re-extracted and analyzed outside of hold times, as necessary for corrective action associated with QC failure. If reanalysis cannot be performed, the data must be qualified and explained in the case narrative. Flagging is only appropriate in cases where the samples cannot be reanalyzed.	Analyst/ Laboratory Project Manager	Bias/ Contamination	Same as Method/ SOP QC Acceptance Limits
Laboratory Control Sample (LCS)	One per prep batch of 20 or fewer samples of similar matrix	Blank spiked with all analytes at a concentration ≥LOQ and ≤ the mid-level calibration concentration. see **Worksheets #15-1 - 15-2** for control limits	Correct problem. Reprep and reanalyze the LCS and all samples in the associated preparatory batch, if sufficient sample material is available. Results may not be reported without a valid LCS. Samples may be re-extracted and analyzed outside of hold times, as necessary for corrective action associated with QC failure. If reanalysis cannot be performed, the data must be qualified and explained in the case narrative. Flagging is only appropriate in cases where the samples cannot be reanalyzed.		Precision/ Accuracy/Bias	

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

QC Sample	Frequency/Number	Method/ SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	Data Quality Indicator	MPC
Matrix Spike/ Matrix Spike Duplicate or Matrix Duplicate (MS/MSD or MD)	One per prep batch of 20 or fewer samples of similar matrix 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. See **Worksheets #15-1 - 15-2** for control limits RPD ≤ 30%. RPD criteria only apply to analytes whose concentration in the sample is greater than or equal to the LOQ.	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).		Precision/ Accuracy/Bias	
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 70-130% of its true value.	When analyte concentrations are calculated as "<LOQ," and the spike recovery does not meet the acceptance criteria, the sample, sample duplicate, and post spike sample must be reanalyzed at consecutively higher dilutions until the criteria is met. Flagging is not appropriate. When analyte concentrations are calculated as "<LOQ," results may not be reported without acceptable post spike recoveries. Flagging is not appropriate.	Analyst/ Laboratory Project Manager	Precision/ Accuracy/Bias	Same as Method/ SOP QC Acceptance Limits

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

QC Sample	Frequency/Number	Method/ SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	Data Quality Indicator	MPC
Extracted Internal Standard (EIS) Analytes	Every field sample, spiked 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. 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.	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 re-extracted and analyzed (greater dilution may be needed). Samples may be re-extracted and analyzed outside of hold times, as necessary for corrective action associated with QC failure. Qualify and discuss in the Case Narrative only if reanalysis confirms failures in exactly the same manner.		Precision/ Accuracy/Bias	

Notes:

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

SAP Worksheet #29—Project Documents and Records Table

Document	Where Maintained
• Field Notebooks • Chain-of-Custody Records • Air Bills • 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, drilling logs, and field forms • 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 • 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 • Laboratory QA Plan	• Field data deliverables such as logbooks entries, chains of custody, airbills, EDDs, and so forth, will be kept on CH2M's network server. • Field parameter data will be loaded with the analytical data into the Navy database • Analytical laboratory hardcopy deliverables and DV reports will be saved on the network server and archived in accordance with the CLEAN contract. • Electronic data from the laboratory as well as field data will be reviewed and loaded simultaneously into Navy database • Following project completion, hardcopy deliverables such as logbooks, chains-of-custody, and so forth will be archived at Iron Mountain. These files are stored for a minimum of 7 years in accordance with the Navy CLEAN contract requirements: Iron Mountain Headquarters 745 Atlantic Avenue Boston, MA 02111 (800) 899-IRON • Following project completion, hardcopy deliverables including chains-of-custody and raw data will be archived at the Washington National Records Center. Files stored here are maintained for 50 years: 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 Number	Method	Data Package Turnaround Time	Laboratory / Organization	Backup Laboratory/ Organization
Soil, Sediment, Groundwater, and Surface water	PFAS	Refer to **Worksheets #18** and **#20**	LC/MS/MS Compliant with QSM v. 5.3, Table B-15[a]	28 calendar days or 7 calendar days[b]	Vista Analytical 1104 Windfield Way El Dorado Hills, CA 95762 Martha Maier (916) 673-1520	TBD[a]
Soil, Sediment	Total Organic Carbon	Refer to **Worksheets #18** and **#20**	Walkley Black	28 calendar days	Katahdin Analytical Services 600 Technology Way Scarborough, ME 04074 Heather Manz (207) 874-2400	TBD[a]
	Grain Size (sieve and hydrometer)		ASTM D422			
	Solids, Percent Moisture		SM 2540G			
Soil	Bulk Density	Refer to **Worksheets #18** and **#20**	ASTM D2937-04	28 calendar days	Eurofins TestAmerica 30 Community Drive Suite 11 South Burlington, VT 05403 Kathryn Kelly (802) 660-1990	TBD[a]
	Porosity		ASTM D854-06			

Notes:

[a] A backup laboratory has not been determined. If circumstances render the subcontracted laboratory unable to perform analytical services, another laboratory will be identified prior to sample collection.

[b] 7-day turn around will be used for groundwater samples related to resuming pumping at supply wells.

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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)
Offsite Laboratory Technical System Audit	Laboratory must have current DoD ELAP accreditation (for each analyte, matrix, and method), which will identify the period of performance. The laboratory must be re-evaluated prior to expiration of period of performance.	External	American Association for Laboratory Accreditation (A2LA) in accordance with DoD ELAP	A2LA	Teresa Morrison/Vista QAO	Teresa Morrison/Vista QAO	A2LA
Field Performance Audit	One during the sampling event	Internal	CH2M	PM CH2M	FTL CH2M	PM CH2M	PM CH2M
Safe Work Observation	One during each week of the sampling event	Internal	CH2M	SSL CH2M	Field Team Member observed CH2M	HSM CH2M	SSL CH2M
Field Document Review	Daily during the sampling event	Internal	CH2M	PM CH2M	FTL CH2M	PM CH2M	PM CH2M

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SAP Worksheet #32–Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (name, title, organization)	Timeframe of Notification	Nature of CA Response Documentation	Individual(s) Receiving CA Response (name, title, organization)	Timeframe for Response	Assessment Type
Field Performance Audit	Checklist and Written Audit Report	FTL CH2M	Within 1 day of audit	Verbal and Memorandum	FTL CH2M	Within 1 day of receipt of CA Form	Field Performance Audit
Safety Observation Report	Safety Observation Report Form	Carl Woods HSM CH2M	Within 1 week of Safe Behavior Observation	Memorandum	Field Team Member CH2M	Immediately	Safety Observation Report
Field Document Review	Markup copy of field documentation	FTL CH2M	Within 1 day of review	Verbal and Memorandum	FTL CH2M	Within 1 day of receipt of markup	Field Document Review

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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:

____
____
____
____

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SAP Worksheet #32-2–Field Performance Audit Checklist

Project Responsibilities

Project No.: ____________________ Date: ____________________

Project Location: ____________________ Signature: ____________________

Team Members

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

Comments ____________________

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

Comments ____________________

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

Comments ____________________

Sample Collection

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

Comments ____________________

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

Comments ____________________

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

Comments ____________________

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

Comments ____________________

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

Comments ____________________

SAP Worksheet #32-2–Field Performance Audit Checklist (Continued)

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

Comments ____________________

____

Yes No 7) Are photographs taken and documented?

Comments ____________________

____

Document Control

Yes No 1) Have any accountable documents been lost?

Comments ____________________

____

Yes No 2) Have any accountable documents been voided?

Comments ____________________

____

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

Comments ____________________

____

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

Comments ____________________

____

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

Comments ____________________

____

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

Comments ____________________

____

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

Comments ____________________

____

SAP Worksheet #32-3–Safety Observation Report Form

☐Federal or ☐Commercial Sector (check one) ☐Construction or ☐Consulting (check one)

Project Number: Client/Program:

Project Name: Observer: Date:

Position/Title of worker observed: Background Information/ comments:

Task/Observation Observed:

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

Actions & Behaviors	**Safe**	**At-Risk**	**Observations/Comments**
Current and accurate Pre-Task Planning/Briefing (for example, Project Safety Plan, Safety Training and Consulting, Activity Hazard Analysis, Pre-task Safety Plan, tailgate briefing, as needed)			**Positive Observations/Safe Work Practices:**
Properly trained/ qualified/ experienced			
Tools/equipment available and adequate			
Proper use of tools			**Questionable Activity/Unsafe Condition Observed:**
Barricades/work zone control			
Housekeeping			
Communication			
Work Approach/Habits			
Attitude			
Focus/attentiveness			**Observer's CAs/Comments:**
Pace			
Uncomfortable/unsafe position			
Inconvenient/unsafe location			
Position/Line of fire			
Apparel (hair, loose clothing, jewelry)			
Repetitive motion			**Observed Worker's CAs/Comments:**
Other…			

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SAP Worksheet #33–QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, and so forth)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
Field Audit Report	One during initial sampling event	Submitted with final report	PM CH2M	Included in project files.

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

Data Review Input	**Description**[a]	**Responsible for Verification/Validation**	**Step I / IIa / IIb**[b]	**Internal/ External**[c]
Field Notebooks and/or Electronic Notes Generated via Tablet	Field notebooks and/or electronic notes will be reviewed internally and placed into the project file for archival at project closeout. If using a tablet, hard copies of field notes will be prepared and archived at project closeout.	FTL (TBD) / 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 will be initialed by the reviewer, a copy of the chains-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chains-of-custody will also be reviewed for adherence to the SAP by the project chemist. Prior to demobilization, chains-of-custody will be cross referenced with the Sampler Table and SAP to ensure all samples were collected.	FTL (TBD) / CH2M Project Chemist: Sonya Gordon / CH2M	Step I	Internal & External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the Project Chemist in the form of laboratory logins.	Project Chemist: Sonya Gordon / CH2M	Step I	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations must be included in the laboratory SOP and reviewed as part of the DoD ELAP Accreditation process.	Project Chemist: Sonya Gordon / CH2M	Step I	External
EDD	EDD will be compared against hardcopy laboratory results (10% check). If errors are found during the 10% check, an additional 25% of the EDD to hard copy data will be checked to ensure that the discrepancy was an anomaly.	Project Chemist: Sonya Gordon / 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: Pei Geng / LDC	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.	QAO: / Vista QAO: Leslie Dimond / Katahdin QAO: Kristine Dusablon/ Eurofins	Step I	Internal

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

Data Review Input	Description[a]	Responsible for Verification/Validation	Step I / IIa / IIb[b]	Internal/ External[c]
Laboratory Data	The data will be verified for completeness by the Project Chemist. In order to ensure completeness, EDDs will be compared to the SAP and Sampler's Table. This is verification that all samples were included in the laboratory data and correct analyte lists were included.	Project Chemist: Sonya Gordon / CH2M	Step I	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If corrective actions are required, a copy of the documented corrective action 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 corrective action forms will be reviewed internally to ensure that all appropriate CAs have been taken and that corrective action reports are attached. If CAs have not been taken, the site manager will be notified to ensure action is taken.	PM: Daniel Hockett / CH2M Project Chemist: Sonya Gordon / CH2M	Step I	Internal
Corrective Action Reports	Corrective action reports will be reviewed by the project chemist or PM and placed into the project file for archival at project closeout.	PM: Daniel Hockett / CH2M Project Chemist: Sonya Gordon / CH2M	Step I	External
Laboratory Methods	Ensure the laboratory analyzed samples using the correct methods by comparing the EDDs to the SAP.	Project Chemist: Sonya Gordon / CH2M	Step IIa	External
Target Compound List and Target Analyte List	Ensure the laboratory reported all analytes from each analysis group as per **Worksheet #15**.	Project Chemist: Sonya Gordon / CH2M	Step IIa	External
Laboratory Limits (LOQ/LOD/DL)	Ensure the laboratory met the project-designated laboratory limits as per **Worksheet #15**. If limits were not met, the reason will be determined and documented. Often time the reason for discrepancy in limits is due to the quarterly update of LOD.	Project Chemist: Sonya Gordon / CH2M	Step IIb	External
Field SOPs	Ensure that all field SOPs were followed.	FTL (TBD) /CH2M	Step IIa	Internal

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

Data Review Input	Description[a]	Responsible for Verification/Validation	Step I / IIa / IIb[b]	Internal/ External[c]
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	QAO: / Vista QAO: Leslie Dimond / Katahdin QAO: Kristine Dusablon / Eurofins	Step I	Internal
Sample Chronology	Holding times from collection to extraction and from extraction to analysis will be considered during the DV process.	Data Validator: Pei Geng / LDC	Step IIa and IIb	External
Raw Data	10% of the data will undergo a Stage 4 validation which consists of a 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 5% difference. If errors are found during the 10% check, an additional 20% of the raw data will be checked to confirm laboratory calculations. 90% of the data will undergo Stage 2B validation.	Data Validator: Pei Geng / LDC	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.	FTL (TBD) / CH2M	Step IIb	Internal
Documentation of Method QC Results	Establish that all required method QC samples were run by comparing laboratory reports against the SAP.	Data Validator: Pei Geng / LDC	Step IIa	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run by comparing the EDDs against the SAP.	Project Chemist: Sonya Gordon / CH2M	Step IIb	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.	Project Chemist: Sonya Gordon / CH2M	Step I	External

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

Data Review Input	Description[a]	Responsible for Verification/Validation	Step I / IIa / IIb[b]	Internal/ External[c]
Analytical data for PFAS	Analytical methods and laboratory SOPs will be evaluated against QA/QC criteria to ensure compliance with DoD QSM, as presented in this SAP. QA/QC criteria for field QC samples are presented in **Worksheet #12**. LOQs, LODs, and DLs are presented in **Worksheet #15**. QA/QC criteria for calibrations are presented in laboratory SOPs (referenced in **Worksheet #23 and #24**). QA/QC criteria for laboratory QC samples are presented in **Worksheet #28**. Data may be qualified if QA/QC exceedances have occurred. Guidance and qualifiers from *General Data Validation Guidelines* (DoD, 2019) and *Data Validation Guidelines Module 3: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-15* (DoD, 2020) will be applied as appropriate. As specific modules for the analytical methods in this project are published, the DVs will refer to those modules for guidance. In the meantime, if specific guidance is not given for these methods in the *General Data Validation Guidelines*, the DV may adapt the guidance from USEPA *National Functional Guidelines for Organic Superfund Methods Data Review (SFAM01.1)* (USEPA, 2020). The project team and validator may reference a USEPA technical brief titled *Per- and Polyfluoroalkyl Substances (PFAS): Reviewing Analytical Methods Data for Environmental Samples* (USEPA, 2019).	Data Validator: Pei Geng / LDC	Step IIa and IIb	External
Analytical data for Geotechnical Parameters	Data will not undergo third-party DV but are subject to all other data review protocols detailed above.	Project Chemist: Sonya Gordon / CH2M	Step IIb	Internal
DV Narratives	Data validation narratives will discuss all QC parameters evaluated, acceptance criteria used to evaluate each QC parameter, a list of all QC exceedances as well as the extent of the exceedance, the samples associated with each exceedance, and the qualifiers applied.	Data Validator: Pei Geng / LDC	Step IIa and IIb	External

Notes:

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

[b] 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).

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

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 PALs in **Worksheet #15** were achieved. If PALs 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 qualifier by the data validator as recommended for rejection. The project team will review the DV narrative taking into consideration the project quality objectives and will decide if the data is usable for project decision making purposes. The X qualifier will be replaced with an R qualifier if the data is not found to be usable by the project team.
  - 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.
  - X = Recommended rejected result by Data Validator.
  - R = Rejected result. Result not reliable. Project team, as a whole, will determine if the final qualifier will be an R qualifier for rejection or will be qualified as estimated with one of the qualifiers listed above.
- 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.
- For statistical comparisons in the human health risk assessment, non-detect values will be represented by the sample LOD. For duplicate sample results, the most conservative value will be used for project decisions.
- Analytical data will be checked to ensure the values and any qualifiers are appropriately transferred to the electronic database. The checks include comparison of hardcopy data and qualifiers to the EDD. Once the data have been uploaded into the electronic database, another check will be performed to ensure all results were loaded accurately.
- Field and laboratory precision will be compared as RPD between the two results.
- Deviations from the SAP will be reviewed to assess whether CA is warranted and to assess impacts to achievement of project objectives.

SAP Worksheet #37—Usability Assessment (continued)

Describe the data quality indicators:

- Precision is assessed via percent difference or RPD. Percent difference is typically used when one value is considered theoretically correct and RPD is typically used when both values are experimental. Percent difference is calculated by taking the absolute value of the difference divided by the theoretical value. This is also expressed as

  $$((|X_1 - X_2|) / X_1) * 100$$

  where X_1 is the theoretical value and X_2 is the experimental value. If it is necessary to imply the direction of a bias, such as for percent drift, the absolute value need not be considered. RPD is calculated by taking the absolute value of the difference divided by the mean. This is also expressed as

  $$((|X_1 - X_2|) / ((X_1 + X_2)/2)) * 100$$

  where X_1 and X_2 are both measured values. Percent difference and RPD often have upper control limits for precision.

- Accuracy is assessed via percent recovery. This is calculated by taking the measured value divided by the theoretical value. This is also expressed as

  $$(X_2 / X_1) * 100$$

  where X_1 is the theoretical value and X_2 is the experimental value, both positive numbers because they are “amounts” or concentrations. Percent recovery can be negative, such as for MS and MSD recovery, if X_2 is calculated by subtracting a parent concentration from an experimental recovery. Percent recovery often has upper and lower control limits for accuracy.

- Completeness is calculated by taking the number of available results divided by the total number of results.

  This is also expressed as

  $$(X_2 / X_1) * 100$$

  where X_2 is the number of distinct results deemed “available for use” (not rejected) and X_1 is the total number of distinct results (not excluded). Completeness is calculated for the entire dataset, for each matrix, and for each combination of matrix and analysis group. If patterns of rejection are evident in the dataset, completeness may also be calculated for select combinations of matrix, analysis group, and analyte or other combinations as applicable for the data quality evaluation (DQE). The completeness goal for this project is 95 percent for all matrix aside from drinking water. The completeness goal for drinking water is 100 percent.

  Completeness is calculated based on the number of non-rejected results compared to the total number of results. Inability to obtain results is an unusual occurrence. If there is breakage (assuming insufficient sample volume) and a resulting data gap is not acceptable, samples are often recollected. Inability to collect a sample results in a moved station or other action based on discussion with the project team. These situations are not due to poor data quality. If this type of situation occurs, it is discussed in the report, as it is a SAP work plan exception (samples which are planned-for but not collected).

- Representativeness is qualitative and is assessed by verifying that the samples were collected and analyzed following approved SOPs.

SAP Worksheet #37—Usability Assessment (continued)

- Comparability is also qualitative and is assessed by examining the other precision, accuracy, representativeness, comparability, and completeness considerations, including common matrices (such as "sediment") in the investigation, and using common analysis methods (i.e., SW-846 series).
- Sensitivity and its effect on usability is examined in detail in the DQE Report, but the procedure for doing so depends on actual investigation results.

Detailed descriptions of precision, accuracy, representativeness, completeness, comparability, and sensitivity will be included in the DQE with sufficient information to support the data usability conclusions.

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

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 the Tier I Partnering Team for review and decisions on the path forward for the site:

- Data tables will be produced to reflect detected and non-detected site analytes and geochemical parameters. Data qualifiers will be reflected in the tables and discussed in the DQE.
- A DQE considering all of the previously presented information will be provided as part of presentations to the Tier I Partnering Team and submitted as a part of the RI. The RI Report will identify any data usability limitations and make recommendations for CA if necessary.

Identify the personnel responsible for performing the usability assessment.

The CH2M Team, including the PM and Project Chemist, will review the data and compile a presentation for the Partnering Team. The Tier I Partnering Team as a whole will assess the usability of the data.

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Figures

\\DC1VS01\GISNAVYCLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\BASEWIDE\PFAS\703185_RI_SAP\FIGURE_10-1_SITEMAP_SITE111_CAMPDAVISSOUTH.MXD AM038876 10/20/2021 6:21:08 AM

Legend

🟧 PFAS Release Area

— Surface Water

— Elevation Contour (5ft interval)

🟥 Installation Boundary

N

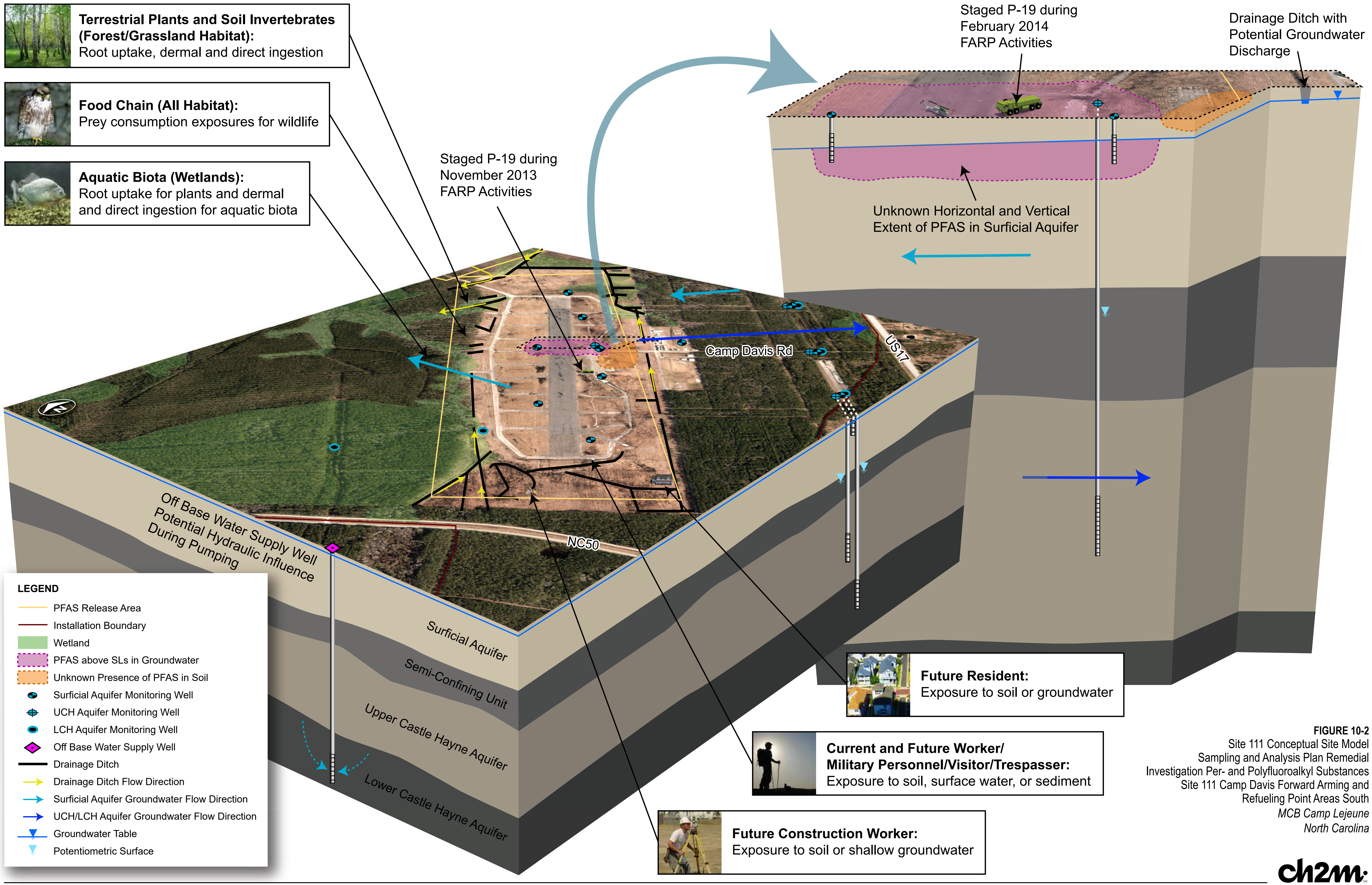
0 500 1,000 2,000 Feet

1 inch = 1,000 feet

Imagery: Esri, 2016

Figure 10-1
Site Map
Sampling and Analysis Plan, Remedial Investigation Per- and Polyfluoroalkyl Substances
Site 111 Camp Davis Forward Arming and Refueling Point Activities South
MCB Camp Lejeune
North Carolina

ch2m:



Terrestrial Plants and Soil Invertebrates (Forest/Grassland Habitat):
Root uptake, dermal and direct ingestion

Food Chain (All Habitat):
Prey consumption exposures for wildlife

Aquatic Biota (Wetlands):
Root uptake for plants and dermal and direct ingestion for aquatic biota

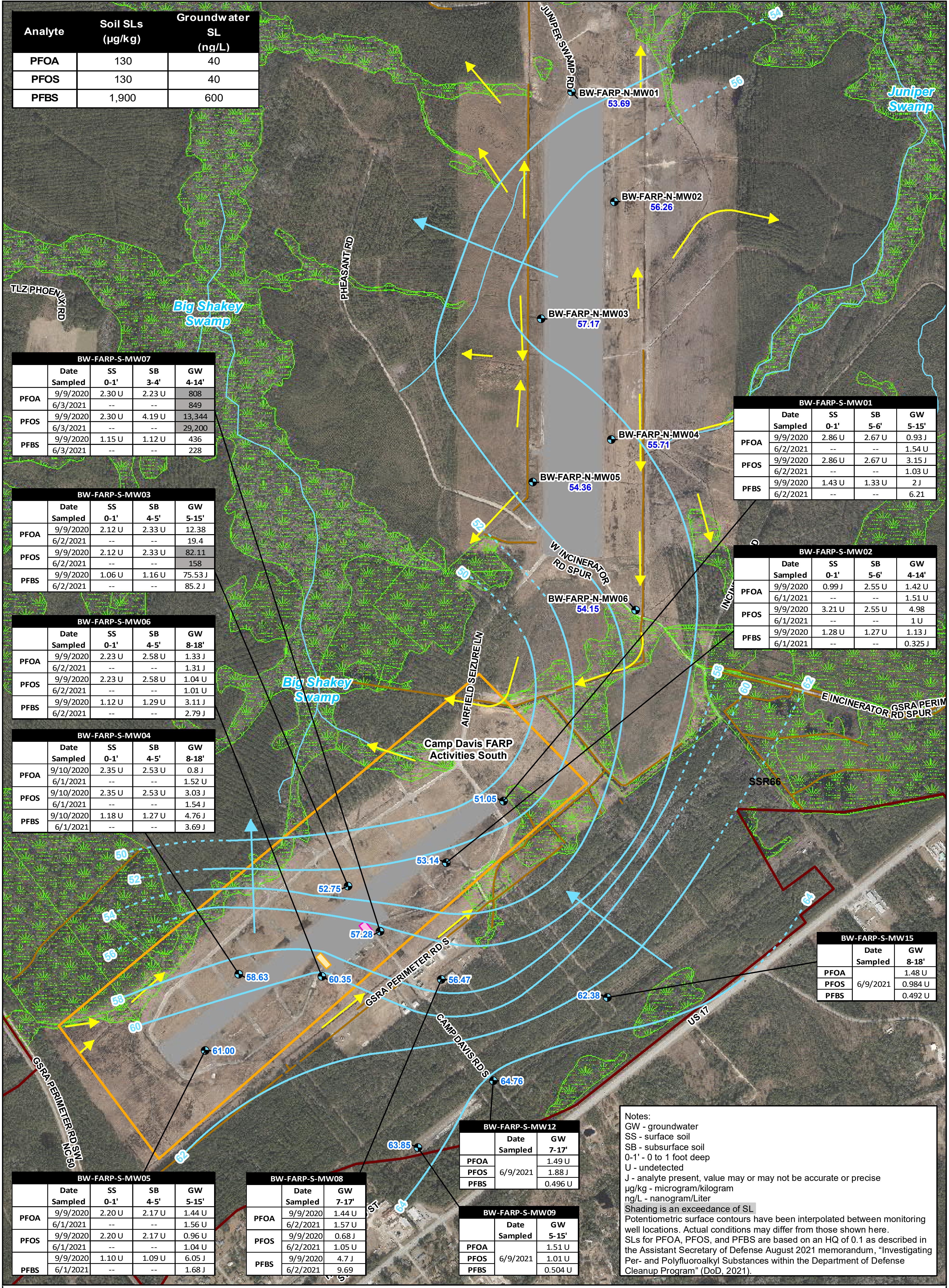
Future Resident:
Exposure to soil or groundwater

Current and Future Worker/ Military Personnel/Visitor/Trespasser:
Exposure to soil, surface water, or sediment

Future Construction Worker:
Exposure to soil or shallow groundwater

FIGURE 10-2
Site 111 Conceptual Site Model
Sampling and Analysis Plan Remedial
Investigation Per- and Polyfluoroalkyl Substances
Site 111 Camp Davis Forward Arming and
Refueling Point Areas South
MCB Camp Lejeune
North Carolina

\\DC1VS01\GISNAVYCLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\BASEWIDE\PFAS\703185_RI_SAP\FIGURE_10-3_CAMPDAVISFARPSOUTH_SURFANDSOILRESULTS.MXD AM038876 12/16/2021 10:52:59 AM



Analyte	Soil SLs (µg/kg)	Groundwater SL (ng/L)
PFOA	130	40
PFOS	130	40
PFBS	1,900	600

BW-FARP-S-MW07

	Date Sampled	SS 0-1'	SB 3-4'	GW 4-14'
PFOA	9/9/2020	2.30 U	2.23 U	808
	6/3/2021	--	--	849
PFOS	9/9/2020	2.30 U	4.19 U	13,344
	6/3/2021	--	--	29,200
PFBS	9/9/2020	1.15 U	1.12 U	436
	6/3/2021	--	--	228

BW-FARP-S-MW03

	Date Sampled	SS 0-1'	SB 4-5'	GW 5-15'
PFOA	9/9/2020	2.12 U	2.33 U	12.38
	6/2/2021	--	--	19.4
PFOS	9/9/2020	2.12 U	2.33 U	82.11
	6/2/2021	--	--	158
PFBS	9/9/2020	1.06 U	1.16 U	75.53 J
	6/2/2021	--	--	85.2 J

BW-FARP-S-MW06

	Date Sampled	SS 0-1'	SB 4-5'	GW 8-18'
PFOA	9/9/2020	2.23 U	2.58 U	1.33 J
	6/2/2021	--	--	1.31 J
PFOS	9/9/2020	2.23 U	2.58 U	1.04 U
	6/2/2021	--	--	1.01 U
PFBS	9/9/2020	1.12 U	1.29 U	3.11 J
	6/2/2021	--	--	2.79 J

BW-FARP-S-MW04

	Date Sampled	SS 0-1'	SB 4-5'	GW 8-18'
PFOA	9/10/2020	2.35 U	2.53 U	0.8 J
	6/1/2021	--	--	1.52 U
PFOS	9/10/2020	2.35 U	2.53 U	3.03 J
	6/1/2021	--	--	1.54 J
PFBS	9/10/2020	1.18 U	1.27 U	4.76 J
	6/1/2021	--	--	3.69 J

BW-FARP-S-MW01

	Date Sampled	SS 0-1'	SB 5-6'	GW 5-15'
PFOA	9/9/2020	2.86 U	2.67 U	0.93 J
	6/2/2021	--	--	1.54 U
PFOS	9/9/2020	2.86 U	2.67 U	3.15 J
	6/2/2021	--	--	1.03 U
PFBS	9/9/2020	1.43 U	1.33 U	2 J
	6/2/2021	--	--	6.21

BW-FARP-S-MW02

	Date Sampled	SS 0-1'	SB 5-6'	GW 4-14'
PFOA	9/9/2020	0.99 J	2.55 U	1.42 U
	6/1/2021	--	--	1.51 U
PFOS	9/9/2020	3.21 U	2.55 U	4.98
	6/1/2021	--	--	1 U
PFBS	9/9/2020	1.28 U	1.27 U	1.13 J
	6/1/2021	--	--	0.325 J

BW-FARP-S-MW15

	Date Sampled	GW 8-18'
PFOA	6/9/2021	1.48 U
PFOS		0.984 U
PFBS		0.492 U

BW-FARP-S-MW12

	Date Sampled	GW 7-17'
PFOA	6/9/2021	1.49 U
PFOS		1.88 J
PFBS		0.496 U

BW-FARP-S-MW09

	Date Sampled	GW 5-15'
PFOA	6/9/2021	1.51 U
PFOS		1.01 U
PFBS		0.504 U

BW-FARP-S-MW05

	Date Sampled	SS 0-1'	SB 4-5'	GW 5-15'
PFOA	9/9/2020	2.20 U	2.17 U	1.44 U
	6/1/2021	--	--	1.56 U
PFOS	9/9/2020	2.20 U	2.17 U	0.96 U
	6/1/2021	--	--	1.04 U
PFBS	9/9/2020	1.10 U	1.09 U	6.05 J
	6/1/2021	--	--	1.68 J

BW-FARP-S-MW08

	Date Sampled	GW 7-17'
PFOA	9/9/2020	1.44 U
	6/2/2021	1.57 U
PFOS	9/9/2020	0.68 J
	6/2/2021	1.05 U
PFBS	9/9/2020	4.7 J
	6/2/2021	9.69

Notes:
GW - groundwater
SS - surface soil
SB - subsurface soil
0-1' - 0 to 1 foot deep
U - undetected
J - analyte present, value may or may not be accurate or precise
µg/kg - microgram/kilogram
ng/L - nanogram/Liter
Shading is an exceedance of SL
Potentiometric surface contours have been interpolated between monitoring well locations. Actual conditions may differ from those shown here.
SLs for PFOA, PFOS, and PFBS are based on an HQ of 0.1 as described in the Assistant Secretary of Defense August 2021 memorandum, “Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program” (DoD, 2021).

Legend

- ◕ Surficial Aquifer Monitoring Well
- ▭ PFAS Release Area
- ● Stormwater Inlet
- — Stormwater Utility Line
- → Drainage Ditch Flow Direction
- ▭ Staged P-19 during February 2014 FARP Activities
- ▭ Staged P-19 during November 2013 FARP Activities
- — Surficial Aquifer Potentiometric Surface Contour, Dashed Where Inferred
- → Surficial Aquifer Groundwater Flow Direction
- — Surface Water
- ▨ Wetland
- ▭ Installation Boundary

54.15 Groundwater Elevation (feet above mean sea level) on 28 July 2021.

Figure 10-3
Surficial Aquifer and Soil Results
Sampling and Analysis Plan, Remedial Investigation Per- and Polyfluoroalkyl Substances
Site 111 Camp Davis Forward Arming and Refueling Point Activities South
MCB Camp Lejeune
North Carolina

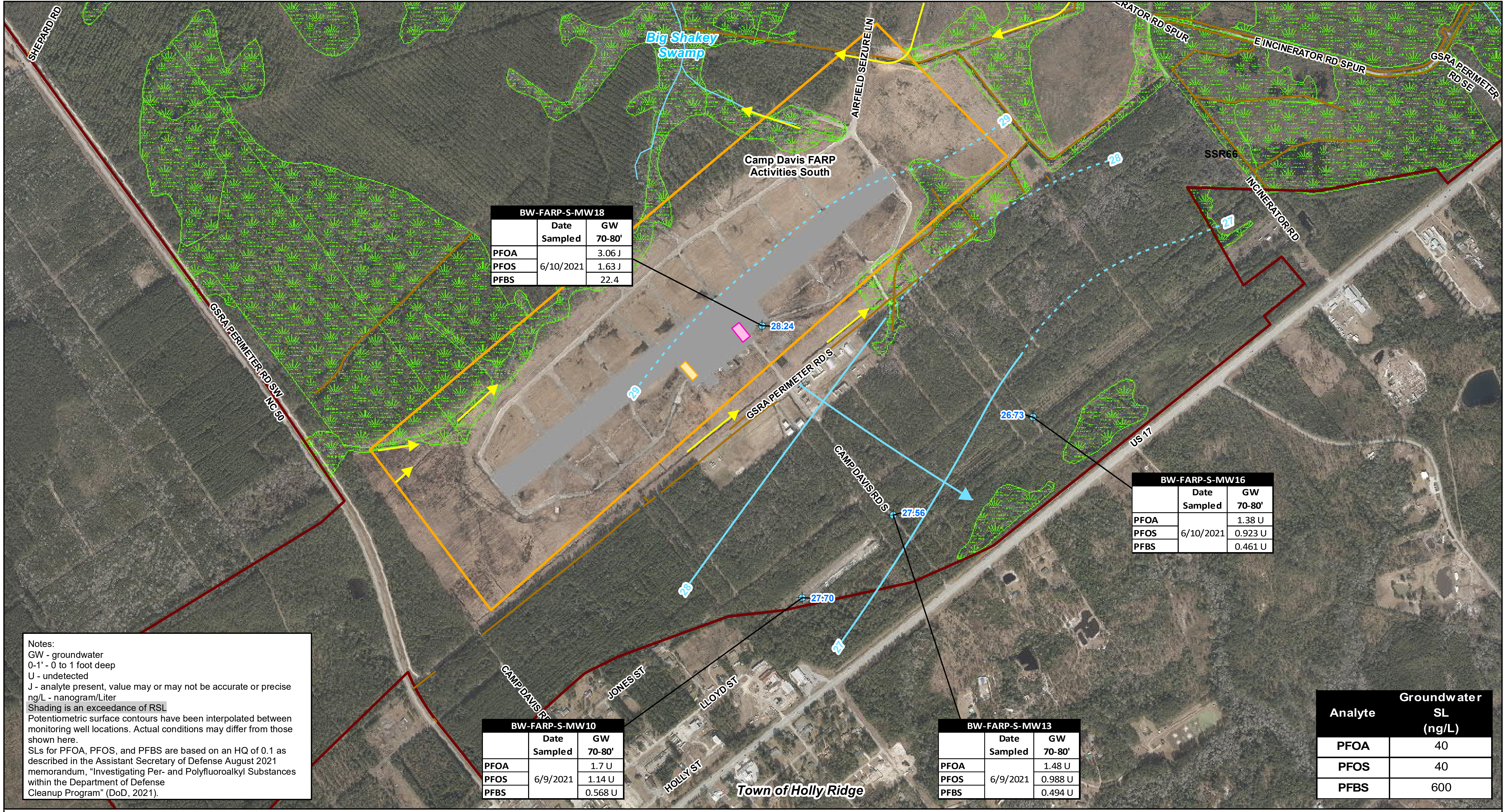
N

0 500 1,000 2,000
Feet

1 inch = 1,000 feet

ch2m

\\DC1VS01\GISNAVYCLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\BASEWIDE\PFAS\703185_RI_SAP\FIGURE_10-4_CAMPDAVISFARPSOUTH_UCH_RESULTS.MXD AM038876 12/16/2021 11:04:42 AM



BW-FARP-S-MW18

	Date Sampled	GW 70-80'
PFOA	6/10/2021	3.06 J
PFOS		1.63 J
PFBS		22.4

BW-FARP-S-MW16

	Date Sampled	GW 70-80'
PFOA	6/10/2021	1.38 U
PFOS		0.923 U
PFBS		0.461 U

BW-FARP-S-MW10

	Date Sampled	GW 70-80'
PFOA	6/9/2021	1.7 U
PFOS		1.14 U
PFBS		0.568 U

BW-FARP-S-MW13

	Date Sampled	GW 70-80'
PFOA	6/9/2021	1.48 U
PFOS		0.988 U
PFBS		0.494 U

Notes:
GW - groundwater
0-1' - 0 to 1 foot deep
U - undetected
J - analyte present, value may or may not be accurate or precise
ng/L - nanogram/Liter
Shading is an exceedance of RSL
Potentiometric surface contours have been interpolated between monitoring well locations. Actual conditions may differ from those shown here.
SLs for PFOA, PFOS, and PFBS are based on an HQ of 0.1 as described in the Assistant Secretary of Defense August 2021 memorandum, “Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program” (DoD, 2021).

Analyte	Groundwater SL (ng/L)
PFOA	40
PFOS	40
PFBS	600

Legend

- ⌖ Upper Castle Hayne Aquifer Monitoring Well
- ▭ PFAS Release Area
- — Stormwater Utility Line
- — Surface Water
- → Drainage Ditch Flow Direction
- — UCH Aquifer Potentiometric Surface Contour, Dashed Where Inferred
- → UCH Aquifer Groundwater Flow Direction
- ▭ Staged P-19 during February 2014 FARP Activities
- ▭ Staged P-19 during November 2013 FARP Activities
- ▨ Wetland
- ▭ Installation Boundary

54.15 Groundwater Elevation (feet above mean sea level) on 28 July 2021.

N

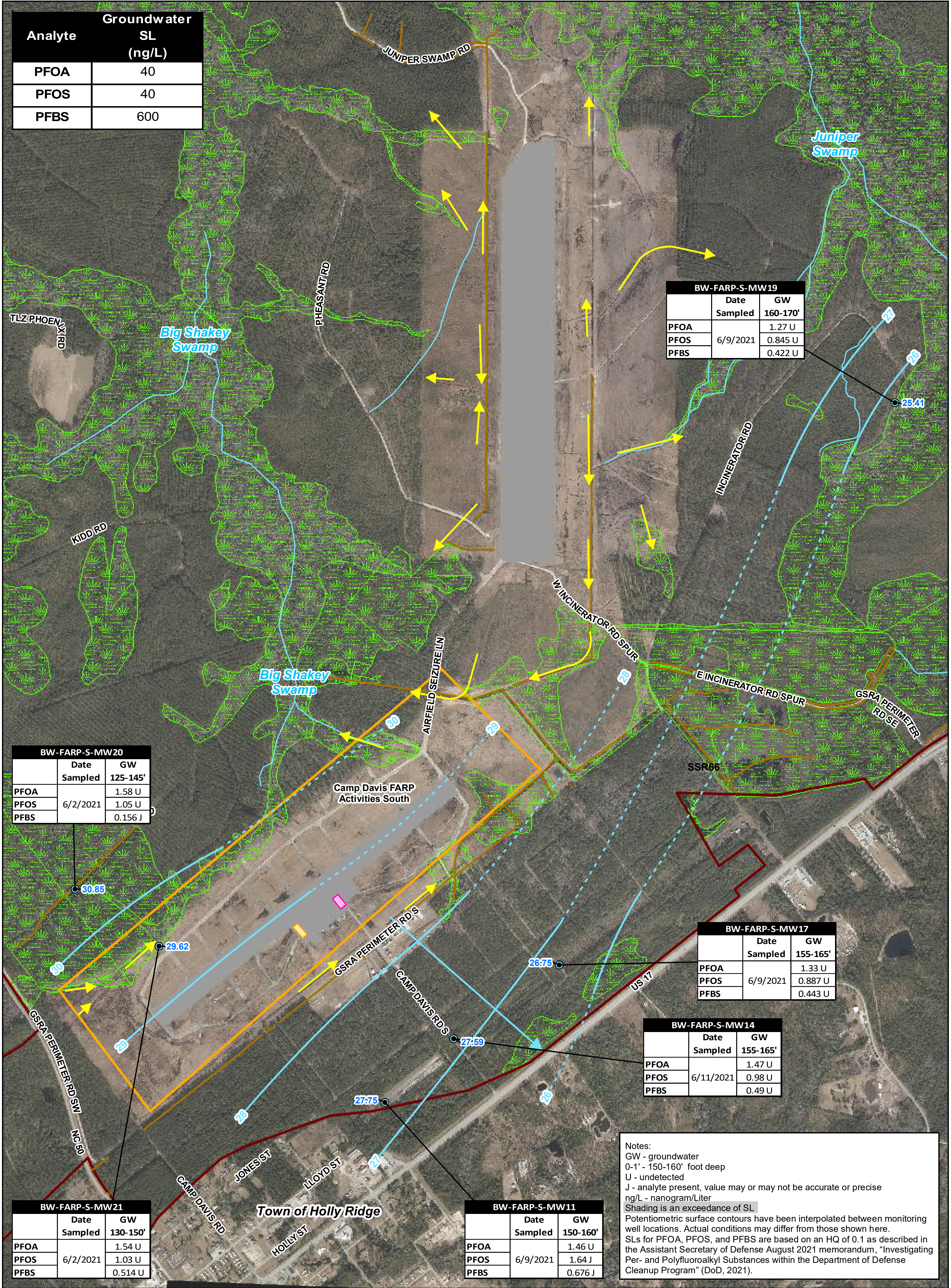
0 425 850
Feet

1 inch = 850 feet

Figure 10-4
Upper Castle Hayne Aquifer Results
Sampling and Analysis Plan, Remedial Investigation Per- and Polyfluoroalkyl Substances
Site 111 Camp Davis Forward Arming and Refueling Point Activities South
MCB Camp Lejeune
North Carolina

ch2m:

\\DC1VS01\GISNAVYCLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\BASEWIDE\PFAS\703185_RI_SAP\FIGURE_10-5_CAMPDAVISFARPSOUTH_LCH_RESULTS.MXD AM038876 12/16/2021 11:07:42 AM



Analyte	Groundwater SL (ng/L)
PFOA	40
PFOS	40
PFBS	600

BW-FARP-S-MW19

	Date Sampled	GW 160-170'
PFOA	6/9/2021	1.27 U
PFOS		0.845 U
PFBS		0.422 U

BW-FARP-S-MW20

	Date Sampled	GW 125-145'
PFOA	6/2/2021	1.58 U
PFOS		1.05 U
PFBS		0.156 J

BW-FARP-S-MW17

	Date Sampled	GW 155-165'
PFOA	6/9/2021	1.33 U
PFOS		0.887 U
PFBS		0.443 U

BW-FARP-S-MW14

	Date Sampled	GW 155-165'
PFOA	6/11/2021	1.47 U
PFOS		0.98 U
PFBS		0.49 U

BW-FARP-S-MW21

	Date Sampled	GW 130-150'
PFOA	6/2/2021	1.54 U
PFOS		1.03 U
PFBS		0.514 U

BW-FARP-S-MW11

	Date Sampled	GW 150-160'
PFOA	6/9/2021	1.46 U
PFOS		1.64 J
PFBS		0.676 J

Notes:
GW - groundwater
0-1' - 150-160' foot deep
U - undetected
J - analyte present, value may or may not be accurate or precise
ng/L - nanogram/Liter
Shading is an exceedance of SL
Potentiometric surface contours have been interpolated between monitoring well locations. Actual conditions may differ from those shown here.
SLs for PFOA, PFOS, and PFBS are based on an HQ of 0.1 as described in the Assistant Secretary of Defense August 2021 memorandum, “Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program” (DoD, 2021).

Legend

- ● Lower Castle Hayne Aquifer Monitoring Well
- ▭ PFAS Release Area
- ● Stormwater Inlet
- — Stormwater Utility Line
- → Drainage Ditch Flow Direction
- — LCH Aquifer Potentiometric Surface Contour, Dashed Where Inferred
- → LCH Aquifer Groundwater Flow Direction
- 🟪 Staged P-19 during February 2014 FARP Activities
- 🟧 Staged P-19 during November 2013 FARP Activities
- — Surface Water
- ▨ Wetland
- ▭ Installation Boundary

54.15 Groundwater Elevation (feet above mean sea level) on 28 July 2021.

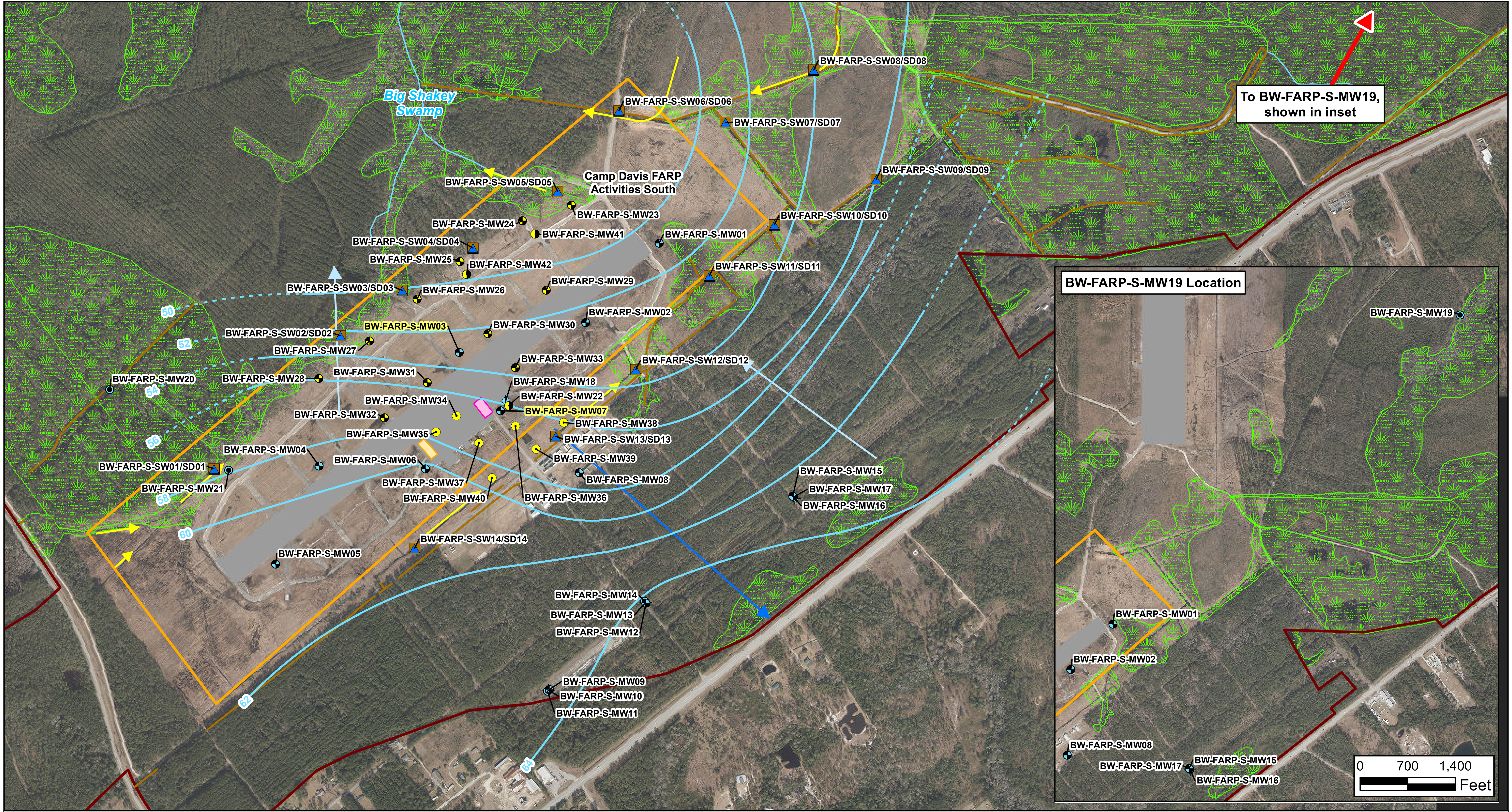
Figure 10-5
Lower Castle Hayne Aquifer Results
Sampling and Analysis Plan, Remedial Investigation Per- and Polyfluoroalkyl Substances
Site 111 Camp Davis Forward Arming and Refueling Point Activities South
MCB Camp Lejeune
North Carolina

N

0 550 1,100 2,200 Feet

1 inch = 1,100 feet

ch2m.



Legend

- ● Proposed Surficial Aquifer Monitoring Well Location
- ● Proposed Surficial Aquifer Monitoring Well and Surface/Subsurface Soil Location
- ◐ Proposed Deep Surficial Aquifer Monitoring Well (top of clay)
- ▲ Proposed Surface Water/Sediment Location
- ● Surficial Aquifer Monitoring Well
- ⊕ Upper Castle Hayne Aquifer Monitoring Well
- ◉ Lower Castle Hayne Aquifer Monitoring Well
- ▭ PFAS Release Area
- → Surficial Aquifer Groundwater Flow Direction
- → UCH/LCH Aquifer Groundwater Flow Direction
- — Stormwater Utility Line
- — Surface Water
- → Drainage Ditch Flow Direction
- 🟪 Staged P-19 during February 2014 FARP Activities
- 🟧 Staged P-19 during November 2013 FARP Activities
- 🟩 Wetland
- ▭ Installation Boundary

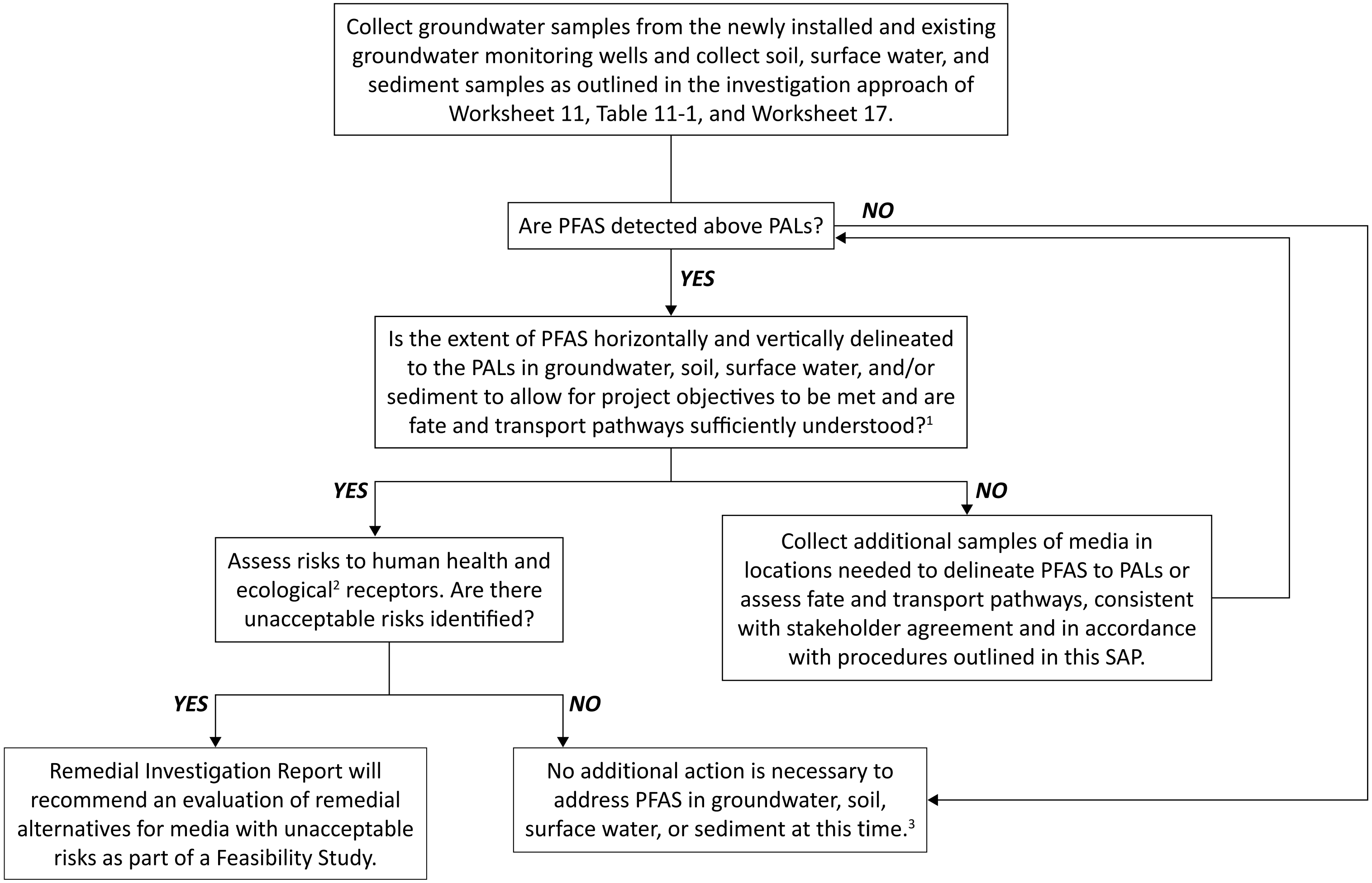
N

0 400 800 Feet

1 inch = 800 feet

Figure 11-1
Proposed Sample Locations
Sampling and Analysis Plan, Remedial Investigation Per- and Polyfluoroalkyl Substances
Site 111 Camp Davis Forward Arming and Refueling Point Activities South
MCB Camp Lejeune
North Carolina

ch2m



Collect groundwater samples from the newly installed and existing groundwater monitoring wells and collect soil, surface water, and sediment 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 horizontally and vertically delineated to the PALs in groundwater, soil, surface water, and/or sediment 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 at this time.[3]

Figure 11-2.

Decision Logic for Project Quality Objectives

Sampling and Analysis Plan Remedial Investigation
Per- and Polyfluoroalkyl Substances
Site 111 Camp Davis Forward Arming and
Refueling Areas South
MCB Camp Lejeune
North Carolina

1 If the extent of PFOA, PFOS, and PFBS extends to down-gradient off-base surface water features that are impacted, additional consideration will be warranted.

2 The Navy currently recommends the nature and extent of PFAS to be defined in an environmental medium prior to performing ecological risk evaluations. Currently available ESVs are provided here for data quality only, to ensure DLs meet requirements for future ecological risk screening, if required, and are not considered PALs. 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 Report is prepared.

3 Data will be archived for future use as necessary based on evolving regulations, guidance, and policies.

Appendix A
Additional Screening Levels

Table A-1. Additional Screening Levels for PFAS in Groundwater, Sediment, Surface Water, and Soil

Chemical	**Groundwater**		**Surface Water**			**Sediment**		**Soil**		
	NC IMAC (April 2018) (ng/L)	*USEPA Lifetime Health Advisory (March 2018) (ng/L)*	*ESV (Freshwater) (ng/L)* [a]	*ESV Reference*	*USEPA Lifetime Health Advisory* [b] *(March 2018) (ng/L)*	*ESV (µg/kg)*	*ESV Reference*	*ESV (µg/kg)*	*ESV Reference*	*NC PSRG (ng/g)*
Perfluorooctanoic acid (PFOA)	2,000	70	370,000	Mammal wildlife value from Argonne 2021	70	1.4	NOAEL-based value from Divine et al. 2020, based on food web model for tree swallow	3,840	Terrestrial mammal value from Argonne 2021	NA
Perfluorooctane Sulfonate (PFOS)	NA	70	117	Mammal wildlife value from Argonne 2021	70	6	NOAEL-based value from Divine et al. 2020, based on food web model for little brown bat	8.7	Terrestrial mammal value from Argonne 2021	NA
Perfluorobutanesulfonic acid (PFBS)	NA	NA	400,000	Mammal wildlife value from Argonne 2021	NA	730	NOAEL-based value from Divine et al. 2020, based on food web model for tree swallow	817	Terrestrial mammal value from Argonne 2021	14
Perfluorononanoic acid (PFNA)	NA	NA	2,080	Mammal wildlife value from Argonne 2021	NA	10	NOAEL-based value from Divine et al. 2020, based on food web model for little brown bat	24	Terrestrial mammal value from Argonne 2021	NA
Perfluorohexanoic acid (PFHxA)	NA	NA	28,800	Mammal wildlife value from Argonne 2021	NA	1,800	NOAEL-based value from Divine et al. 2020, based on food web model for little brown bat	6,200	Terrestrial mammal value from Argonne 2021	NA
Perfluorodecanoic acid (PFDA)	NA	NA	660	Mammal wildlife value from Argonne 2021	NA	NA	NA	67.7	Terrestrial mammal value from Argonne 2021	NA
Perfluoroheptanoic acid (PFHpA)	NA	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	NA
Perfluorohexane sulfonate (PFHxS)	NA	NA	5,500	Mammal wildlife value from Argonne 2021	NA	NA	NA	2.8	Terrestrial mammal value from Argonne 2021	NA

Notes

[a] At the current time, EPA has not issued consensus-based ecological screening values for PFAS in any environmental medium. Initial ecological screening values, based on available documents in the literature are presented here 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.

[b] If used as a drinking water source

µg/kg = microgram(s) per kilogram

ng/g = nanogram(s) per gram

ng/L = nanogram(s) per liter

IMAC = interim maximum contaminant level

ESV = ecolgoical screening value

NA = not available

NOAEL = no observed adverse effect level

NOEC = no observed effects concentration

PSRG = preliminary soil remediation goal

References:

Argonne National Laboratory (Argonne). 2021. Final Derivation of PFAS Ecological Screening Values. Environmental Science Division, Argonne National Laboratory. Completed under interagency agreement between the U.S. Department of Energy (DOE), Argonne National Laboratory (Argonne), and the Air Force Civil Engineer Center (AFCEC). September.

Karnjanapiboonwong, A., S.K. Deb, S. Subbiah, D. Wang, and T.A. Anderson. 2018. “Perfluoroalkylsulfonic and Carboxylic Acids in Earthworms (Eisenia fetida): Accumulation and Effects Results from Spike

Divine, C., J. Zodrow, M. Frenchmeyer, K. Dally, E. Osborn, and P. Anderson. 2020. Approach for Assessing PFAS Risk to Threatened and Endangered Species. Strategic Environmental Research and Development Program (SERDP). Project ER18-1653.

Appendix B
Field Standard Operating Procedures – CH2M/Jacobs

Note: CH2M is a wholly-owned subsidiary of Jacobs and SOPs may refer to either CH2M or Jacobs but are all applicable for work being conducted under this SAP.

STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books (hard copy and electronic) during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities. Field notes may be recorded in field log books or electronically on computer tablets.

III. Equipment and Materials

- Log book
- Indelible pen
- Jacobs supplied electronic tablet or laptop with notebook software

IV. Procedures and Guidelines

Properly completed field log books are a requirement for all of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Rite in the Rain® or Sanford Sharpie® permanent markers. **Note:** for sites where PFC is being analyzed for, Rite-in-the-Rain®, Sanford Sharpie®, or anything water-resistant or with Teflon® cannot be used in the field. All field book materials must be “fluorine free”. Acceptable substitutes would be a sewn notebook

without a plastic cover, or loose-leaf notebook paper.

2. Alternatively, field notes may be recorded electronically in Jacobs provided field tablets or laptop computers. Notes are recorded in appropriate note collection software; e.g., Microsoft One Note. At the end of each day, the electronic notes must be digitally signed by the author and downloaded for electronic file storage. The notes may be converted to an Adobe pdf file prior to storage. It is important that the field notes be downloaded daily to ensure the electronic time stamp of the notes is the same as the day the notes were recorded.

3. On the inside cover of the log book the following information should be included:

    - Company name and address
    - Log-holders name if log book was assigned specifically to that person
    - Activity or location
    - Project name
    - Project manager's name
    - Phone numbers of the company, supervisors, emergency response, etc.

4. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."

5. If field notes are recorded electronically, the author will not have any spaces between entries.

6. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.

7. Daily entries will be made chronologically.

8. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.

9. Each page of the log book will have the date of the work and the note takers initials.

10. The final page of each day's notes will include the note-takers

signature as well as the date.

11. Only information relevant to the subject project will be added to the log book.

12. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector’s memory. Entries must be legible and complete.

2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.

4. Weather: Record the weather conditions and any significant changes in the weather during the day.

5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified, and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work

plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

    - Description of the general sampling area – site name, buildings and streets in the area, etc.
    - Station/Location identifier
    - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
    - Sample matrix and type
    - Sample date and time
    - Sample identifier
    - Draw a box around the sample ID so that it stands out in the field notes
    - Information on how the sample was collected – distinguish between “grab,” “composite,” and “discrete” samples
    - Number and type of sample containers collected
    - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)

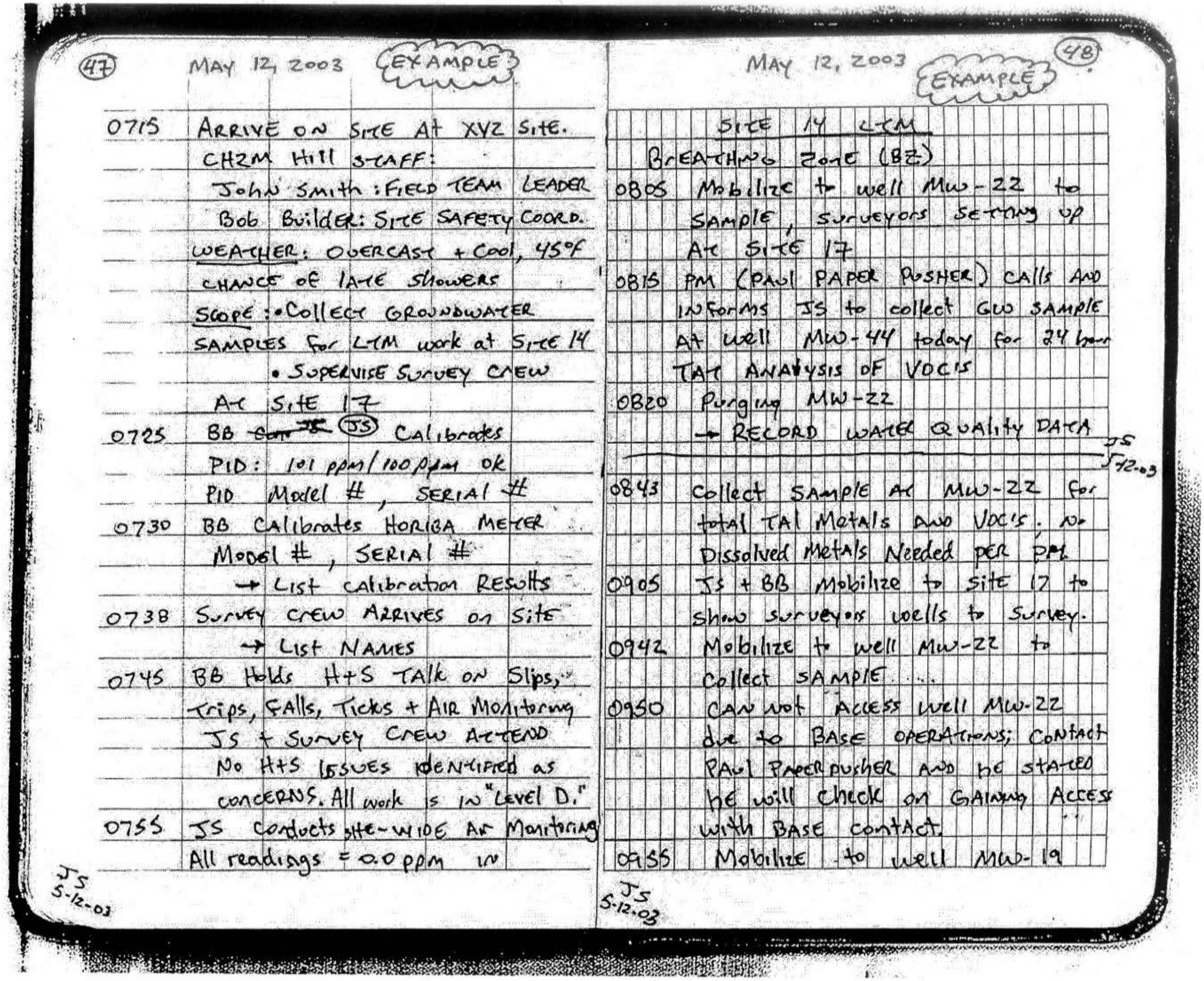
- Parameters to be analyzed for, if appropriate
- Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).
2. Use tables to record sampling information and field data from multiple samples.
3. Sketch sampling locations and other pertinent information.
4. Sketch well construction diagrams.

V. Attachments

Example field notes.



㊼ MAY 12, 2003 EXAMPLE

0715 ARRIVE ON SITE At XYZ SitE.
CH2M Hill STAFF:
John Smith : FIELD TEAM LEADER
Bob Builder: SITE SAFETY COORD.
WEATHER: OVERCAST + Cool, 45°F
CHANCE of LATE Showers
SCOPE: • Collect GROUNDWATER
SAMPLES for LTM work at SitE 14
• SUPERVISE Survey CREW
At SitE 17
0725 BB ~~Cal JS~~ (JS) CAlibrates
PID: 101 ppm/100 ppm ok
PID Model #, SERIAL #
0730 BB CAlibrates HORIBA METER
Model #, SERIAL #
→ List calibration Results
0738 Survey crew ARRIVES on Site
→ List NAMES
0745 BB Holds H+S TAlk on Slips,
Trips, FAlls, Ticks + AIR Monitoring
JS + Survey Crew ATTEND
No H+S ISSUES IdENTIFIED as
concERNS. All work is in "Level D."
0755 JS Conducts SitE-WIDE Air Monitoring
All readings = 0.0 ppm in

JS
5-12-03

MAY 12, 2003 EXAMPLE ㊽

SITE 14 LTM
BrEATHING ZonE (BZ)
0805 Mobilize to well MW-22 to
SAmplE, surveyors setting up
At SitE 17
0815 PM (PAul PAPER PUSHER) CAlls AND
INforms JS to collect GW SAMPLE
At well MW-44 today for 24 hour
TAT ANALYSIS OF VOC's
0820 Purging MW-22
→ RECORD WATER QUALity DATA
JS
5-12-03
0843 Collect SAMPLE At MW-22 for
total TAL Metals AND VOC's. No
Dissolved Metals Needed PER PM
0905 JS + BB Mobilize to SitE 17 to
show surveyors wells to Survey.
0942 Mobilize to well MW-22 to
Collect SAMPLE ...
0950 CAN not ACCESS well MW-22
due to BASE OPERATIONS; CONTACT
PAul PAPERPUSHER AND he stAtED
he will check on GAINING ACCESS
with BASE contAct.
0955 Mobilize to well MW-19

JS
5-12-03

STANDARD OPERATING PROCEDURE
NAVY CLEAN PROGRAM

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized (“DI”) water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® and water solution
- Pesticide-grade (90%) isopropanol in squeeze bottle
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.
2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls (“Tyvek”) and discard into DOT-approved 55-gallon drum.
4. Remove respirator (if worn).
5. Remove inner gloves and discard.
6. At the end of the work day, shower entire body, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Spread plastic on the ground to keep equipment from touching the ground
3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.
4. Turn pump back on and recirculate 1 gallon of Liquinox® solution through the sampling pump for a minute. Turn off the pump and containerize the used solution.
5. Turn pump back on and recirculate 1 gallon of tap water for a minute. (deionized water may be substituted for tap water) Turn off the pump and containerize the used solution.
6. If pump was exposed to non-aqueous phase liquids remove pump from the tube and rinse lightly (a few cc’s of solvent is sufficient) with isopropanol, over and through the pump, and allow to air dry. Note that isopropanol is highly flammable and should be used very sparingly and away from potential sources of ignition.
7. Turn pump back on and recirculate 1 gallon of tap water for a minute. (deionized water may be substituted for tap water) Turn off the pump and containerize the used solution.
8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.
9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.

4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. If equipment was exposed to non-aqueous phase liquids rinse lightly with isopropanol and allow to air dry.
7. Rinse with deionized water.
8. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, and finally three times with a towel wet with distilled water. Solvents should not be used to clean plastic instruments as they could cause damage. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.
2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox® and distilled water.
- Use isopropanol only if heavy organic contamination is present, and then sparingly. Isopropanol should be allowed to evaporate rather than contained as it may render liquid investigation derived waste ignitable.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE
NAVY CLEAN PROGRAM

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

The purpose of this guideline is to provide methods for the decontamination of drilling rigs, downhole drilling tools, and water-level measurement equipment. Personnel decontamination procedures are not addressed in this SOP; refer to the site safety plan and SOP *Decontamination of Personnel and Equipment*. Sample bottles will not be field decontaminated; instead they will be purchased with certification of laboratory sterilization.

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- 2.5% (W/W) Liquinox® and water solution
- Buckets
- Brushes
- Isopropanol, pesticide grade
- Personal Protective Equipment as specified by the Health and Safety Plan
- ASTM–Type II grade water or Lab Grade DI Water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

Before the onset of drilling, after each borehole, before drilling through permanent isolation casing, and before leaving the site, heavy equipment and machinery will be decontaminated by steam cleaning at a designated area. The steam-cleaning area will be designed to contain decontamination wastes and waste waters and can be an HDPE-lined, bermed pad. A pumping system will be used to convey decontaminated water from the pad to drums.

Surface casings may be steam cleaned in the field if they are exposed to contamination at the site prior to use.

B. Downhole Drilling Tools

Downhole tools will be steam cleaned before the onset of drilling, prior to drilling through permanent isolation casing, between boreholes, and prior to leaving the site. This will include, but is not limited to, rods, split spoons or similar samplers, coring equipment, augers, and casing.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for physical characterization, the sampler shall be cleaned by scrubbing with a detergent solution followed by a potable water rinse.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for chemical analysis, the sampler shall be decontaminated following the procedures outlined in the following subsection.

C. Field Analytical Equipment

1. Water Level Indicators

   Water level indicators that consist of a probe that comes into contact with the groundwater must be decontaminated using the following steps:

   - Rinse with Liquinox® and water solution
   - Rinse with de-ionized water
   - Solvent rinse with isopropanol (Optional)
   - Rinse with de-ionized water

2. Probes

   Probes, for example, pH or specific ion electrodes, geophysical probes, or thermometers that would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise. For probes that make no direct contact, for example, PID equipment, the probe will be wiped with clean paper-towels or cloth wetted with isopropanol.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

The effectiveness of field cleaning procedures may be monitored by rinsing decontaminated equipment with organic-free water and submitting the rinse water in standard sample containers for analysis.

STANDARD OPERATING PROCEDURE
NAVY CLEAN PROGRAM

Disposal of Waste Fluids and Solids

I. Purpose and Scope

This SOP describes the procedures used to dispose of hazardous fluid and solid materials generated as a result of the site operations. This SOP does not provide guidance on the details of Department of Transportation regulations pertaining to the transport of hazardous wastes; the appropriate Code of Federal Regulations (49 CFR 171 through 177) should be referenced. Also, the site investigation-derived waste management plan should be consulted for additional information and should take precedence over this SOP.

II. Equipment and Materials

A. Fluids

- DOT-approved 55-gallon steel drums or frac tanks
- Tools for securing drum lids
- Funnel for transferring liquid into drum
- Labels
- Paint Pens
- Marking pen for appropriate labels
- Seals for 55-gallon steel drums

B. Solids

- DOT-approved 55-gallon steel drums or rolloffs
- Tools for securing drum lids
- Paint Pens
- Plastic sheets
- Labels
- Marking pen for appropriate labels

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or roll-offs or frac tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. The drums will be filled with the drilling and well installation wastes (fill drum ¾, not to top), capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will be labeled as they are filled in the field and labels indicating that the contents are pending analysis affixed.

The drum contents will be sampled to determine the disposal requirements of the drilling wastes. Check with the Environmental Manager (EM) assigned to the project prior to sample collection for frequency and analysis. Unless otherwise specified by the EM, the drum sampling will be accomplished through the collection and submittal of composite samples, one sample per 10 drums (check with disposal facility to determine sample frequency) containing the same media. Similar compositing will be performed in each rolloff to obtain a representative sample. The compositing of the sample will be accomplished by collecting a specific volume of the material in each drum into a large sample container. When samples from each of the drums being sampled in a single compositing are collected, the sample will be submitted for TCLP, ignitability, corrosivity, and reactivity analysis. Additional analysis may be required by your EM.

If rolloffs are used, compositing and sampling of soil will comply with applicable state and federal regulations.

B. Labels

Drums and other containers used for storing wastes from drilling operations will be labeled when accumulation in the container begins. Analysis pending labels should be used initially. Labels will include the following minimum information:

- Container number
- Container contents
- Origin (source area including individuals wells, piezometers, and soil borings)
- Date that accumulation began
- Date that accumulation ended
- Generator Contact Information
- When laboratory results are received, drum labels will be completed or revised to indicate the hazardous waste constituents in compliance with Title 40 of the Code of Federal Regulations, Part 262, Subpart C if the results indicate hazardous waste or labeled as non-hazardous if applicable.

C. Fluids

Drilling fluids generated during soil boring and groundwater discharged during development and purging of the monitoring wells will be collected in 55-gallon, closed-top drums. When a drum is filled, the bung will be secured tightly. Fluids may also be transferred to frac tanks after being temporarily contained in drums to minimize the amount of drums used.

When development and purging is completed, the water will be tested for appropriate hazardous waste constituents as per instruction from the project EM. Compositing and sampling of fluids will comply with applicable state and federal regulations.

D. Solids

The soil cuttings from well and boring drilling will constitute a large portion of the solids to be disposed of.

The solid waste stream also will include plastic sheeting used for decontamination pads, Tyveks, disposable sampling materials, and any other disposable material used during the field operations that appears to be contaminated. These materials will be placed in designated drums.

E. Storage and Disposal

The wastes generated at the site at individual locations will be transported to the drum storage area by the drilling services subcontractor. Drums should be stored on plastic sheeting with a short berm wall (hay bales or 2 x 4 planks or equivalent) to capture small spills. The drums should be staged such that the labels are all visible and there should be enough room to walk between rows of drums if applicable.

Waste solid materials that contain hazardous constituents will be disposed of at an offsite location in a manner consistent with applicable solid waste, hazardous waste, and water quality regulations. Transport and disposal will be performed by a commercial firm under subcontract.

The liquid wastes meeting acceptable levels of discharge contamination may be disposed of through the sanitary sewer system at the site. However, prior to disposal to the sanitary sewer system, approval and contract arrangements will be made with the appropriate authorities. Wastes exceeding acceptable levels for disposal through the sanitary sewer system will be disposed of through contract with a commercial transport and disposal firm.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Contact the project Environmental Manager prior to containerizing waste to determine containerization method and sampling frequency and analysis.
- Check that representative samples of the containerized materials are obtained.
- Be sure that all state and federal regulations are considered when classifying waste for disposal.

Standard Operating Procedure

Locating and Clearing Underground Utilities

I. Purpose

The purpose of this SOP is to provide general guidelines and specific procedures that must be followed on Navy CLEAN projects for locating underground utilities and clearing dig locations in order to maximize our ability to avoid hitting underground utilities and to minimize liabilities to Jacobs and its subcontractors and health and safety risks to our project staff.

This SOP shall be used by Activity Managers and Project Managers to, in-turn, develop Activity-specific and project-specific utility location procedures. The activity and project-specific procedures will become part of work plans and project instructions and will be used to prepare scopes of work (SOWs) for the procurement of utility location subcontractors to meet the needs of individual projects.

This SOP also identifies the types of utility locating services that are available from subcontractors and the various tools that are used to locate utilities, and discusses when each type of service and tool may or may not be applicable.

II. Scope

Depending on the Navy/Marine Activity we typically find ourselves in one of two scenarios:

Scenario 1

The Activity provides utility locating (or dig clearance) services through the public works department or similar organization, or has a contract with an outside utility clearance service. Some of these services are provided in the form of dig permits which are required before you can dig or drill. In other cases no official permit is required and the process is somewhat vague.

Scenario 2

The Activity does not get involved in any utility locating processes aside from possibly providing the most recent utility maps, and relies on Jacobs to clear the dig locations.

Scenario 1 is preferred because under this scenario the Navy tends to assume the responsibility if the location is improperly cleared, a utility is struck, and property damage results. However, our experience has been that the clearance services provided by the Navy do not meet the standards that we consider to be adequate, in that they often simply rely on available base maps to mark utilities and do not verify locations using field geophysics. And if they do use locating tools, they do not provide adequate documentation or marking to confirm that a location has been cleared. So, while the Navy's process may protect us from liability for property damage, it does not adequately protect our staff and subcontractors from health risks nor does it compensate us for down time, should a utility be hit.

Therefore, regardless of what services the Navy provides, in most cases we still need to supplement this effort with clearance services from our own third-party utility location subcontractor following the procedures and guideline outlined in Section IV of this SOP. The cost implications of providing this service will range from $500 to several $1,000 depending on the size of the project.

The scope of services that we ask our subcontractors to provide can involve utility marking/mapping or the clearing of individual dig locations. In the former we ask our subs to mark all utilities within a "site" and often ask them to prepare a map based on their work. In the later, we ask them to clear (identify if there are any utilities within) a certain radius of a proposed dig/drill location.

The appropriate requested scope of services for a project will depend on the project. Clearing individual boreholes is often less expensive and allows the sub to concentrate their efforts on a limited area. However if the scope of the investigation is fluid (all borehole locations are not predetermined) it may be best to mark and map an entire site or keep the subcontractor on call.

Clearance of individual dig locations should be done to a minimum 20-foot radius around the location.

An example SOW for a utility subcontractor procurement is provided in Attachment A.

III. Services and Equipment

This section provides a general description of the services available to help us locate subsurface utilities and describes the types of equipment that these services may (or may not) use to perform their work. It identifies the capabilities of each type of equipment to help the PM specify what they should require from our utility location subs.

Services

The services that are available to us for identifying and marking underground utilities are:

- The local public/private utility-run service such as Miss Utility or 811
- Utility location subcontractors (hired by us)
- Jacobs internal Subsurface Utility Investigation team

Attachment B provides a detailed description of each type of organization. It also provides contact numbers and web sites for the various Miss-Utility-type organizations in the areas where we do work for the Navy and contacts and services provided by several subcontractors that we have used or spoken to in the past.

Equipment

Attachment C provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the PM determine if the equipment being used by a subcontractor is adequate.

It is important to make the potential subcontractors aware of the possible types of utilities (and utility materials) that are at the site, and to have them explain in their bid what types of equipment they will use to locate utilities /clear dig locations, and what the limitations of these equipment are.

A list of in-house experts that can be used to help you evaluate bids or answer questions you may have is provided in **Appendix C.**

IV. Procedures and Guidelines

This section presents specific procedures to be followed for the utility location work to be conducted by Jacobs and our subcontractors. In addition, a PM will have to follow the procedures required by the Activity to obtain their approvals, clearances and dig permits where necessary. These "dig permit" requirements vary by Activity and must be added to the project-specific SOP, or project instructions. It is preferable that the Activity perform their clearance processes before we follow up with our clearance work.

Activity Notification and Dig Permit Procedures

Identify Activity-specific permit and/or procedural requirements for excavation and drilling activities. Contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Activity Specific: To be provided by Activity or Project Manager

Jacobs Utility Clearance Procedures

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted by Jacobs as a follow-up to the services provided by the Navy. The use of as-built drawings and utility company research will be compiled and must be supplemented with a geophysical or other survey by a qualified, independent survey contractor (subcontracted to Jacobs) to identify additional and undiscovered buried utilities.

Examples of the type of geophysical technologies include (these are further described in Attachment C):

- **Ground Penetrating Radar (GPR),** which can detect pipes, including gas pipes, tanks, conduits, cables etc, both metallic and non-metallic at depths up to 30 feet depending on equipment. Sensitivity for both minimum object size and maximum depth detectable depends on equipment selected, soil conditions, etc.

- **Radio Frequency (RF),** involves inducing an RF signal in the pipe or cable and using a receiver to trace it. Some electric and telephone lines emit RF naturally and can be detected without an induced signal. This method requires knowing where the conductive utility can be accessed to induce RF field if necessary.
- **Dual RF**, a modified version of RF detection using multiple frequencies to enhance sensitivity but with similar limitations to RF
- **Ferromagnetic Detectors**, are metal detectors that will detect ferrous and non-ferrous utilities. Sensitivity is limited, e.g. a 100 mm iron disk to a depth of about one meter or a 25 mm steel paper clip to a depth of about 20 cm.
- **Electronic markers,** are emerging technologies that impart a unique electronic signature to materials such as polyethylene pipe to facilitate location and tracing after installation. Promising for future installations but not of help for most existing utilities already in place.

The following procedures shall be used to identify and mark underground utilities during subsurface construction activities on the project:

- Contact utility companies or the state/regional utility protection service (such as Miss Utility) at least two (2) working days prior to intrusive activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation: this is a law. These services will only mark the location of public-utility-owned lines and not Navy-owned utilities. In many cases there will not be any public-utility-owned lines on the Activity. There may also be Base-access issues to overcome.
- Procure and schedule the independent survey.
- The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project site, based on the survey contractor's experience and expertise, types of utilities anticipated to be present and specific site conditions. ***The types of utilities must be provided to the bidding subcontractors in the SOW and procedures to be used must be specified by the bidder in their bid. It is extremely helpful to provide the sub with utility maps, with the caveat that all utilities are not necessarily depicted.***
- The survey subcontractor shall employ the same geophysical techniques used to identify the buried utilities, to survey the proposed path of subsurface investigation/construction work to confirm no buried utilities are present.
- Obtain utility clearances for subsurface work on both public and private property.
- Clearances provided by both the "Miss Utility" service and the Jacobs-subcontracted service are to be in writing, signed by the party conducting the clearance. The Miss Utility service will have standard notification forms/letters which typically simply state that they have been to the site and have done their work. The Jacobs

subcontractor shall be required to fill out the form provided in Attachment D (this can be modified for a particular project) indicating that each dig/drill location has been addressed. ***This documentation requirement (with a copy of the form) needs to be provided in the subcontractor SOW.***

- Marking shall be done using the color coding presented in Attachment E defined by the American Public Works Association (APWA). The type of material used for marking must be approved by the Activity prior to marking. Some base commanders have particular issues with persistent spray paint on their sidewalks and streets. ***Any particular marking requirements need to be provided in the subcontractor SOW.***
- Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.
- Perform a field check prior to drilling/digging (preferably while the utility location sub is still at the site) to see if field utility markings coincide with locations on utility maps. Look for fire hydrants, valves, manholes, light poles, lighted signs, etc to see if they coincide with utilities identified by the subcontractor.
- Underground utility locations must be physically verified (or dig locations must be physically cleared) by hand digging using wood or fiberglass-handled tools, air knifing, or by some other acceptable means approved by Jacobs when the dig location (e.g. mechanical drilling, excavating) is expected to be within 3 feet of a marked underground system. Hand clearance shall be done to a depth of four feet unless a utility cross-section is available that indicates the utility is at a greater depth. In that event, the hand clearance shall proceed until the documented depth of the utility is reached.
- Conduct a site briefing for employees at the start of the intrusive work regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.

Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon during drilling or change in color, texture or density during excavation that could indicate the ground has been previously disturbed).

IV. Attachments

A- Example SOW for Utility Location Subcontractor Procurement
B - Services Available for Identifying and Marking Underground Utilities
C – Equipment Used for Identifying Underground Utilities
D – Utility Clearance Documentation Form
E – Utility Marking Color Codes

Attachment A – Example SOW for Subcontracting Underground Utilities Locating Services

CTO-XXX

Scope of Work

Subsurface Utility Locating

Site XX

Navy Activity

City, State

A licensed and insured utility locator will be subcontracted to identify and mark out subsurface utilities for an environmental investigation/remediation project at Site XX of <<insert name of base, city, and state>>. The subcontractor will need to be available beginning at <<insert time>> on <<insert date>>. It is estimated that the work can be completed within XX days.

Proposed Scope of Work

The subcontractor will identify and mark all subsurface utilities (CHOOSE 1) that lie within a radius of 20 feet of each of XX sampling locations at Site XX shown on the attached Figure 1; (OR) that lie within the bounds of Site XX as delineated on the attached Figure 1. (If multiple sites are to be cleared, provide maps of each site with sample locations or clearance boundaries clearly delineated and a scale provided.)

Utilities will be identified using all reasonably available as-built drawings, electronic locating devices, and any other means necessary to maintain the safety of drilling and sampling personnel and the protection of the base infrastructure. The location of utilities identified from as-built drawings or other maps must be verified in the field prior to marking.

Base utility drawings for the Site(s) (CHOOSE 1) can be found at <<insert specific department and address or phone number on the base>> and should be reviewed by the subcontractor and referenced as part of the utility locating. (OR), will be provided to the subcontractor by Jacobs upon the award of the subcontract. (OR), are not available. Utility drawings shall not be considered definitive and must be field verified.

Field verification will include detection using nonintrusive subsurface detection equipment (magnetometers, GPR, etc) as well as opening manhole covers to verify pipe directions. As part of the bid, the Subcontractor shall provide a list of the various subsurface investigation tools they propose to have available and use at the site and what the limitations are of each tool.

A Jacobs representative shall be present to coordinate utility clearance activities and identify points and features to be cleared.

Field Marking and Documentation

All utilities located within **(CHOOSE 1)** ***a 20-ft radius of the XX proposed soil boring locations*** **(OR)** ***within the boundary of the site(s)*** as identified on the attached figure(s) will be marked using **paint** ***(some Bases such as the WNY may have restrictions on the use of permanent paint)*** and/or pin flags color coded to indicate electricity, gas, water, steam, telephone, TV cable, fiber optic, sewer, etc. The color coding shall match the industry standard as described on the attached form. In addition, the ***Buried Utility Location Tracking Form*** (attached) will be completed by the Subcontractor based upon what is identified in the field during the utility locating and submitted back to Jacobs (field staff or project manager) within 24 hours of completing the utility locating activities.

(OPTIONAL) ***The subcontractor shall also provide a map (or hand sketch) of the identified utilities to the Engineer within XX days of field demobilization. The map shall include coordinates or ties from fixed surface features to each identified subsurface utility.***

Bid Sheet/Payment Units

The subcontractor will bid on a time and materials basis for time spent on site and researching utility maps. Mobilization (including daily travel to the site) should be bid as a lump sum, as well as the preparation of the AHA and any required mapping. The per diem line item should be used if the field crew will require overnight accommodations at the project site.

Health and Safety Requirements

The utility locating subcontractor is to provide and assume responsibility for an adequate corporate Health and Safety Plan for onsite personnel. Standard personal safety equipment including: hard hat, safety glasses, steel-toed boots, gloves are recommended for all project activities. Specific health and safety requirements will be established by the Subcontractor for each project. The health and safety requirements will be subject to the review of Jacobs.

The subcontractor shall also prepare and provide to the Engineer, at least 48 hours prior to mobilization, an acceptable Activity Hazard Analysis (AHA) using the attached AHA form or similar.

It is also required that all subcontractor personnel who will be on site attend the daily 15-minute health and safety tailgate meeting at the start of each day in the field.

Subcontractor personnel showing indications of being under the influence of alcohol or illegal drugs will be sent off the job site and their employers will be notified. Subcontractor personnel under the influence of prescription or over-the-counter medication that may impair their ability to operate equipment will not be permitted to do so. It is expected that the subcontractor will assign them other work and provide a capable replacement (if necessary) to operate the equipment to continue work.

Security

The work will be performed on US Navy property. Jacobs will identify the Subcontractor personnel who will perform the work to the appropriate Navy facility point-of-contact, and will identify the Navy point-of-contact to the Subcontractor crew. The Subcontractor bears final responsibility for coordinating access of his personnel onto Navy property to perform required work. This responsibility includes arranging logistics and providing to Jacobs, in advance or at time of entry as specified, any required identification information for the Subcontractor personnel. Specifically, the following information should be submitted with the bid package for all personnel that will perform the work in question (this information is required to obtain a base pass):

- Name
- Birth Place
- Birth Date
- Social Security Number
- Drivers License State and Number
- Citizenship

Please be advised that no weapons, alcohol, or drugs will be permitted on the Navy facility at any time. If any such items are found, they will be confiscated, and the Subcontractor will be dismissed.

Quality Assurance

The Subcontractor will be licensed and insured to operate in the State of <<state>> and will comply with all applicable federal, state, county and local laws and regulations. The subcontractor will maintain, calibrate, and operate all electronic locating instruments in accordance with the manufacturer's recommendations. Additionally, the Subcontractor shall make all reasonable efforts to review as-built engineering drawings maintained by Base personnel, and shall notify the Jacobs Project Manager in writing (email is acceptable) whenever such documentation was not available or could not be reviewed.

Subcontractor Standby Time

At certain periods during the utility locating activities, the Subcontractor's personnel may be asked to stop work and standby when work may normally occur. During such times, the Subcontractor will cease activities until directed by the Jacobs representative to resume operations. Subcontractor standby time also will include potential delays caused by the Jacobs representative not arriving at the site by the agreed-upon meeting time for start of the work day. Standby will be paid to the Subcontractor at the hourly rate specified in the Subcontractor's Bid Form attached to these specifications.

Cumulative Subcontractor standby will be accrued in increments no shorter than 15 minutes (i.e., an individual standby episode of less than 15 minutes is not chargeable).

During periods for which standby time is paid, the surveying equipment will not be demobilized and the team will remain at the site. At the conclusion of each day, the daily logs for the Subcontractor and Jacobs representative will indicate the amount of standby time incurred by the Subcontractor, if any. Payment will be made only for standby time recorded on Jacobs's daily logs.

Down Time

Should equipment furnished by the Subcontractor malfunction, preventing the effective and efficient prosecution of the work, or inclement weather conditions prevent safe and effective work from occurring, down time will be indicated in the Subcontractor's and Jacobs representative's daily logs. No payment will be made for down time.

Schedule

It is anticipated that the subsurface utility locating activities will occur on <<insert date>>. It is estimated that the above scope will be completed within XXX days.

Attachment B - Services Available for Identifying and Marking Underground Utilities

The services that are available to us for identifying and marking underground utilities are:

- The Activity's PWC (or similar organization)
- The local public/private utility -run service such as Miss Utility or 811
- Utility location subcontractors (hired by Jacobs)
- Non-contact excavation (vacuum excavation) subconstractor

Each are discussed below.

Navy Public Works Department

A Public Works Department (PWD) is usually present at each Activity. The PWD is responsible for maintaining the public works at the base including management of utilities. In many cases, the PWD has a written permit process in place to identify and mark-out the locations of Navy-owned utilities [Note: The PWD is usually NOT responsible for the locations/mark-outs of non-Navy owned, public utilities (e.g., Washington Gas, Virginia Power, municipal water and sewer, etc.). Therefore, it is likely that we will have to contact other organizations besides the PWD in order to identify non-Navy owned, public utilities].

At some Activities, there may not be a PWD, the PWD may not have a written permit process in place, or the PWD may not take responsibility for utility locating and mark-outs. In these cases, the PWD should still be contacted since it is likely that they will have the best understanding of the utility locations at the Activity (i.e., engineering drawings, institutional knowledge, etc.). Subsequently, the PWD should be brought into a cooperative arrangement (if possible) with the other services employed in utility locating and mark-out in order to have the most comprehensive assessment performed.

At all Activities we should have a contact (name and phone number), and preferably an established relationship, with PWD, either directly or through the NAVFAC Atlantic, Midlant, or Washington NTR or Activity Environmental Office that we can work with and contact in the event of problems.

Miss Utility or "811 One Call" Services for Public Utility Mark-outs

Miss Utility or "811 One Call" service centers are information exchange centers for excavators, contractors and property owners planning any kind of excavation or digging. The "811 One Call" center notifies participating public utilities of the upcoming excavation work so they can locate and mark their underground utilities in advance to prevent possible damage to underground utility lines, injury, property damage and service outages. In some instances, such with southeastern Virginia bases, the Navy has entered into agreement with Miss (?) Utilities and is part of the response process for Miss Utilities. Generally, a minimum of 48 hours is required for the public utility mark-outs to be performed. The “811 One Call” services are free to the public. Note that the “811 One Call” centers only coordinate with participating public utilities. There may be some public utilities that do NOT participate in the “One Call” center which may need to be contacted separately. For example, in Washington, DC, the Miss Utility “811 One Call” center does not locate and mark public sewer and water lines. Therefore, the municipal water and sewer authority must be contacted separately to have the sewer and water lines marked out. The AM should contact the appropriate one-call center to determine their scope of services.

For the Mid-Atlantic region, the following “One Call” service centers are available.

Name	Phone	Website	Comments
Miss Utility of DELMARVA	800-257-7777	www.missutility.net	Public utility mark-outs in Delaware, Maryland, Washington, DC, and Northern Virginia
Miss Utility of Southern Virginia (One Call)	800-552-7001	not available	Public utility mark-outs in Southern Virginia
Miss Utility of Virginia	800-257-7777 800-552-7007	www.missutilityofvirginia.com	General information on public utility mark-outs in Virginia, with links to Miss Utility of DELMARVA and Miss Utility of Southern Virginia (One Call)
Miss Utility of West Virginia, Inc	800-245-4848	none	Call to determine what utilities they work with in West Virginia
North Carolina One Call Center	800-632-4949	www.ncocc.org/ncocc/default.htm	Public Utility Markouts in North Carolina

Private Subcontractors

1. Utility-locating support is required at some level for most all Jacobs field projects in "clearing" proposed subsurface boring locations on the project site. Utility location and sample clearance can include a comprehensive effort of GIS map interpretation, professional land surveying, field locating, and geophysical surveying. Since we can usually provide our own GIS-related services for projects and our professional land surveying services are normally procured separately, utility-locating subcontractors will normally only be required for some level of geophysical surveying support in the field. This level of geophysical surveying support can range widely from a simple electromagnetic (EM) survey over a known utility line, to a blind geophysical effort,

including a ground-penetrating radar (GPR) survey and/or a comprehensive EM survey to delineate and characterize all unknown subsurface anomalies.

The level of service required from the subcontractor will vary depending on the nature of the site. At sites where utility locations are well defined on the maps and recent construction is limited, Jacobs may be confident with a limited effort from a traditional utility-locating subcontractor providing a simple EM survey. At sites where utility locations are not well defined, where recent constructions may have altered utility locations, or the nature of the site makes utility location difficult, Jacobs will require the services of a comprehensive geophysical surveying subcontractor, with a wide range of GPR and EM services available for use on an "as-needed" basis. Typical costs for geophysical surveying subcontractors will range from approximately $200 per day for a simple EM effort (usually one crew member and one instrument) to approximately $1,500 per day for a comprehensive geophysical surveying effort (usually a two-person crew and multiple instruments). Comprehensive geophysical surveying efforts may also include field data interpretation (and subsequent report preparation) and non-destructive excavation to field-verify utility depths and locations.

The following table provides a list of recommended geophysical surveying support subcontractors that can be used for utility-locating services:

Company Name and Address	**Contact Name and Phone Number**	**Equipment**[1]					**Other Services**[2]		
		1	**2**	**3**	**4**	**5**	**A**	**B**	**C**
US Radar, Inc.* PO Box 319 Matawan, NJ 07747	Ron LaBarca 732-566-2035			✓					
Utilities Search, Inc.*	Jim Davis 703-369-5758	✓				✓	✓	✓	✓
So Deep, Inc.* 8397 Euclid Avenue Manassas Park, VA 20111	703-361-6005	✓					✓	✓	✓
Accurate Locating, Inc. 1327 Ashton Rd., Suite 101 Hanover, MD 21076	Ken Shipley 410-850-0280	✓	✓						
NAEVA Geophysics, Inc. P.O. Box 7325 Charlottesville, VA 22906	Alan Mazurowski 434-978-3187	✓	✓	✓	✓	✓	✓	✓	✓
Earth Resources Technology. Inc. 8106 Stayton Rd. Jessup, MD 20794	Peter Li 240-554-0161	✓	✓	✓	✓	✓	✓	✓	

Geophex, Ltd 605 Mercury Street Raleigh, NC 27603	I. J. Won 919-839-8515	☐	☐	☐	☐	☐	☐	☐	☐

Notes:

*Companies denoted with an asterisk have demonstrated reluctance to assume responsibility for damage to underground utilities or an inability to accommodate the insurance requirements that Jacobs requests for this type of work at many Navy sites.

[1] Equipment types are:

1. Simple electromagnetic instruments, usually hand-held
2. Other, more innovative, electromagnetic instruments, including larger instruments for more area coverage
3. Ground-penetrating radar systems of all kinds
4. Audio-frequency detectors of all kinds
5. Radio-frequency detectors of all kinds

[2] Other services include:

A. Data interpretation and/or report preparation to provide a permanent record of the geophysical survey results and a professional interpretation of the findings, including expected accuracy and precision.
B. Non-destructive excavation to field-verify the depths, locations, and types of subsurface utilities.
C. Concrete/asphalt coring and pavement/surface restoration.

Non-Contact Excavation Subcontractors

In certain circumstances it may be necessary for utility location to be carried out by non-contact excavation (also known as vacuum excavation). Please refer to the reference list of non-contact excavation subcontractors.

Attachment C – Equipment Used for Identifying Underground Utilities

This attachment provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the AM and PM determine if the equipment being proposed by a subcontractor or Navy is adequate. A list of in-house experts that can be used to answer questions you may have is provided below.

Jacobs In-house Utility Location Experts

Steve Saville/KNV

Home Office Phone – 720-261-5367

Nick Jones/DEN

Home Office Phone- 303-478-0655

Electromagnetic Induction (EMI) Methods

EMI instruments, in general, induce an electromagnetic field into the ground (the primary field) and then record the response (the secondary field), if any. Lateral changes in subsurface conductivity, such as caused by the presence of buried metal or by significant soil variations, cause changes in the secondary field recorded by the instrument and thus enable detection and mapping of the subsurface features. It should be noted that EMI only works for electrically conductive materials--plastic or PVC pipes are generally not detected with EMI. Water and gas lines are commonly plastic, although most new lines include a copper “locator” strip on the top of the PVC to allow for detection with EMI.

EMI technology encompasses a wide range of instruments, each with inherent strengths and weaknesses for particular applications. One major division of EMI is between “time-domain” and “frequency-domain” instruments that differ in the aspect of the secondary field they detect. Another difference in EMI instruments is the operating frequency they use to transmit the primary field. Audio- and radio-frequencies are often used for utility detection, although other frequencies are also used. Consideration of the type of utility expected, surface features that could interfere with detection, and the “congestion” of utilities in an area, should be made when choosing a particular EMI instrument for a particular site.

One common EMI tool used for utility location is a handheld unit that can be used to quickly scan an area for utilities and allows for marking locations in “real time”. This method is most commonly used by “dig-safe” contractors marking out known utilities prior to excavation. It should be noted that this method works best when a signal (the primary field) can be placed directly onto the line (i.e., by clamping or otherwise connecting to the end of the line visible at the surface, or for larger utilities such as sewers, by running a transmitter through the utility). These types of tools also have a limited capability to scan an area for unknown utilities. Usually this requires having enough area to separate a hand held transmitter at least a hundred feet from the receiver. Whether hunting for unknown, or confirming known, utilities, this method will only detect continuous lengths of metallic conductors.

In addition to the handheld EMI units, larger, more powerful EMI tools are available that provide more comprehensive detection and mapping of subsurface features. Generally, data with these methods are collected on a regular grid in the investigation area, and are then analyzed to locate linear anomalies that can be interpreted as utilities. These methods will usually detect *all* subsurface metal (above a minimum size), including pieces of abandoned utilities. In addition, in some situations, backfill can be detected against native soils giving information on trenching and possible utility location. Drawbacks to these methods are that the secondary signals from utilities are often swamped (i.e., undetectable) close to buildings and other cultural features, and that the subsurface at heavily built-up sites may be too complicated to confidently interpret completely.

Hand-held metal detectors (treasure-finders) are usually based on EMI technology. They can be used to locate shallow buried metal associated with utilities (e.g., junctions, manholes, metallic locators). Advantages of these tools is the ease of use and real-time marking of anomalies. Drawbacks include limited depths of investigations and no data storage capacity.

Ground Penetrating Radar (GPR)

GPR systems transmit radio and microwave frequency (e.g., 80 megaHertz to 1,000 megaHertz) waves into the ground and then record reflections of those waves coming back to the surface. Reflections of the radar waves typically occur at lithologic changes, subsurface discontinuities, and subsurface structures. Plastic and PVC pipes can sometimes be detected in GPR data, especially if they are shallow, large, and full of a contrasting material such as air in a wet soil, or water in a dry soil. GPR data are usually collected in regular patterns over an area and then analyzed for linear anomalies that can be interpreted as utilities. GPR is usually very accurate in x-y location of utilities, and can be calibrated at a site to give very accurate depth information as well. A significant drawback to GPR is that depth of investigation is highly dependant on background soil conductivity, and it will not work on all sites. It is not uncommon to get only 1-2 feet of penetration with the signal in damp, clayey environments. Another drawback to GPR is that sites containing significant fill material (e.g., concrete rubble, scrap metal, garbage) will result in complicated anomalies that are difficult or impossible to interpret.

Magnetic Field Methods

Magnetic field methods rely on detecting changes to the earth's magnetic field caused by ferrous metal objects. This method is usually more sensitive to magnetic metal (i.e., deeper detection) than EMI methods. A drawback to this method is it is more susceptible to being swamped by surface features such as fences and cars. In addition, procedures must usually be implemented that account for natural variations in the earth's background field as it changes throughout the day. One common use of the method is to measure and analyze the gradient of the magnetic field, which eliminates most of the drawbacks to the method. It should be noted this method only detects ferrous metal, primarily iron and steel for utility location applications. Some utility detector combine magnetic and EMI methods into a single hand-held unit.

Optical Methods

Down the hole cameras may be useful in visually reviewing a pipe for empty conduits and/or vaults.

Attachment D – Utility Clearance Documentation Form

Buried Utility Location Tracking Form

(Submit to Jacobs PM within 24 hrs of location activities)

Project Location:
Jacobs Project No.:
Jacobs Project Manager: Name/Phone:
Fax:
Email:
Jacobs Field Team Leader: Name/Phone:

Jacobs Purchase Order:

Utility Location Subcontractor:
Subcontractor POC:

Dates of location activities:

	Check each box using an "X" if a buried utility is present within 5 feet of a marked Station ID. If color of the flag or paint differs from listed color, note change in color on the form.															
Station ID	**Gas (Yellow)**	**Electric (Red)**	**Fiber optic (Orange)**	**Cable (Orange)**	**Water (Blue)**	**San. Sewer (Green)**	**Storm Sewer (Green)**	**Steam (Yellow)**	**Petroleum (Yellow)**	**Compressed air (Yellow)**	**Other ____**	**Other ____**	**Other ____**	**Other ____**	**Date completed**	**Technician initials**	Notes (methods/tools used

The findings of the buried utility location activities summarized herein were conducted in strict accordance with the Jacobs scope of work.

Subcontractor's Signature ______________________ Date ____________

Attachment E – Utility Marking Color Codes

The following is the standard color code used by industry to mark various types of utilities and other features at a construction site.

White – Proposed excavations and borings

Pink – Temporary survey markings

Red – Electrical power lines, cables, conduits and lighting cables

Yellow – Gas, oil, steam, petroleum or gaseous materials

Orange – Communication, alarm or signal lines, cables, or conduits

Blue – Potable water

Purple – Reclaimed water, irrigation and slurry lines

Green – Sewer and storm drain lines

STANDARD OPERATING PROCEDURE

Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region IV

I. Purpose and Scope

This SOP presents general guidelines for the collection of groundwater samples from monitoring wells using low-flow purging and sampling procedures.

II. Equipment and Materials

- Adjustable-rate positive-displacement pump, electric submersible pump, or peristaltic pump
- Multi parameter water quality meter and flow through cell to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature
- Air monitoring equipment
- Personal protective equipment
- Generator or alternate power source depending on pump type
- Hand tools (9/16-inch socket, screwdrivers, tubing cutter, scissors)
- Water-level indicator
- Disposable Teflon, Teflon-lined polyethylene tubing or polyethylene tubing for metals and other inorganics
- Plastic sheeting
- Well-construction information
- Calibrated container and stopwatch to determine flow rate
- Purged water containers
- Sample containers
- Waste container labels
- In-line disposable 0.45µm filters (QED® FF8100 or equivalent)
- Shipping supplies (labels, coolers, and ice)
- Aluminum foil
- Field book

III. Procedures and Guidelines

A. Setup and Purging

1. Obtain information on well location, diameter(s), depth, and screen interval(s), and the method for disposal of purged water.

2. Calibrate instruments according to manufacturer's instructions.

3. Record well number, site, date, and condition in the field logbook.

4. Place plastic sheeting on the ground surrounding well head. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed. Do not let any downhole equipment touch the ground.

5. Open the well and begin screening breathing zone with the air monitoring device until sampling is complete, in accordance with the HASP.

6. All sampling equipment and any other equipment to be placed in the well is cleaned and decontaminated before sampling in accordance with SOP *Decontamination of Personnel and Equipment*.

7. Water level measurements are collected in accordance with the *Water Level Measurements* SOP. **Do not measure the depth to the bottom of the well at this time**; this reduces the possibility that any accumulated sediment in the well will be disturbed. Obtain depth to bottom information from well construction log.

7. Attach and secure the tubing to the pump. Lower the pump slowly into the well and set it at approximately the middle of the screen, or wetted screen interval, and at least two feet above the bottom of the well to avoid disturbance of sediment. Submersible pumps should be lowered by the suspension cable rather than the discharge tubing.

8. Insert the water quality measurement probes into the flow-through cell and place in a shaded area. The purged groundwater must enter the flow through the cell by the lower port and exit via the upper port. Wrap exposed tubing and the flow through cell in aluminum foil to minimize heat loss/gain due to environmental conditions.

9. Generators and fuel, if used, must be located at least 30 feet downwind from the well to avoid exhaust fumes contaminating the samples.

10. Begin purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Purging rates for more transmissive formations could be started at 0.5-liter to 1 liter per minute. The initial field parameters of pH, specific conductance, dissolved oxygen, ORP, turbidity, and temperature of water are measured and recorded in the field logbook.

11. Contain purged water for placement in labeled 55-gallon drum or tank, as appropriate.

12. The water level should be monitored frequently during purging, and, ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well (i.e., less than 0.3-foot). The water

level should stabilize for the specific purge rate. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if needed, be decreased to the minimum capabilities of the pump (0.1- to 0.2-liter per minute) to avoid excessive water level drawdown. <u>If the water level is drawn down by more than 1 foot, or 5% of the static water column, purging should be conducted using the 'well volume' method in accordance with SOP *Groundwater Sampling from Monitoring Wells*</u>.

13. During purging, the field parameters are measured frequently (every 5 minutes) until the parameters have stabilized. Field parameters are considered stable when three consecutive measurements meet the following criteria:

    - pH: within 0.1 Standard Unit
    - Specific conductance: within 5 percent

B. Sample Collection

Once purging is complete the well is ready to sample. The pump should be allowed to operate at the same rate as the purge cycle until sampling begins, whereupon the discharge should be reduced to 0.1 L/m.

Volatile organic compound (VOC) samples are normally collected first and directly into pre-preserved sample containers (see Special Conditions for Sampling with Peristaltic Pumps).

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.

2. The sample is slowly poured so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.

3. Inorganics, including metals, may be collected and preserved in the filtered form as well as the unfiltered form. Disposable in-line filters (0.45-micron filter), connected to the end of the sample tubing, are typically used for field filtration. Samples are field filtered as the water is being placed into the sample container.

4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to the top with a positive meniscus. VOC vials should be capped slowly to prevent introduction of air bubbles in the sample. Once capped, the VOC vial should be inverted and tapped to detect the presence of air bubbles.

5. Immediately upon collection, all samples for chemical analysis are to be labeled and placed on ice.

6. Re-usable equipment is cleaned and decontaminated in accordance with the *Decontamination of Personnel and Equipment* SOP.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, and field parameter measurements
4. Sample disposition (preservative; laboratory name, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

Special Conditions for Sampling with Peristaltic Pumps

The EPA Region 4 Groundwater Sampling SOP states, *"Samples for organic analyses cannot be exposed to the flexible peristaltic pump-head tubing due to the risk that the tubing would sorb contaminants and the propensity of this tubing to contribute organic compounds to the sample."* Consequently, when collecting samples for organic compound analyses using a peristaltic pump it is necessary to use a vacuum container ("Vacuum Jug Method"), placed between the pump and the well for semi-volatile organic compounds (SVOC) sample collection or the "Soda-straw" method for VOC samples, as described below.

When sampling by peristaltic pump, samples should be collected in order of turbidity sensitivity, as follows:

- Metals and wet chemistry – directly from the pump discharge
- SVOCs, pesticides, herbicides, PCBs, dioxins, furans – by "vacuum jug" method
- VOCs – by "soda-straw" method

Vacuum Jug Method

The following step-by-step procedures describe the process of sampling with a peristaltic pump and vacuum jug:

1. Disconnect the purge tubing from the pump. Make sure the tubing is securely attached to the protective casing or other secure object.
2. Insert the tubing into one of the ferrule nut fittings of a Teflon® vacuum container transfer cap assembly.

3. Place a suitable length of Teflon® tubing between the remaining transfer cap assembly ferrule nut fitting and the vacuum side of the flexible tubing in the peristaltic pump head. Securely hand-tighten both fittings.
4. Turn the pump on. Water should begin to collect in the transfer container (typically a 1-liter "Boston round" glass sample container) within a few minutes. If water does not begin to flow into the container within several minutes, check the transfer cap fittings and make sure the assembly is tightly attached to the container. It may be necessary to tighten the ferrule nuts with a wrench or pliers to achieve a vacuum in the system, particularly when approaching the maximum head difference between the pump and water table (limit of suction).
5. When the transfer container is nearly full, turn off the pump, remove the transfer cap assembly, and pour the sample into the appropriate containers.
6. If additional sample volume is needed, replace the transfer cap assembly, turn the pump on, and collect additional volume.

Soda-Straw Method

The "soda straw" method involves allowing the tubing to fill, by either lowering it into the water column (A) or by filling it via suction applied by the pump head (B). To avoid having to reinsert the tubing into the well to collect additional sample volume samplers should cut the tubing several feet longer than the well depth requires thereby increasing the storage capacity.

1. If method (A) is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vials.
2. If method (B) is used, after running the pump and filling the tubing with sample, the pump speed is reduced, and the direction reversed to push the sample out of the tubing into the vials.
3. Avoid completely emptying the tubing when filling the sample vials when using method (B) to prevent introducing water that was in contact with the flexible pump head tubing.
4. Either method is repeated, as necessary, until all vials are filled, taking care to prevent the tubing from contacting any surface.

Samples for some constituents, primarily inorganic analytes such as metals and cyanide, may be collected directly from the peristaltic pump head tubing. This method is acceptable under the following conditions:

- The pump head tubing must be changed between sampling locations;
- An equipment rinsate blank must be collected by pumping de-ionized water through a piece of the tubing.

C. Additional remarks

1. If the well goes dry during purging, wait until it recovers sufficiently to remove the required volumes to sample all parameters. It may be necessary to return periodically to the well but a particular sample (e.g., large amber bottles for semivolatile analysis) should be filled at one time rather than over the course of two or more visits to the well.
2. Disposable tubing is disposed of with PPE and other site trash.

IV. Attachments

White paper on reasons and rationale for low-flow sampling.

V. Key Checks and Preventative Maintenance

- The drawdown in the well should be minimized as much as possible (preferably no more than 0.5-foot to 1 foot) so that natural groundwater-flow conditions are maintained as closely as possible.
- The highest purging rate should not exceed 1 liter per minute. This is to keep the drawdown minimized.
- Stirring up of sediment in the well should be avoided so that turbidity containing adsorbed chemicals is not suspended in the well and taken in by the pump.
- Overheating of electric submersible pumps should be avoided to minimize the potential for losing VOCs through volatilization. Submersible pumps used in large diameter wells should be equipped with a shroud to force water flow across the pump motor to dissipate heat build-up.
- 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 sampling pump regularly and replace as warranted
  - ✓ Inspect quick-connects regularly and replace as warranted
  - ✓ Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

Attachment to the SOP on Low-Flow Sampling Groundwater Sampling from Monitoring Wells

White Paper on Low-Flow Sampling

EPA recommends low-flow sampling as a means of collecting groundwater samples in a way that minimizes the disturbance to the natural groundwater flow system and minimizes the introduction of contamination into the samples from extraneous sources. The following are details about these issues.

When a pump removes groundwater from the well at the same rate that groundwater enters the well through the screen, the natural groundwater-flow system around the well experiences a minimum of disturbance. Some disturbance is bound to occur because you are causing groundwater to flow to the well in a radial fashion that otherwise would have flowed past it. However, the resulting low-flow sample provides the most-representative indication we can get of groundwater quality in the immediate vicinity of the well.

Normally, when a well is pumped at an excessive rate that drops the water level in the well below the water level in the aquifer, the water cascades down the inside of the well screen when it enters the well. The turbulence from this cascading causes gases such as oxygen and carbon dioxide to mix with the water in concentrations that are not representative of the native groundwater and are higher than expected. This causes geochemical changes in the nature of the water that can change the concentrations of some analytes, particularly metals, in the groundwater sample, not mention it's effect on the dissolved oxygen levels that then will be measured in the flow-through cell. Such turbulence also may cause lower-than-expected concentrations of volatile organic compounds due to volatilization.

For wells in which the water level is above the top of the screen, the water up in the riser is out of the natural circulation of the groundwater and, therefore, can become stagnant. This stagnant water is no longer representative of natural groundwater quality because its pH, dissolved-oxygen content, and other geochemical characteristics change as it contacts the air in the riser. If we minimize the drawdown in the well when we pump, then we minimize the amount of this stagnant water that is brought down into the well screen and potentially into the pump. As a result, a more-representative sample is obtained.

Typically, wells contain some sediment in the bottom of the well, either as a residue from development that has settled out of the water column or that has sifted through the sand pack and screen since the well was installed. This sediment commonly has adsorbed on it such analytes as metals, SVOCs, and dioxins that normally would not be dissolved in the groundwater. If these sediments are picked up in the groundwater when the well is disturbed by excessive pumping, they can:

- Make filtering the samples for metals analysis more difficult
- Add unreasonably to the measured concentration of SVOCs and other organic compounds

The SOP for low-flow sampling has been modified recently and should be consulted for additional information about low-flow sampling and ways of dealing with wells in which the water level cannot be maintained at a constant level.

STANDARD OPERATING PROCEDURE

Groundwater Sampling from Monitoring Wells -EPA Region IV

I. Purpose and Scope

This procedure presents general guidelines for collecting groundwater samples from monitoring wells using the well-volume approach. The procedure **does not** address purging and sampling using "low-flow" techniques (see SOP *Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region IV)*. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Adjustable-rate positive-displacement pump, electric submersible pump, or peristaltic pump
- Bailers (polyethylene or Teflon) and nylon cord, if applicable
- Multi parameter water quality meter and flow through cell to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature Air monitoring equipment
- Personal protective equipment
- Generator or alternate power source depending on pump type
- Water-level indicator
- Disposable Teflon, Teflon-lined polyethylene tubing or polyethylene tubing
- Plastic sheeting
- Well-construction information
- Calibrated container and stopwatch to determine flow rate
- Purged water containers
- Sample containers
- Waste container labels
- In-line disposable 0.45μm filters (QED® FF8100 or equivalent)
- Shipping supplies (labels, coolers, and ice)
- Aluminum foil
- Field book
- Hand tools

Note: bailers and peristaltic pumps should only be used when site access or other limitations prevent the use of sampling pumps

III. Procedures and Guidelines

A. Setup and Purging

1. Obtain information on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.
2. A pump will be used for well purging if the well yield is adequate; otherwise, a bailer may be used depending on project requirements.
3. Sampling equipment is cleaned and decontaminated prior to sampling in accordance with SOP *Decontamination of Personnel and Equipment*.
4. Instruments are calibrated according to manufacturer's instructions.
5. The well number, site, date, and condition are recorded in the field logbook.
6. Plastic sheeting is placed on the ground, and the well is unlocked and opened.
7. Open the well and begin screening breathing zone with air monitoring device until sampling is complete, in accordance with the HASP.
8. Water level measurements are collected in accordance with the *Water Level Measurement* SOP. **Do not measure the depth to the bottom of the well at this time**; this reduces the possibility that any accumulated sediment in the well will be disturbed. Obtain depth to bottom information from well construction log.
9. Calculate the volume (V) of water in a well casing as follows:

   $$V = 0.041\, d^2 h$$

   where: V = volume of water in well (gallons)
   d = diameter of well in <u>inches</u>
   h = height of water column in <u>feet</u>

   The volume of water in common well casing diameters may be calculated as follows:

   2-inch diameter well:
   0.163 gal/ft x ___ (linear feet of water) = gallons

   4-inch diameter well:
   0.653 gal/ft x ___ (linear feet of water) = gallons

   6-inch diameter well:
   1.469 gal/ft x ___ (linear feet of water) = gallons

10. Attach tubing, support cable or rope, and air line (if applicable) to the pump. The support line should bear the weight of the pump. Set the

pump intake near the top of the water column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. It is recommended that the pump not be lowered more than 3 to 5 feet into the water column. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is within 1 foot of the top of the water column. If the pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the drawdown.

11. If an electric submersible pump is to be used in a large diameter well (greater than 4 inches), a pump shroud should be used to direct the flow of water across the pump motor. Failure to use a shroud in this situation can lead to overheating of the motor and loss of volatiles from the pump discharge.

12. Generators and fuel, if used, must be located at least 30 feet downwind from the well to avoid exhaust fumes contaminating the samples.

13. If a bailer is being used, it should be removed from its protective covering and attached to a cord compatible with the site contaminants. The bailer should be lowered into the top of the water column, allowed to fill, and removed. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. The use of bailers for purging and sampling is discouraged because the correct technique is highly operator dependent and improper use may result in an unrepresentative sample.

14. Insert the water quality measurement probes into the flow-through cell and place in a shaded area. The purged groundwater must enter the flow through the cell by the lower port and exit via the upper port. Wrap exposed tubing and the flow through cell in aluminum foil to minimize heat loss/gain due to environmental conditions. Field parameters including pH, ORP, turbidity, dissolved oxygen, specific conductance, and temperature are measured and recorded in the field logbook.

15. A minimum of three well volumes must be purged (up to 5 well volumes may be purged if water quality parameters do not stabilize) prior to sampling. In low-yielding wells, if the well is purged dry it is <u>not necessary to remove a minimum of three well volumes</u>; however, the well should be allowed to recover sufficiently to allow collection of all samples at one time.

16. During purging, the field parameters are measured frequently (every 5 to 10 minutes) until the parameters have stabilized. Field parameters are considered stable when three consecutive measurements meet the following criteria:

- pH: within 0.1 Standard Units
- Specific conductance: within 5 percent

B. Sample Collection

Once purging is complete the well is ready to sample. The pump should be allowed to operate at the same rate as the purge cycle until sampling begins, whereupon the discharge should be reduced to 0.1 L/m.

Samples will be placed in sample containers that have been cleaned to laboratory standards and are preserved in accordance with the analytical method. The containers are typically pre-preserved, if required.

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of disturbance. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.
3. Inorganics, including metals, may be collected and preserved in the filtered form as well as the unfiltered form. Disposable in-line filters (0.45 micron filter), connected to the end of the sample tubing, are typically used for field filtration. Samples are field filtered as the water is being placed into the sample container. If a bailer is used, filtration may be driven by a peristaltic pump.
4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to the top with a positive meniscus. VOC vials should be capped slowly to prevent introduction of air bubbles in the sample. Once capped, the VOC vial should be inverted and tapped to detect the presence of air bubbles.
5. The bottle is capped and clearly labeled.
6. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice.
7. If the sample tubing or bailer is dedicated, it is returned to the well and the well is capped and locked. Nondedicated equipment is cleaned and decontaminated in accordance with the *Decontamination of Personnel and Equipment* SOP.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)

2. Sample source and description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservative; laboratory name, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

IV Additional remarks

Special Conditions for Sampling with Peristaltic Pumps
The EPA Region 4 Groundwater Sampling SOP states, *"Samples for organic analyses cannot be exposed to the flexible peristaltic pump-head tubing due to the risk that the tubing would sorb contaminants and the propensity of this tubing to contribute organic compounds to the sample."* Consequently, when collecting samples for organic compound analyses using a peristaltic pump it is necessary to use a vacuum container ("Vacuum Jug Method"), placed between the pump and the well for semi-volatile organic compounds (SVOC) sample collection or the "Soda-Straw" method for VOC samples, as described below.

When sampling by peristaltic pump, samples should be collected in order of turbidity sensitivity, as follows:

- Metals and wet chemistry – directly from the pump discharge
- SVOCs, pesticides, herbicides, PCBs, dioxins, furans – by "vacuum jug" method
- VOCs – by "soda-straw" method

Vacuum Jug Method
The following step-by-step procedures describe the process of sampling with a peristaltic pump and vacuum jug:

1. Disconnect the purge tubing from the pump. Make sure the tubing is securely attached to the protective casing or other secure object.
2. Insert the tubing into one of the ferrule nut fittings of a Teflon® vacuum container transfer cap assembly.
3. Place a suitable length of Teflon® tubing between the remaining transfer cap assembly ferrule nut fitting and the vacuum side of the flexible tubing in the peristaltic pump head. Securely hand-tighten both fittings.
4. Turn the pump on. Water should begin to collect in the transfer container (typically a 1-liter "Boston round" glass sample container) within a few minutes. If water does not begin to flow into the container within several minutes, check the transfer cap fittings and make sure the assembly is tightly attached to the container. It may be necessary to

tighten the ferrule nuts with a wrench or pliers to achieve a vacuum in the system, particularly when approaching the maximum head difference between the pump and water table (limit of suction).

5. When the transfer container is nearly full, turn off the pump, remove the transfer cap assembly, and pour the sample into the appropriate containers.
6. If additional sample volume is needed, replace the transfer cap assembly, turn the pump on, and collect additional volume.

Soda-Straw Method

The "soda straw" method involves allowing the tubing to fill, by either lowering it into the water column (A) or by filling it via suction applied by the pump head (B). To avoid having to reinsert the tubing into the well to collect additional sample volume samplers should cut the tubing several feet longer than the well depth requires thereby increasing the storage capacity.

1. If method (A) is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vials.
2. If method (B) is used, after running the pump and filling the tubing with sample, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials.
3. Avoid completely emptying the tubing when filling the sample vials when using method (B) to prevent introducing water that was in contact with the flexible pump head tubing.
4. Either method is repeated, as necessary, until all vials are filled, taking care to prevent the tubing from contacting any surface.

Samples for some constituents, primarily inorganic analytes such as metals and cyanide, may be collected directly from the peristaltic pump head tubing. This method is acceptable under the following conditions:

- The pump head tubing must be changed between sampling locations;
- An equipment rinsate blank must be collected by pumping de-ionized water through a piece of the tubing.

V. Attachments

None.

VI. Key Checks and Preventative Maintenance

- Use of peristaltic pumps and bailers should be avoided, if possible.

- Allow the field parameters to stabilize within the specified criteria as much as possible.
- Fill bottles for VOC samples first.
- Be sure the sample identification is properly specified.
- Maintain field equipment in accordance with the manufacturer's recommendations. This may include, but is not limited to:
  - ✓ Inspect sampling pump regularly and replace as warranted
  - ✓ Bring supplies for replacing the bladder and "O" rings if using a positive-displacement bladder pump
  - ✓ Inspect tubing regularly and replace as warranted
  - ✓ Inspect air/sample line quick-connects regularly and replace as warranted
  - ✓ Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

STANDARD OPERATING PROCEDURE
NAVY CLEAN PROGRAM

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Water Quality Meter with Flow-Through Cell

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using a water quality meter for field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of aqueous samples. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Water Quality Monitoring System with flow-though cell (Horiba, YSI, In-Situ, Ion Science, etc.)
- Calibration Standard Solution(s) (provided by rental company)
- Deionized water in spray bottle

III. Procedures and Guidelines

A. General Parameters and Specifications:

Note: the general parameters listed below may not be available for every type of meter used. Please refer to the specific meter's manual to determine meter's range of measurement and accuracy.

Parameter	**Range of measurement**	**Accuracy**
pH	0 to 14 pH units	+/- 0.1 pH units
Specific conductance	0 to 9.99 S/m	+/- 3 % full scale
Turbidity	0 to 800 NTU	+/- 5 % full scale
Dissolved oxygen	0 to 19.99 mg/l	+/- 0.2 mg/l
Temperature	0 to 55 ^{o}C	+/- 1.0 ^{o}C
ORP	-999 to +999 mV	+/- 15 mV
Salinity	0 to 4 %	+/- 0.3 %

B. Calibration:

Prior to each day's use, clean the probe and flow-through cell using deionized water and calibrate using the Standard Solution. Refer to the specific instrumentation manual for the proper calibration methods.

C. Sample Measurement:

The water quality probes are inserted into a flow-through cell, and the purged groundwater is directed through the cell by connecting the pump discharge tubing to the bottom port on the flow through cell, allowing measurements to be collected before the water contacts the atmosphere. The flow-through cell should be positioned out of direct sunlight to reduce solar heating, and wrapped in aluminum foil to minimize heat loss or gain.

As water passes through the flow-through the flow cell, press MEAS to obtain readings or the readings are displayed on the meter for each parameter (dependent on the type of meter used). Record the water quality parameter data in a field notebook.

Once the parameters have stabilized (see *Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III* or *Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region IV* depending on project site location), remove the tubing from the bottom port of the flow-through cell.

Never collect a groundwater sample for laboratory analysis from the flow-through cell. Rinse the flow-through cell between wells to remove any sediment buildup within the cell.

IV. Key Checks and Preventive Maintenance

- Calibrate meter
- Clean probe with deionized water when done
- Refer to operations manual for recommended maintenance and troubleshooting
- Check batteries, and have a replacement set on hand
- Due to the importance of obtaining these parameters, the field team should have a spare unit readily available in case of an equipment malfunction

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

Equipment Blank and Field Blank Preparation

I. Purpose

To prepare blanks to determine whether decontamination procedures are adequate and whether any cross-contamination is occurring during sampling due to contaminated air and dust.

II. Scope

The general protocols for preparing the blanks are outlined. The actual equipment to be rinsed will depend on the requirements of the specific sampling procedure.

III. Equipment and Materials

- Blank liquid (use ASTM Type II or lab grade deionized water)
- Sample bottles as appropriate
- Gloves
- Preservatives as appropriate

IV. Procedures and Guidelines

A. Decontaminate all sampling equipment that has come in contact with sample according to SOP *Decontamination of Personnel and Equipment.*

B. To collect an equipment blank for volatile analysis from the surfaces of sampling equipment other than pumps, pour blank water over one piece of equipment and into two or three (lab dependent) 40-ml vials until there is a positive meniscus, then seal the vials. Note the sample number and associated piece of equipment in the field notes as well as the type and lot number of the water used.

For non-volatiles analyses, one aliquot is to be used for equipment. For example, if a pan and trowel are used, place trowel in pan and pour blank fluid in pan such that pan and trowel surfaces which contacted the sample are contacted by the blank fluid. Pour blank fluid from pan into appropriate sample bottles.

Do not let the blank fluid come in contact with any equipment that has not been decontaminated.

C. When collecting an equipment blank from a pump, run an extra gallon of deionized water through the pump while collecting the pump outflow into appropriate containers. Make sure the flow rate is low when sampling VOCs. If a submersible pump with disposable tubing is used, remove the disposable tubing after sampling but before decon. When decon is complete, put a 3- to 5-foot segment of new tubing onto the pump to collect the equipment blank.

D. To collect a field blank, slowly pour ASTM Type II or lab grade deionized water directly into sample containers.

E. Document and ship samples in accordance with the procedures for other samples.

F. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

- Wear gloves.
- Do not use any non-decontaminated equipment to prepare blank.
- Use ASTM-Type II or lab grade deionized water.

STANDARD OPERATING PROCEDURE

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one’s custody if:

- It is in one’s actual possession.
- It is in one’s view, after being in one’s physical possession.
- It was in one’s physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When *in situ* measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

Sample Label

Samples, other than for *in situ* measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see **Attachment A**). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project – Name of project site.

- Sample Identification - The unique sample number identifying this sample.

- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 05/21/17).
- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name or initials of the sampler.
- Remarks - Any pertinent additional information.

The field team should always follow the sample ID system prepared by the Project Chemist and reviewed by the Project Manager.

Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include ***only*** the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample locations in photographs, an easily read sign with the appropriate sample location number should be included.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. **A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler**. A Chain-of-Custody Record Form example is shown in **Attachment B**. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under “Relinquished by” entry.
- Have the person receiving the sample sign the “Received by” entry. If shipping samples by a common carrier, print the carrier to be used and enter the airbill number under “Remarks,” in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. **Attachment C** is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

A. Sample Label
B. Chain of Custody Form
C. Custody Seal

VII References

USEPA. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Attachment A

Example Sample Label

QAL

Quality Analytical Laboratories, Inc.
2567 Fairlane Drive
Montgomery, Alabama 36116
PH. (334)271-2440

Client
Sample No.
Location
Analysis
Preservative HCL
Date By

CEIMIC
CORPORATION
10 Dean Knauss Drive, Narragansett, R.I. 02882 • (401) 782-8900

SITE NAME	**DATE**
ANALYSIS	**TIME**
	PRESERVATIVE

SAMPLE TYPE

☐ **Grab** ☐ **Composite** ☐ **Other** ________

COLLECTED BY:

Attachment B

Example Chain-of-Custody Record

CH2M H

APPLIED S ENCES LABORATORY

CHAIN OF CUSTODY CORD AND AGREEMENT TO PERFORM SERVICES

CH2M Hill Project #
☐☐☐☐☐☐☐☐.☐☐.☐☐

Purchase Order #

Project Name

Company Name CH2M HILL Office

Project Manager & Phone #
Mr. [ ]
Ms. [ ]
Dr. [ ]

Report Copy to:

Requested Completion Date:

Sampling Requirements
SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

Sample Disposal:
Dispose ☐ Return ☐

\# OF CONTAINERS

LAB TEST CODES

ANALYSES REQUESTED

SHADED AREA– FOR LAB USE ONLY

Lab 1 #	Lab 2 #
Quote #	Kit Request #
Project #	
No. of Samples	Page of
Login	LIMS Ver

Sampling		Type		Matrix			CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS	ANALYSES REQUESTED	REMARKS	LAB 1 ID	LAB 2 ID
Date	Time	COMP	GRAB	WATER	SOIL	AIR						

Sampled By & Title (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time	QC Level: 1 2 3 Other: ____
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time	COC Rec / ICE
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time	Ana Req / TEMP Cust Seal / Ph
Received By (Please sign and print name)	Date/Time	Shipped Via UPS BUS Fed-Ex Hand Other ____	Shipping #	
Work Authorized By (Please sign and print name)	Remarks			

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: Original - LAB, Yellow - LAB, Pink - Client

REV 3/94 FORM 340

Attachment C
Example Custody Seal

CH2M HILL

CUSTODY SEAL

Date

Signature

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should contact a designated Jacobs HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- Strapping tape
- Contractor bags
- Absorbent pads or equivalent
- Resealable bags
- Bubble bags (for glass bottle ware)
- Bubble wrap (if needed)
- Ice

- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

A. Prepare coolers for shipment:

  - Tape drains shut.
  - Place mailing label with laboratory address on top of coolers.
  - Fill bottom of coolers with absorbent pads or similar material.
  - Place a contractor bag inside the cooler.

B. Affix appropriate adhesive sample labels to each container. Protect with clear packing tape.

C. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks. Cross check CoC to ensure all samples are present.

D. Seal each glass sample bottle within a separate bubble bag (VOCs grouped per sample location). Sample labels should be visible through the bag. Whenever possible, group samples per location for all analytes and place in resealable bags. Make sure to release as much air as practicable from the bag before sealing.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in resealable bags and placed on and around the containers.

G. Fill remaining spaces with bubble wrap if needed.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear packing tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with clear packing tape to avoid seals being able to be peeled from the cooler.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Scan air bill receipt and CoC and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express (preferred) or other overnight carrier (if necessary). If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result, only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should contact a designated Jacobs HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals

STANDARD OPERATING PROCEDURE

Global Positioning System

I. Purpose

The procedure describes the calibration, operation, and functions associated with a Trimble® GeoExplorer® 6000 series. The GeoExplorer 6000 series includes the GeoXH™ and GeoXT™ handhelds. These handhelds combine a Trimble GNSS receiver with a field computer powered by Microsoft Windows Mobile version 6.5 operating system. If using a different instrument, the operation manual supplied by the manufacturer should be consulted for instructions.

II. Scope

This procedure provides information regarding the field operation and general maintenance of a Trimble® GeoExplorer® 6000 series. The information contained herein presents the operation procedures for this equipment. Review of the equipment's instruction manual is a necessity for more detailed descriptions pertaining to the operation and maintenance of the equipment.

III. Definitions

GPS: Global Positioning System - A system of satellites developed and operated by the US DOD. Continuous 3D coordinate information is broadcast free of charge on a worldwide basis enabling precise positional location. The GeoExplorer 6000 series handheld includes an integrated GNSS receiver that enables the collection of GPS and GLONASS data for incorporating into a GIS or for managing assets.

GPS (Global Positioning System) and GLONASS (GLObal NAvigation Satellite System) are Global Navigation Satellite Systems (GNSS). Each system consists of a constellation of satellites that orbit the earth. GNSS provides worldwide, all-weather, 24-hour time and position information.

IV. Procedures and Guidelines

The procedure for calibration, operation, and maintenance of the GPS unit is outlined below. Daily calibration and battery recharging is typical operating procedure; frequencies other than daily shall be noted in the logbook and reason for increased frequency recorded. If using a different instrument, the operation manual supplied by the manufacturer should be consulted for instructions.

The procedures described below include additional features pre-programmed into the GPS datalogger to aid the data collection process.

A. GeoExplorer 6000 Unit

Parts of the GeoExplorer 6000 series handheld

The following diagrams show the main parts of the handheld.

Keypad buttons

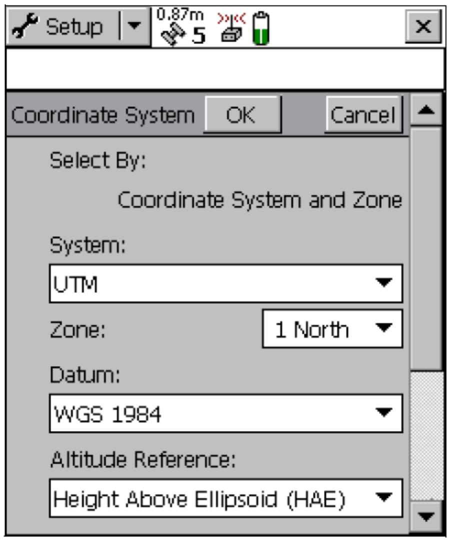
The GeoExplorer 6000 series handheld has a keypad for fast, easy access to common actions. LEDs provide visual notifications of system events.

B. Operations for surveying coordinates of a location

The TerraSync software consists of five sections as described below:

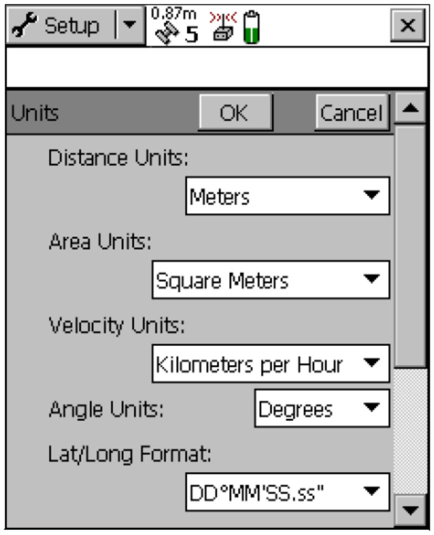
Use this section …	to …
Map	view features, background files, and the GPS trail graphically
Data	work with data files: • create a new data file or open an existing data file • log base station data to file or broadcast real-time corrections • collect new features or maintain existing features • move, copy, delete, or rename data and background files
Navigation	navigate to features using the *Direction Dial* and *Close-up* screens, or the graphical lightbar
Status	view information about: • the satellites the TerraSync software is tracking, their relative positions in the sky, and your current position • the predicted satellite constellation and position quality over the next 12 hours • communication ports that the TerraSync software is using • your GPS receiver and real-time correction source • the current UTC time • the TerraSync software version and trademark information
Setup	configure the TerraSync software

1. Configure coordinate settings: To open the **Coordinate System** form, tap Coordinate System in the Setup screen. Use this form to specify the coordinate system you want the TerraSync software to display foreground and background files.



Select By:
Coordinate System and Zone
System: UTM
Zone: 1 North
Datum: WGS 1984
Altitude Reference: Height Above Ellipsoid (HAE)

2. Configure unit settings: To open Units form, tap **Units** in the Setup screen. Use this form to specify the units used for measurements and display.



Distance Units: Meters

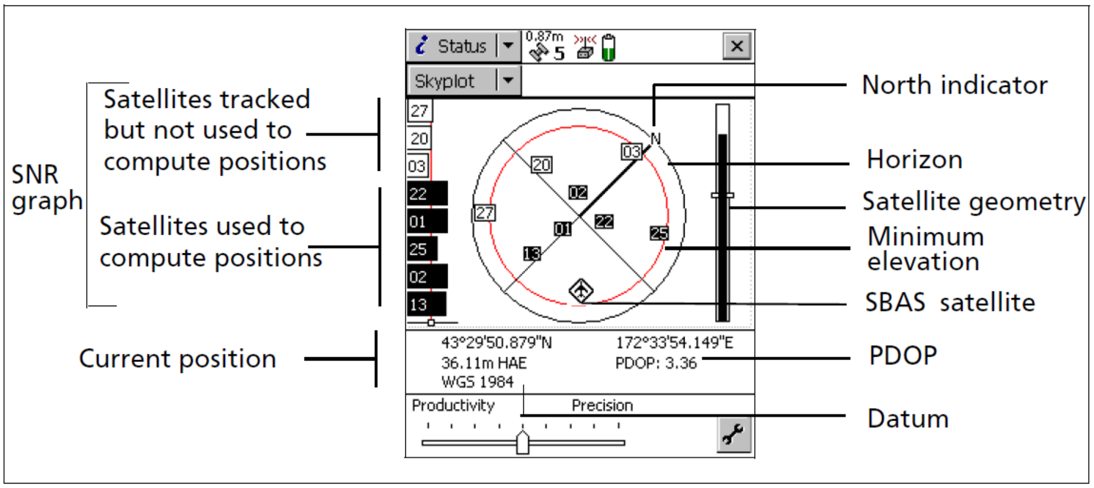
Area Units: Square Meters

Velocity Units: Kilometers per Hour

Angle Units: Degrees

Lat/Long Format: DD°MM'SS.ss"

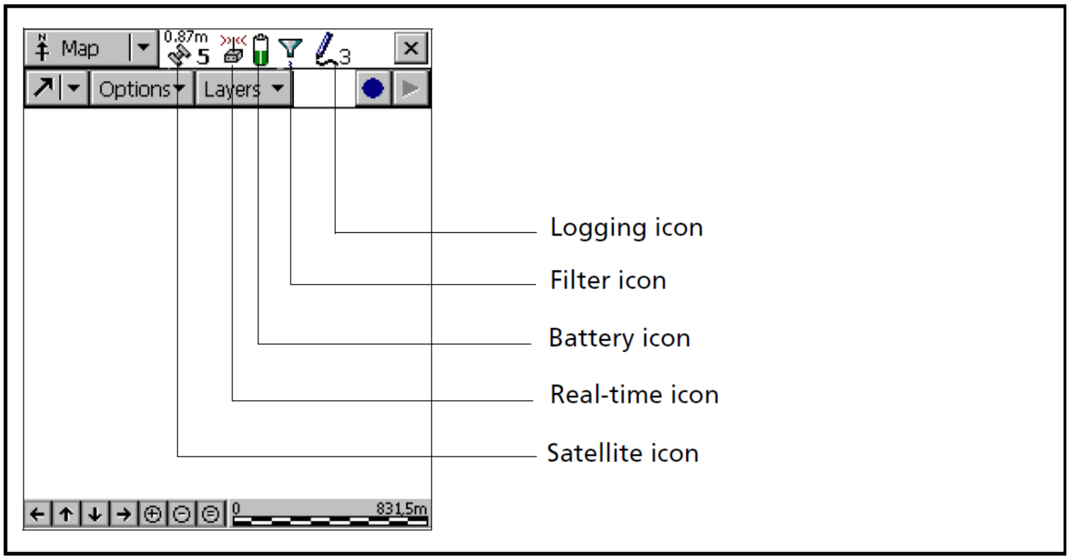
3. Starting the TerraSync Software:
   - When you are outside and ready to begin, switch on your data collector and start the TerraSync software. The GPS receiver should activate automatically.
   - On the Microsoft Windows® or Windows Mobile® taskbar, tap the windows icon and the select Programs/TerraSync. While the software is loading, a Trimble identification screen appears.
4. Getting a clear view of the sky. Move to a location where the receiver has a clear view of the sky. Signals can be received from any direction. Satellite signals can be blocked by people, buildings, heavy tree cover, large vehicles, or powerful transmitters. GPS signals can go through leaves, plastic, and glass, but they will weaken the signal.
5. Checking the GPS status. When you start the TerraSync software, it automatically connects to the GPS receiver and begins to track visible satellites to calculate its current position. Use the satellite icon on the status bar to check whether the receiver is computing GPS positions.
6. To view the GPS status: The Skyplot screen appears when you first run the TerraSync software. If this screen is not visible, tap the Section button, select Status, tap the Subsection list button and then select Skyplot.



43°29'50.879"N 172°33'54.149"E
36.11m HAE PDOP: 3.36
WGS 1984

- Filled black boxes represent satellites that the receiver is using to compute its current GPS position.
- White boxes represent satellites that the receiver is getting signals from but is not using because the signals are too weak.

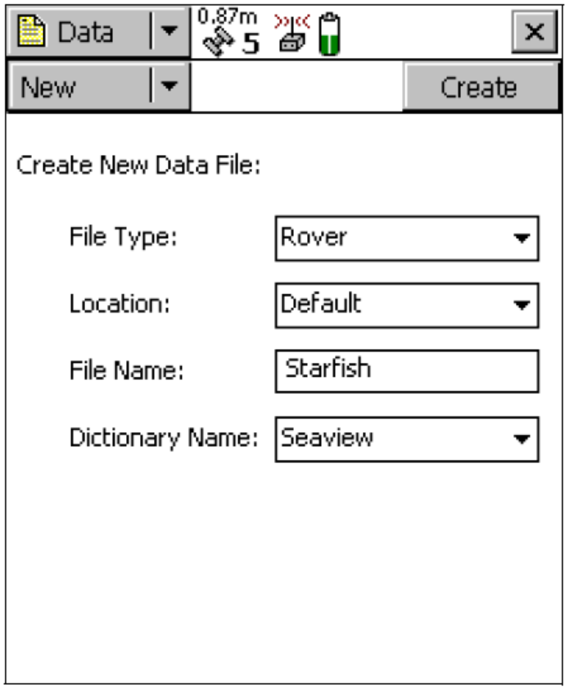
7. You need a minimum of four satellites with good geometry to computer a 3D GPS position.
8. Status Bar: The status bar appears in the top row of the TerraSync screen. It is always visible, but the icons displayed depend on the current status of the TerraSync software.



9. Creating a New Data File: Before starting the data collection session, you need t create a new data file to store the new features and attributes you collect. Use the Data section to do this.

    - Tap the Section list button and then select Data

- Tap the Subsection list button and then select New.



Create New Data File:

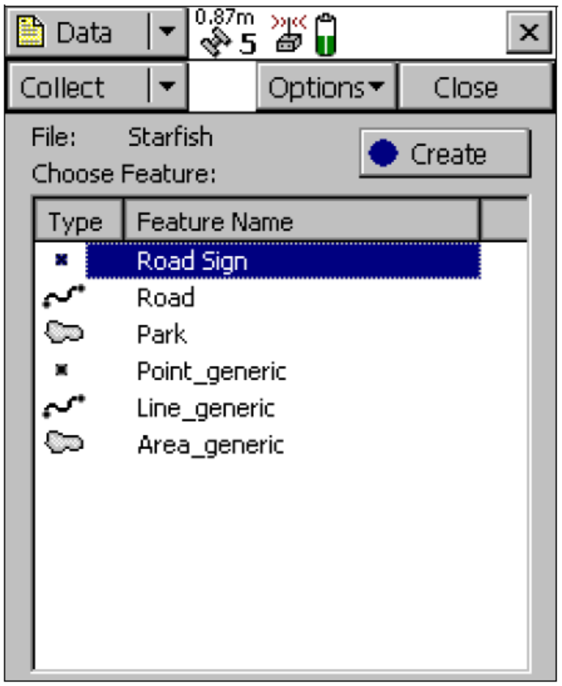
File Type: Rover

Location: Default

File Name: Starfish

Dictionary Name: Seaview

- In the Dictionary Name field, select a data dictionary.
- Tap **Create**. The Collect Features screen appears:



File: Starfish

Choose Feature:

Type	Feature Name
✖	Road Sign
	Road
	Park
✖	Point_generic
	Line_generic
	Area_generic

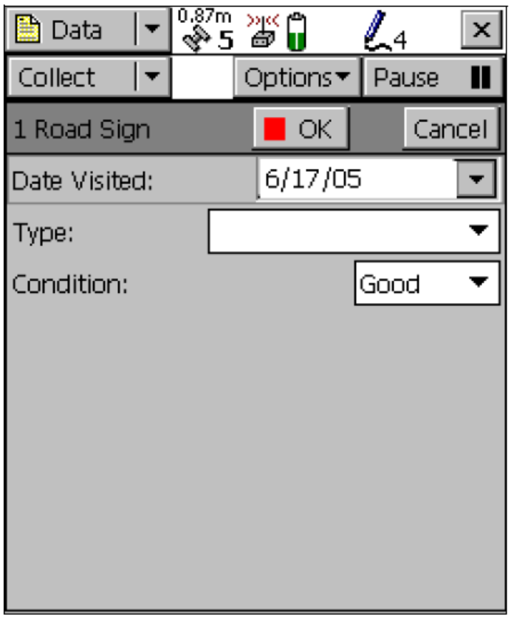
10. Collecting a Point Feature: When you record a point feature, you remain stationary for some time. The TerraSync software logs a number of GPS positions during this time.

These positions are averaged together to compute the final GPS position of the point feature.

When the TerraSync software is logging GPS positions, the logging icon appears in the status bar. The number beside the icon indicates how many positions have been logged for the selected feature. It is recommended that a minimum of 20 positions are logged prior to recording the feature.

To record a Point Feature:

- Ake sure the Collect Features screen is open.
- In the Choose Feature list, highlight an appropriate point feature and then tap **Create**. The attribute entry form for the feature type appears:
- Fill in the attribute field with appropriate values



Date Visited: 6/17/05

Type:

Condition: Good

- Once you have reached the desired amount of positions, tap OK to close the road sign feature. The attribute entry form closes and you are returned to the Collect Features screen.
- Refer to the TerraSync Orientation Guide for steps on how to collect other features.

11. Ending the data collection session: When the data collection session is complete, close the data file and then exit the Terra Sync software.
    - In the Collect Features screen, tap **Close**.
    - A message appears asking you to confirm that you want to close the open file. Tap **Yes** to close.

- Tap the X button in the top right corner of the screen.
- A message appears asking you to confirm that you want to close the TerraSync software. Tap **Yes** to close.

C. Preventive Maintenance

Data should be downloaded from the datalogger a minimum of once daily, twice daily is preferred. At the end of each day the receiver batteries should be recharged. For technical assistance call the rental company through which you acquired the Trimble® unit. Guidance is also provided in the manual and at http://www.trimble.com.

V.   References

GeoExplorer® 6000 series, Trimble, February 2011.

TerraSync and GPS Pathfinder Office Software Guide, December 2006

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.

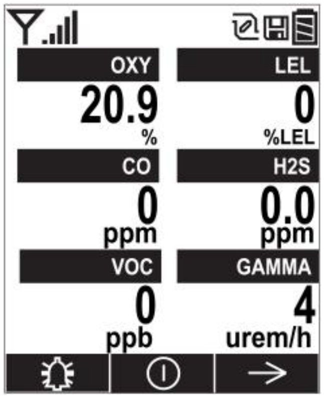
The following subsections will discuss Mini RAE calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

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.

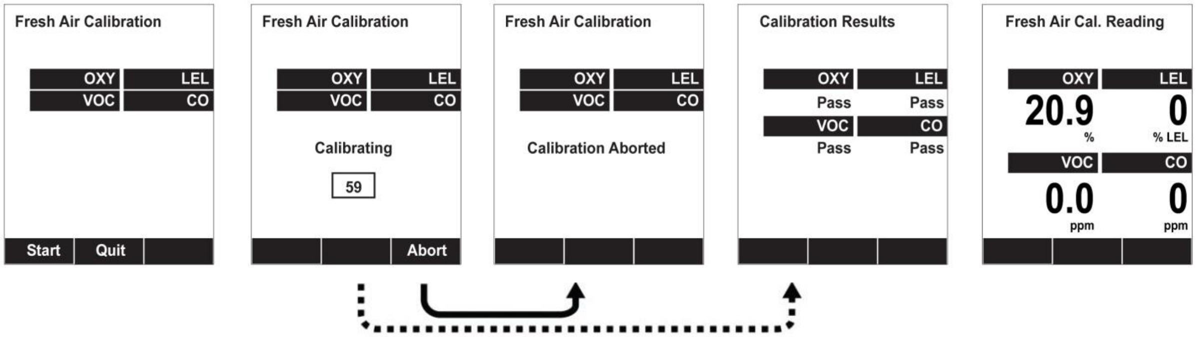


Calibration Check and Adjustment

Zero Calibration

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

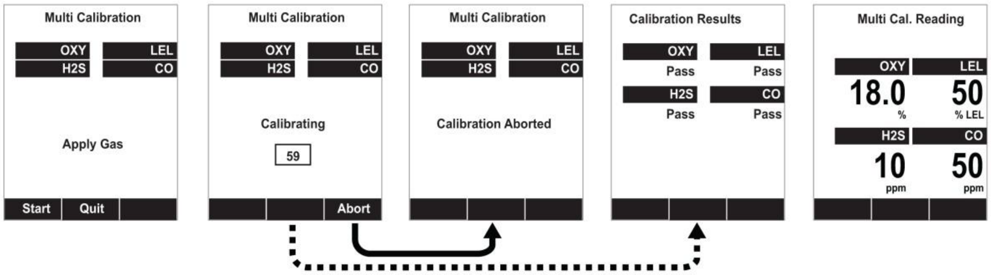
- Press **[Y/+]** to start fresh air calibration
- A countdown screen appears. You can abort the calibration at any time during the countdown by pressing [N/-].

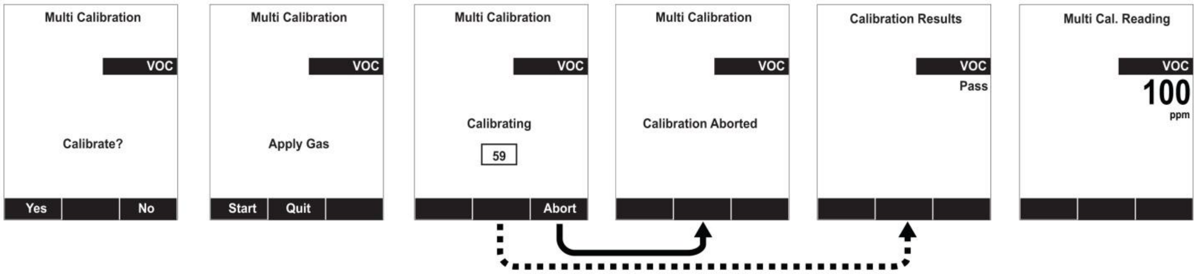


- Note: Dotted line indicates automatic progression
- If the calibration is not aborted, the display shows the sensor names and tells you whether the fresh air calibration passed or failed, followed by the sensors' fresh air readings

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/-]**.



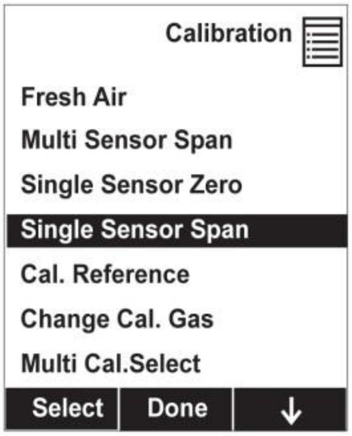


- Note: Dotted line indicates automatic progression
- If the calibration is not aborted, the display shows the sensor names and tells you whether the calibration passed or failed, followed by the sensor readings.

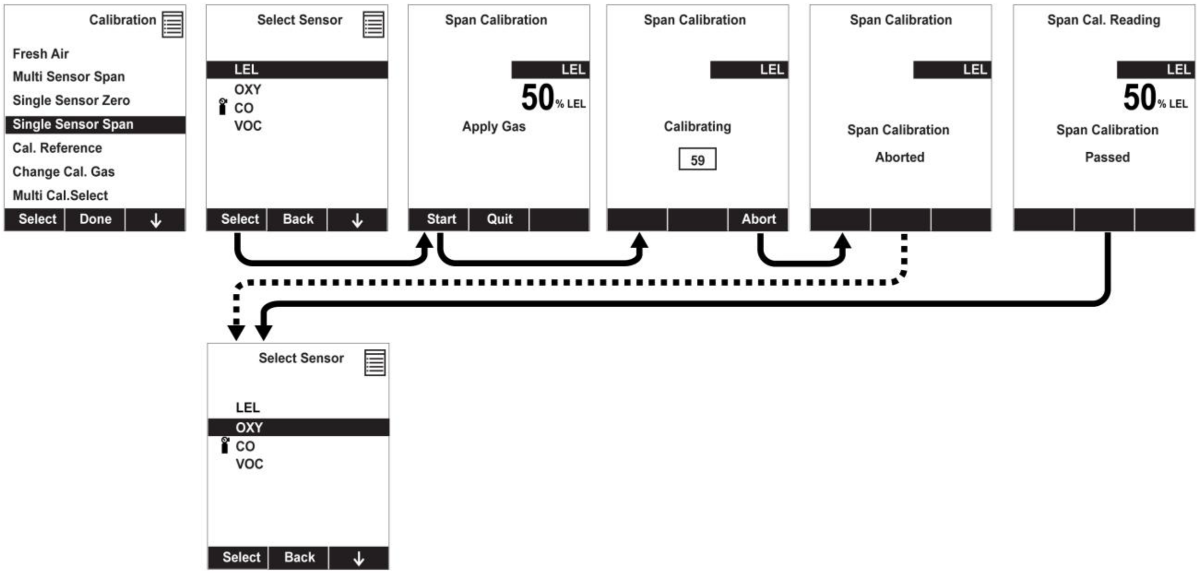
Single Sensor Span Calibration

- 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/-].



- 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.

STANDARD OPERATING PROCEDURE

Shallow Soil Sampling

I. Purpose

To provide general guidelines for the collection and handling of surface soil samples during field operations.

II. Scope

The method described for surface soil sampling is applicable for loosely packed earth and is used to collect disturbed-soil samples.

III. Equipment and Materials

- Sample jars.
- A hand auger or other device that can be used to remove the soil from the ground. Stainless-steel is preferred. However, split spoons, which are most commonly available in carbon steel are acceptable for use only if they are not rusty.
- A stainless-steel spatula or 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 (if available)

IV. Procedures and Guidelines

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

B. To locate samples, identify the correct location using the pin flags or stakes. Proceed to collect a sample from the undisturbed soil adjacent to the marker following steps C and D. If markers are not present, the following procedures will be used.

  1. For samples on a grid:

    a. Use measuring tape to locate each sampling point on the first grid line as prescribed in the sampling plan. As each point is located, drive a numbered stake in the ground and record its location on the site map and in the logbook.

    b. Proceed to sample the points on the grid line.

    c. Measure to location where next grid line is to start and stake first sample. For subsequent samples on the line take two orthogonal measurements: one to the previous grid line, and one to the previous sample on the same grid line.

    d. Proceed to sample the points on the grid line as described in Section C below.

    e. Repeat 1c and 1d above until all samples are collected from the area.

    f. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

2. For non-grid samples:

    a. Use steel measuring tape to position sampling point at location described in the sampling plan by taking two measurements from fixed landmarks (e.g., corner of house and fence post).

    b. Note measurements, landmarks, and sampling point on a sketch in the field notebook, and on a site location map.

    c. Proceed to sample as described in Section C below.

    d. Repeat 2a through 2c above until all samples are collected from the area.

    e. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

C. To the extent possible, differentiate between fill and natural soil. If both are encountered at a boring location, sample both as prescribed in the field sampling plan. Do not locate samples in debris, tree roots, or standing water. In residential areas, do not sample in areas where residents’ activities may impact the sample (e.g., barbecue areas, beneath eaves of roofs, driveways, garbage areas). If an obstacle prevents sampling at a measured grid point, move as close as possible, but up to a distance of one half the grid spacing in any direction to locate an appropriate sample. If an appropriate location cannot be found, consult with the Field Team Leader (FTL). If the FTL concurs, the sampling point will be deleted from the program. The FTL will contact the project manager (PM) immediately. The PM and Navy Technical Representative (NTR) will discuss whether the point should be deleted from the program. If it is deleted, the PM will follow-up with the NTR in writing.

D. To collect samples:

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.

2. If sampling:

    a. Surface soil: Obtain soil sample by scooping soil using the augering scoop/trowel, starting from the surface and digging down to a depth of about 6 inches, or the depth specified in the workplan.

    b. Subsurface soil: Obtain the subsurface soil sample using an auger down to the depths prescribed in the field sampling plan.

3. Take a photo ionization detector (PID) reading of the sampled soil if organics are anticipated to be present and record the response in the field notebook. Also record lithologic description and any pertinent observations (such as discoloration) in the logbook.

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. For TCL VOC and field GC aliquots, fill sample jars directly with the trowel or scoop or specialized sampling equipment (i.e. Encore® or Terra Core® sampler) and cap immediately upon filling. DO NOT HOMOGENIZE.

7. For TCL pesticides/PCBs and SVOCs, TAL metals, and field XRF aliquots, homogenize cuttings in the pan using a decontaminated stainless-steel utensil in accordance with SOP *Decontamination of Drilling Rigs and Equipment*.

8. For TCL PCBs, soil samples should include rocks and hard chunks encountered. The extraction procedure may require that the lab screen the soil to eliminate rocks larger than 3/8 inch in diameter, but the criteria are too complicated to allow a decision to be made in the field.

9. Transfer sample for analysis into appropriate containers with a decontaminated utensil.

10. 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

11. 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.

V. Attachments

None.

VI. Key Checks and Items

- Use phthalate-free latex or surgical gloves and other personal protective equipment.
- Transfer volatiles first, avoid mixing.
- Decontaminate utensils before reuse, or use dedicated, disposable utensils.

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 __________

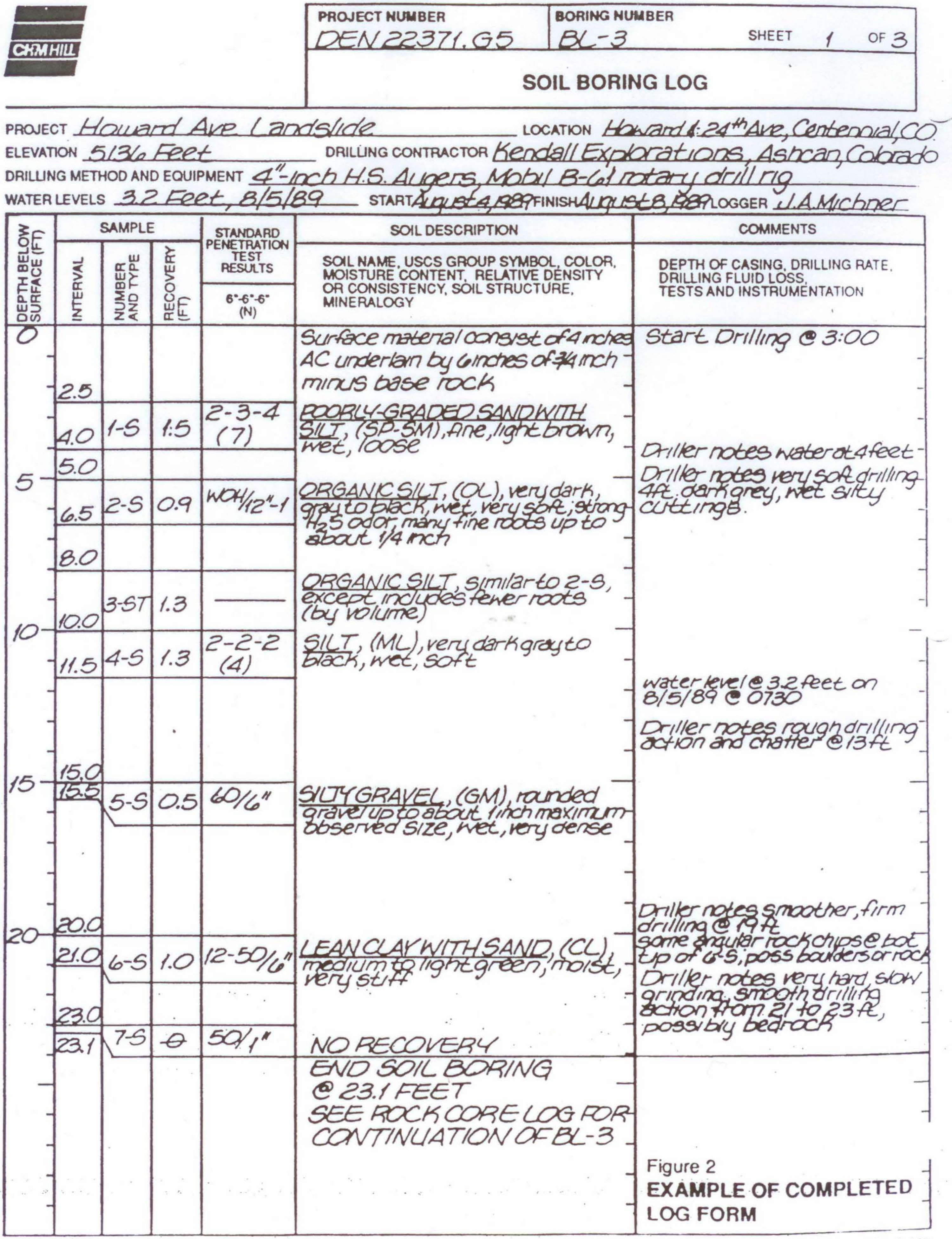
WATER LEVELS __________ START __________ FINISH __________ LOGGER __________

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

(8-30)

REV 11/89 FORM D1586



CH2M HILL

PROJECT NUMBER DEN 22371.G5

BORING NUMBER BL-3

SHEET 1 OF 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	5.0					Driller notes very soft drilling 4ft. dark grey, wet silty cuttings.
	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					Driller notes smoother, firm drilling @ 19 ft
	21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ bot tip of 6-S, poss boulders or rock
	23.0					Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	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

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

Sampling Contents of Tanks and Drums

I. Scope and Application

This procedure provides an overview approach and guidelines for the routine sampling of drums and tanks. Its purpose is to describe standard procedures and precautions which are applied in sampling drums and tanks. Procedures for opening drums with the individual instruments are included in **Attachment D**.

The samples obtained may be used to obtain physical chemical or radiological data. The resulting data may be qualitative or quantitative in nature and are appropriate for use in preliminary surveys as well as confirmatory sampling.

II. Summary of Methods

Drums are generally sampled by means of sampling tubes such as glass sample tubes or COLIWASA samplers. In either case, the sampling tube is manually inserted into the waste material. A sample of the drum contents is withdrawn by the sampling device. Should a drum contain bottom sludge, a glass tube will be used to retrieve a sample of this as well.

Storage tank and tank trailers, because of their greater depths, require sampling devices that can be lowered from the top, filled at a particular depth, and then withdrawn. Such devices are a COLIWASA, a Kemmerer depth sampler, or a Bacon Bomb. Where samples of bottom sludge are desired, a gravity corer can be utilized. This heavy tube with a tapered nose piece will penetrate the sludge as it free falls through the tank.

III. Comments

The sampling of tanks, containers, and drums present unique problems not associated with environmental samples. Containers of this sort are generally closed except for small access ports, manways, or hatches on the larger vessels, or taps and bungs on smaller drums. The physical size, shape, construction material, and location of access limit the types of equipment and methods of collection that can be used.

When liquids are contained in sealed vessels, gas vapor pressure can build up, sludges can settle out, and density layerings (stratification) can develop. Bulging drums may be under pressure and extreme caution should be exercised. The potential exists for explosive reactions or the release of noxious gases when containers are opened. All vessels should be opened with extreme caution. Check the HSP for the level of personnel protection to be worn. A preliminary sampling of any headspace gases is warranted. As a minimum, a preliminary check with a MultiRAE or equivalent may be of aid in selecting a sampling method.

In most cases it is impossible to observe the contents of these sealed or partially sealed vessels. Since some layering or stratification is likely in any solution left undisturbed over time, a sample must be taken that represents the entire depth of the vessel.

IV. Required Equipment and Apparatus

A. **Health and safety equipment/materials**: As listed in the site safety plan.

B. **Sampling equipment**: COLIWASA, glass sample tubes, Kemmerer depth sampler, Bacon Bomb, gravity corer.

C. **Tools**: Rubber mallet, bung wrench, speed wrench with socket, etc., (all non-sparking), paint marker.

D. **Heavy equipment**: Backhoe equipped with explosion shield, drum grappler, and 3-foot copper-beryllium (non-sparking) spike with 6-inch collar (to puncture top of drums for sampling, if necessary).

E. **Sample Containers**: As specified in the field sampling plan.

V. Procedures

A. Drums

NOTE: DO NOT open more than one drum at a time. Each drum must be handled and sampled as a separate entity to reduce vapors in the sampling area.

1. Drums will be sampled on an area-by-area basis. Drums will be sampled after they have been placed in overpack drums but before they are transferred from the excavation to the onsite storage area.
2. Record, in logbook, all pertinent information from visual inspection of drum (e.g., physical condition, leaks, bulges, and labels). Label each drum with a unique identifying number.
3. If possible, stage drums for easy access.
4. If necessary, attach ground strap to drums and grounding point.
5. Remove any standing material (water, etc.) from container top.
6. Using non-sparking tools, carefully remove the bung or lid while monitoring air quality with appropriate instruments. If necessary (and as a last resort), the non-sparking spike affixed to the backhoe can

also be used to puncture the drum for sampling. See **Attachment D** for method of drum opening. Record air-quality monitoring results.

7. When sampling a previously sealed vessel, a check should be made for the presence of bottom sludge. This is accomplished by measuring the depth to apparent bottom, then comparing it to the known interior depth.

8. Agitation to disrupt the layers and rehomogenize the sample is physically difficult and almost always undesirable. If the vessel is greater than 3 feet in depth (say, a 55-gallon drum), the appropriate sampling method is to slowly lower the sampling device (i.e., suction line of peristaltic pump, glass tube) in known increments of length. Discrete samples can be collected from various depths, then combined or analyzed separately. If the depth of the vessel is greater than the lift capacity of the pump, an at-depth water sampler, such as the Kemmerer or Bacon Bomb type, may be required.

9. Extract a representative sample from the drum using a glass rod, COLIWASA, Bacon Bomb, Kemmerer bottle, or gravity corer (See **Attachments**). Ensure that the entire depth of material is penetrated. Depending on the size of the opening of the drum, three to four takes should be collected from random locations across the drum surface, to ensure a representative sample. Any observed stratification must be recorded in logbook, including number and thickness of the layers and a conceptualized sketch.

10. Record a visual description of the sample (e.g., liquid, solid, color, viscosity, and percent layers).

11. When possible, sampling equipment (like glass tubes) should be expendable and be left inside the drum for disposal with drum contents, once sampling is completed.

12. Place lid, bung, cap, etc., back in place on drum. Tighten hand tight. If necessary, the sampling port can be sealed using a cork.

13. Wipe up spilled material with lab wipes. Wipe off sample containers.

14. Mark the drum with a unique sample identification number and date using a paint marker.

15. Samples will be handled as high hazard samples. Samples will be placed in containers defined according to the analytical needs, wiped clean, and then packed in paint cans for shipping. Packaging, labeling, and preparation for shipment procedures will follow procedures as specified in the field sampling plan.

B. Underground Storage Tanks

1. A sampling team of at least two people is required for sampling—one will collect samples, the other will relay required equipment and implements.
2. Sampling team will locate a sampling port on the tank. Personnel should be wearing appropriate protective clothing at this time and carrying sampling gear.
3. Do not attempt to climb down into tank. Sampling MUST BE accomplished from the top.
4. Collect a sample from the upper, middle, and lower section of the tank contents with one of the recommended sampling devices.
5. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.
6. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

C. Tank Trailers or Above-Ground Storage Tanks

1. A sampling team of two is required. One will collect samples, the other will relay required equipment and implements.
2. Samples will be collected through the manhole (hatch) on top of the tanker or the fill port. Do not open valves at the bottom. Before opening the hatch, check for a pressure gauge or release valve. Open the release valve slowly to bring the tank to atmospheric pressure.
3. If tank pressure is too great, or venting releases large amounts of toxic gas, discontinue venting and sampling immediately. Measure vented gas with organic vapor analyzer and explosimeter.
4. If no release valve exists, slowly loosen hatch cover bolts to relieve pressure in the tank. (Again, stop if pressure is too great.)
5. Once pressure in tank has been relieved, open the hatch and withdraw sample using one of the recommended sampling devices.
6. Sample each trailer compartment.
7. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.
8. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging,

labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

D. **Refer to Attachment B for procedures for sampling with appropriate devices as follows:**

<u>Drum</u>

Glass tube — Procedure 1
COLIWASA — Procedure 2

<u>Storage Tank and Tank Trailer</u>

COLIWASA — Procedure 2
Bacon Bomb — Procedure 3
Gravity Corer — Procedure 4
(for bottom sludge)

VI. Contamination Control

Sampling tools, instruments, and equipment will be protected from sources of contamination prior to use and decontaminated after use as specified in SOP *Decontamination of Personnel and Equipment*. Liquids and materials from decontamination operations will be handled in accordance with the waste management plan. Sample containers will be protected from sources of contamination. Sampling personnel shall wear chemical resistant gloves when handling any samples. Gloves will be decontaminated or disposed of between samples.

VIII. Attachments

A. Collection of Liquid-Containerized Wastes Using Glass Tubes

B. Sampling Containerized Wastes Using the Composite Liquid Waste Sample (COLIWASA)

C. Sampling Containerized Wastes Using the Bacon Bomb Sampler

D. Gravity Corer for sampling Sludges in Large Containers

E. Construction of a Typical COLIWASA

F. Drum Opening Techniques and Equipment

IX. References

A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001, U.S. Environmental Protection Agency, Washington, D.C., 1987.

Data Quality Objectives for Remedial Activities - Development Process, EPA/540/G-87/003, U.S. Environmental Protection Agency, Washington, D.C., 1987.

Annual Book of ASTM Standards, *Standard Recommended Practices for Sampling Industrial Chemicals*, ASTM-E-300, 1986.

Test Method for Evaluating Solid Waste, SW-846, Volume II, Field Methods, Second Edition, U.S. Environmental Protection Agency, Washington, D.C., 1982.

U.S. Environmental Protection Agency, *Characterization of Hazardous Waste Sites — A Method Manual: Volume II, Available Sampling Methods*, USEPA Environmental Monitoring Systems Laboratory, Las Vegas, EPA-600/4-84-076, December, 1984.

Environmental Surveillance Procedures, Quality Control Program, Martin Marietta Energy Systems, ESH/Sub/87-21706/1, Oak Ridge, TN, September 1988.

X. Field Checklist

_______ Sampling Instruments

_______ Tools

_______ Rubber Mallet

_______ Logbook

_______ Safety Glasses or Monogoggles

_______ Safety Shoes

_______ Ice/Cooler, as required

_______ Custody Seals, as required

_______ Chain-of-Custody Forms

_______ Drum Labels, as required

_______ Paint Marker, if drum sampling

_______ Black Indelible Pen

_______ Monitoring Instruments

_____ Labels

_____ Sampling and Analysis Plan

_____ Health and Safety Plan

_____ Decontamination Equipment

_____ Lab Wipes

_____ Lab Spatulas or Stainless Steel Spoons

_____ Chemical Preservatives, as required

_____ Appropriate Containers for Waste and Equipment

_____ Duct Tape

_____ Plastic Sheeting

Attachment A: Collection of Liquid-Containerized Wastes Using Glass Tubes

Discussion

Liquid samples from opened containers (i.e., 55-gallon drums) are collected using lengths of glass tubing. The glass tubes are normally 122 centimeters long and 6 to 16 millimeters inside diameter. Larger diameter tubes may be used for more viscous fluids if sampling with the small diameter tube is not adequate. The tubing is broken and discarded in the container after the sample has been collected, eliminating difficult cleanup and disposal problems. This method should not be attempted with less than a two-person sampling team.

Uses

This method provides for a quick, relatively inexpensive means of collecting concentrated containerized wastes. The major disadvantage is from potential sample loss that is especially prevalent when sampling low-viscosity fluids. Splashing can also be a problem and proper protective clothing should always be worn.

Note: A flexible tube with an aspirator attached is an alternative method to the glass tube and allows various levels to be sampled discretely.

Procedures for Use

1. Remove cover from sample container.
2. Insert glass tubing almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 centimeters extend above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the tube with a safety-gloved thumb or a stopper.
5. Carefully remove the capped tube from the drum. If the tube has passed through more than one layer, the boundary should be apparent in the glass tube.
6. Insert the bottom, uncapped end into the sample container.
7. Partially release the thumb or stopper on the top of the tube and allow the sample to slowly flow into the sample container. If separation of phases is desired, cap off tube before the bottom phase has completely emptied. It may be advisable to have an extra container for “waste,” so that the fluid on either side of the phase boundary can be directed into a separate container, allowing collection of pure phase liquids in the sample containers. The liquid remaining after the boundary fluid is removed is collected in yet a third container. NOTE: It is not necessary to put phases in separate containers if analysis of separate phases is not desired.
8. Repeat steps 2 through 6 if more volume is needed to fill the sample container.

9. Remove the tube from the sample container and replace the tube in the drum, breaking it, if necessary, in order to dispose of it in the drum.

Optional Method (if sample of bottom sludge is desired)

1. Remove the cover from the container opening.
2. Insert glass tubing slowly almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 cm extends above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Gently push the tube towards the bottom of the drum into the sludge layer. Do not force it.
5. Cap the top of the tube with a safety-gloved thumb or stopper.
6. Carefully remove the capped tube from the drum and insert the uncapped end into the sample container.
7. Release the thumb or stopper on the top of the tube and allow the sample container to fill to approximately 90 percent of its capacity. If necessary, the sludge plug in the bottom of the tube can be dislodged with the aid of the stainless-steel laboratory spatula.
8. Repeat if more volume is needed to fill sample container and recap the tube.

Note:

1. If a reaction is observed when the glass tube is inserted (violent agitation, smoke, light, etc.), the investigators should leave the area immediately.
2. If the glass tube becomes cloudy or smoky after insertion into the drum, the presence of hydrofluoric acid maybe indicated, and a comparable length of rigid plastic tubing should be used to collect the sample.
3. When a solid is encountered in a drum (either layer or bottom sludge) the optional method described above may be used to collect a core of the material, or the material may be collected with a disposable scoop attached to a length of wooden or plastic rod.

Attachment B: Sampling Containerized Wastes using the Composite Liquid Waste Sampler (COLIWASA)

Discussion

The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. The sampler is commercially available or can be easily fabricated from a variety of materials, including PVC, glass, or Teflon. In its usual configuration it consists of a 152 cm by 4 cm (inside diameter) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. See Attachment E: Construction of a COLIWASA.

Uses

The COLIWASA is primarily used to sample containerized liquids. The PVC COLIWASA is reported to be able to sample most containerized liquid wastes except for those containing ketones, nitrobenzene, dimethylforamide, mesityloxide, and tetrahydrofuran. A glass COLIWASA is able to handle all wastes unable to be sampled with the plastic unit except strong alkali and hydrofluoric acid solutions. Due to the unknown nature of many containerized wastes, it would therefore be advisable to eliminate the use of PVC materials and use samplers composed of glass or Teflon.

The major drawback associated with using a COLIWASA is concern for decontamination and costs. The sampler is difficult, if not impossible, to decontaminate in the field, and its high cost in relation to alternative procedures (glass tubes) makes it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

Procedures for Use

1. Check to make sure the sampler is functioning properly. Adjust the locking mechanism, if present, to make sure the neoprene rubber stopper provides a tight closure.

2. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler’s locking block.

3. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.

4. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the

closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

5. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a laboratory wipe with the other hand. A phase boundary, if present, can be observed through the tube.
6. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.
7. Unscrew the T-handle of the sampler and disengage the locking block.

Attachment C: Sampling Containerized Wastes using the Bacon Bomb Sampler

Discussion

The Bacon Bomb is designed for the withdrawal of samples from various levels within a storage tank. It consists of a cylindrical body with an internal tapered plunger that acts as a valve to admit the sample. A line attached to the top of the plunger is used to open and close the valve. A removable cover provides a point of attachment for the sample line and has a locking mechanism to keep the plunger closed after sampling. The Bacon Bomb is usually constructed of chrome-plated brass and bronze with a rubber O-ring acting as the plunger-sealing surface. Stainless steel versions are also available. The volumetric capacity is 8, 16, or 32 oz (237, 473, or 946 ml).

Uses

The Bacon Bomb is a heavy sampler suited best for viscous materials held in large storage tanks or in lagoons. If a more non-reactive sampler is needed, the stainless steel version would be used, or any of the samplers could be coated with Teflon.

Procedures for Use

1. Attach the sample line and the plunger line to the sampler.
2. Measure and then mark the sampling line at the desired depth.
3. Gradually lower the sampler by the sample line until the desired level is reached.
4. When the desired level is reached, pull up on the plunger line and allow the sampler to fill for a sufficient length of time before releasing the plunger line to seal off the sampler.
5. Retrieve the sampler by the sample line, being careful not to pull up on the plunger line, thereby accidentally opening the bottom valve.
6. Wipe off the exterior of the sampler body.
7. Position the sampler over the sample container and release its contents by pulling up on the plunger line.

Attachment D: Gravity Corer for Sampling Sludges in Large Containers

Discussion

A gravity corer is a metal tube with a replaceable tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents a washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. Most corers are constructed of brass or steel and many can accept plastic liners and additional weights.

Uses

Corers are capable of collecting samples of most sludges and sediments. They collect essentially undisturbed samples that represent the strata profile that may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the corer, penetration to depths of 75 cm (30 in.) can be attained. Exercise care when using gravity corers in vessels or lagoons that have liners because penetration depths could exceed those of the substrate; this could result in damage to the liner material.

Procedures for Use

1. Attach a precleaned corer to the required length of sample line. Solid braided 5-mm (3/16-in.) nylon line is sufficient; however, 20-mm (3/4-in.) nylon is easier to grasp during hand hoisting. An additional weight can be attached to the outside of the corer if necessary.
2. Secure the free end of the line to a fixed support to prevent accidental loss of the corer.
3. Allow corer to free fall through the liquid to the bottom.
4. Retrieve corer with a smooth, continuous, up-lifting motion. Do not bump corer because this may result in some sample loss.
5. Remove nosepiece from corer and slide sample out of corer into stainless steel or Teflon pan (preferred).
6. Transfer sample into appropriate sample bottle with a stainless steel lab spoon or laboratory spatula.

Attachment E: Construction of a Typical COLIWASA

The sampling tube consists of a 1.52-m (5-ft) by 4.13-cm (1-5/8 in) I.D. translucent plastic pipe, usually polyvinyl chloride (PVC) or borosilicate glass plumbing tube. The closure-locking mechanism consists of a short-length, channeled aluminum bar attached to the sampler's stopper rod by an adjustable swivel. The aluminum bar serves both as a T-handle and lock for the samplers' closure system. When the sampler is in the open position, the handle is placed in the T-position and pushed down against the locking block. This manipulation pushes out the neoprene stopper and opens at the sampling tube. In the closed position, the handle is rotated until one leg of the T is squarely perpendicular against the locking block. This tightly seats the neoprene stopper against the bottom opening of he sampling tube and positively locks the sampler in the closed position. The closure tension can be adjusted by shortening or lengthening the stopper rod by screwing it in or out of the T-handle swivel. The closure system of the sampler consists of a sharply tapered neoprene stopper attached to a 0.95-cm (3/8-in) O.D. rod, usually PVC. The upper end of the stopper rod is connected to the swivel of the aluminum T-handle. The sharply tapered neoprene stopper can be fabricated according to specifications by plastic-products manufacturers at an extremely high price, or it can be made in-house by grinding down the inexpensive stopper with a shop grinder.

COLIWASA samplers are typically made out of plastic or glass. The plastic type consists of translucent plastic (usually PVC) sampling tube. The glass COLIWASA uses borosilicate glass plumbing pipe as the sampling tube and a Teflon plastic stopper rod. For purpose of multiphase sampling, clear plastic or glass is desirable in order to observe the profile of the multiphase liquid.

The sampler is assembled as follows:

a. Attach the swivel to the T-handle with the 3.18-cm (1-1/4 in) long bolt and secure with the 0.48-cm (3/16-in) National Coarse (NC) washer and lock nut.

b. Attach the PFTE stopper to one end of the stopper rod and secure with the 0.95-cm (3/8-in) washer and lock nut.

c. Install the stopper and stopper rod assembly in the sampling tube.

d. Secure the locking block sleeve on the block with glue or screw. This block can also be fashioned by shaping a solid plastic rod on a lathe to the required dimension.

e. Position the locking block on top of the sampling tube such that the sleeveless portion of the block fits inside the tube, the sleeve sits against the top end of the tube, and the upper end of the stopper rod slips though the center hole of the block.

f. Attach the upper end of the stopper rod to the swivel of the T-handle.

g. Place the sampler in the close position and adjust the tension on the stopper by screwing the T-handle in or out.

Attachment F: Drum Opening Techniques and Equipment [1]

I. Introduction

The opening of closed drums prior to sampling entails considerable risk if not done with the proper techniques, tools, and safety equipment. The potential for vapor exposure, skin exposure due to splash or spraying, or even explosion resulting from sparks produced by friction of the tools against the drum, necessitate caution when opening any closed container. Both manual drum opening and remote drum opening will be discussed in the following paragraphs. When drums are opened manually risks are greater than when opened remotely; for this reason, the remote opening of drums is advised whenever possible.

Prior to sampling, the drums should be staged to allow easy access. Also, any standing water or other material should be removed from the container top so that the representative nature of the sample is not compromised when the container is opened. There is also the possibility of encountering a water-reactive substance.

II. Manual Drum Opening

A. Bung Wrench

A common method for opening drums manually is using a universal bung wrench. These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium (a non-sparking alloy formulated to reduce the likelihood of sparks). The use of bung wrenches marked “NON SPARKING” is encouraged. However, the use of a “NON SPARKING” wrench does not completely eliminate the possibility of spark being produced. Such a wrench only prevents a spark caused by wrench-to-bung friction, but it cannot prevent sparking between the threads on the drum and the bung.

A simple tool to use, the fitting on the bung wrench matching the bung to be removed is inserted into the bung and the tool is turned counterclockwise to remove the bung. Since the contents of some drums may be under pressure (especially, when the ambient temperature is high), the bung should be turned very slowly. If any hissing is heard, the person opening the drum should back off and wait for the hissing to stop. Since drums under pressure can spray out liquids when opened, the wearing of appropriate eye and skin protection in addition to respiratory protection is critical.

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[1] Taken from EPA Training Course: “Sampling for Hazardous Materials,” U.S. Environmental Protection Agency, Office of Emergency and Remedial Response Support Division, March 24, 1987.

B. Drum Deheader

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums (i.e., DOT Specification 17E and 17F drums); drums with removable heads must be opened by other means.

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off if so desired. If the top chime of a drum has been damaged or badly dented it may not be possible to cut the entire top off. Since there is always the possibility that a drum may be under pressure, the initial cut should be made very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote pressure release method prior to using the deheader.

C. Hand Pick or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, then it can be opened for sampling by using a hand pick, pickaxe, or spike. These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available, whereas the spikes are generally uniquely fabricated 4-ft long poles with a pointed end. Often the drum lid or head must be hit with a great deal of force in order to penetrate it. Because of this, the potential for splash or spraying is greater than with other opening methods and therefore this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes used for drum opening have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

Since drums, some of which may be under pressure, cannot be opened slowly with these tools, “sprayers” may result and appropriate safety measures must be taken. The pick or spike should be decontaminated after each drum is opened to avoid cross contamination and/or adverse chemical reaction from incompatible materials.

III. Remote Opening

A. Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

Drums should be “staged,” or placed in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with the spike.

The spike should be decontaminated after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator’s cage. This, combined with the normal sampling safety gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system. The hole in the drum can be sealed with a cork.

B. Hydraulic Devices

Recently, remotely operated hydraulic devices have been fabricated to open drums remotely. One such device is discussed here. This device uses hydraulic pressure to pierce through the wall of a drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line. A piercing device with a metal point is attached to the end of this line and is pushed into the drum by the hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head/lid of the drum. Some of the metal piercers are hollow or tube-like so that they can be left in place, if desired, and serve as a permanent tap or sampling port. The piercer is designed to establish a tight seal after penetrating the container.

C. Pneumatic Devices

Pneumatically-operated devices utilizing compressed air have been designed to remove drum bungs remotely. A pneumatic bung remover consists of a compressed air supply (usually SCBA cylinders) that is controlled by a heavy-duty, 2-stage regulator. A high pressure air line of desired length delivers compressed air to a pneumatic drill that is adapted to turn a bung fitting (preferably, a bronze-beryllium alloy) selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This attachment and removal procedure is time-consuming and is the major drawback of this device. This remote bung opener does not permit the slow venting of the container, and therefore appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device.

IV. Summary

The opening of closed containers is one of the most hazardous site activities. Maximum efforts would be made to ensure the safety of the sampling team. Proper protective equipment and a general wariness of the possible dangers will minimize the risk inherent to sampling operations. Employing proper drum opening techniques and equipment will also safeguard personnel. The use of remote sampling equipment whenever feasible is highly recommended.

STANDARD OPERATING PROCEDURE

Installation of Monitoring Wells by Sonic Drilling

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of groundwater monitoring wells and piezometers in unconsolidated or poorly consolidated materials using sonic drilling techniques. Sonic drilling technology potentially eliminates telescoping monitoring wells, allowing the installation of aquifer penetrating, single-cased wells.

II. Equipment and Materials

Drilling

- Sonic drilling rig without per- and polyfluoroalklyl substances (PFAS)-containing components (Avoid Teflon, Viton, PTFE and all other fluorinated compounds). This includes drilling and well development equipment.
- Override casings and core barrel
- 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.
- Do not use water from the facility (e.g. fire hydrants) for decontamination of equipment or preparation of grout mix if there is a possibility that the water available is contaminated with PFAS.

Well Riser/Screen

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainless steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless-steel screen.

Bottom Cap

- PVC, threaded to match the well screen; alternatively, stainless-steel
- Centering guides (if used)

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal
- Stainless-steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse – e.g., Morie #1) filter pack, and secondary (fine sand seal) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- PFAS-free Pure, additive-free bentonite pellets
- PFAS-free Pure, additive-free powdered bentonite
- PFAS-free Coated bentonite pellets; coating must biodegrade within 7 days
- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 pounds of bentonite added per bag of cement to reduce shrinkage

Protective Casing

- Above-grade well completion: 6-inch minimum ID black iron steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: 8-inch or 12-inch dia. manhole cover, or equivalent; rubber seal to prevent leakage

Well Development

- Surge block
- Well-development pump and associated equipment
- Calibrated meters to measure pH, temperature, specific conductance, and turbidity of development water
- Containers (e.g., 55-gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Drill rods and core barrel with a minimum 6-inch inside diameter (ID) will be used to drill monitoring well boreholes. Continuous core soil samples (4-inches outside diameter) will be collected for lithologic classification and intervals may be selected for chemical analysis. Soil sampling procedures are detailed in SOP *Shallow Soil Sampling.*

The use of water and additives to assist in sonic drilling for monitoring well installation will be minimized, unless required for such conditions as running sands or drilling bedrock formations.

Override casings, core barrels, and other downhole drilling tools will be decontaminated prior to the initiation of drilling activities and between each borehole location. Core barrels and other downhole soil sampling equipment will also be decontaminated before and after each use. SOP *Decontamination of Drilling Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Sampling and Analysis Plan.

B. Monitoring Well Installation

Sonic drilling technology eliminates the necessity to install double or triple cased wells since the borehole will be fully cased during drilling activities. Monitoring wells will be constructed inside the override casing(s), once the borehole has been advanced to the desired depth. Following setting the well screen, riser, filter pack, and bentonite seal, the well will be grouted as the temporary casing is withdrawn, preventing cross contamination. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or a bentonite-cement slurry to a depth approximately 2 feet below the intended well depth. Approximately 2 feet of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the temporary casing to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

A primary sand pack consisting of clean Morie No. 00 (or DSI No.1) silica sand for 0.010-inch slotted screen and Morie No. 01 (or DSI No.2) silica sand for 0.020-inch slotted screen will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The inner-most override casing will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the innermost override casing be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will extend from the bottom of the borehole to a minimum of 2 feet above the top of the well screen. A secondary, finer-grained sand pack may be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for a shallow water table and small saturated thickness of the surficial aquifer.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to discharge laterally into the borehole and not disturb the bentonite pellet seal.

C. Well Completion

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 2 feet into the ground and 3 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square, approximately 2 feet per side (unless otherwise specified in the project plans) and poured into wooden forms. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber gasket and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 feet per side (unless otherwise specified in the project plans), will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12-inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

C. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a tight-fitting surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, turbidity and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of one hour until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan.

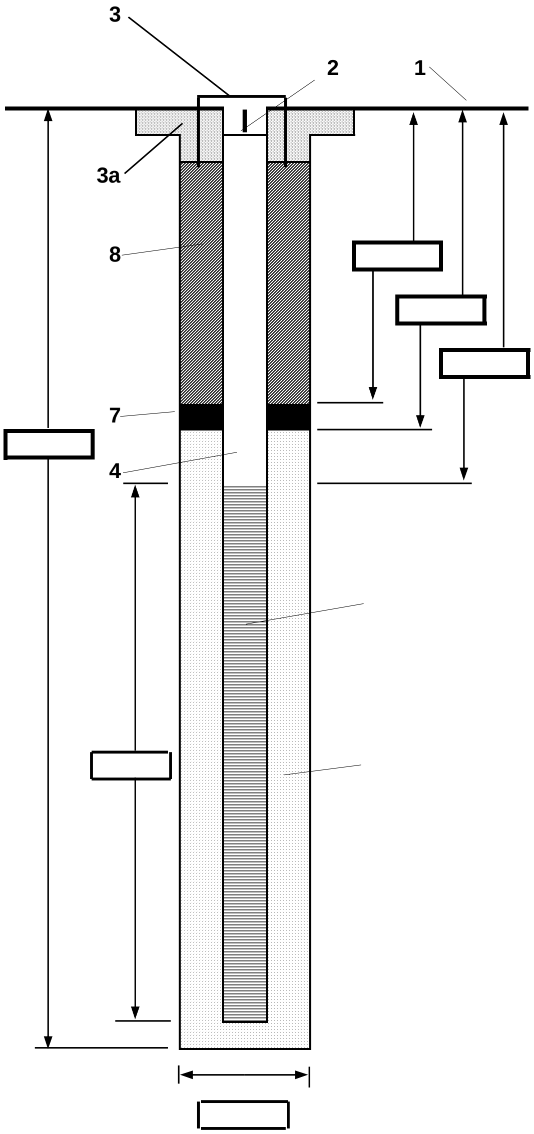
IV. Attachments

Schematic diagram of shallow monitoring well construction (MWSingleDiag.xls)

JACOBS	**PROJECT NUMBER**	**WELL NUMBER** SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT :
LOCATION :
DRILLING CONTRACTOR :
DRILLING METHOD AND EQUIPMENT USED :
WATER LEVELS :
START :
END :
LOGGER :



1- Ground elevation at well

2- Top of casing elevation

3- Wellhead protection cover type
(a) concrete pad dimensions

4- Dia./type of well casing

5- Type/slot size of screen

6- Type screen filter
a) Quantity used

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
NAVY CLEAN PROGRAM

Groundwater Sampling for Per- and Polyfluoroalkyl Substances (PFAS)

I. Purpose and Scope

This SOP provides guidelines for groundwater sample collection for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with 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.

STANDARD OPERATING PROCEDURE
NAVY CLEAN PROGRAM

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

Civil Surveying

I. Purpose and Scope

The SOP describes survey procedures to be used on CLEAN projects. Modified third-order survey procedures will be used for most surveying. Geographic Positioning System techniques will be used for measurement of some horizontal coordinates. These procedures are general guidelines only and are in no way intended to replace the specifications in the surveyor's subcontract.

II. Records and Definitions

All field notes should be kept in bound books. Each book should have an index. Each page of field notes should be numbered and dated and should show the initials of all crew members. The person taking field notes will be identified in the log. Information on weather (wind speed/wind direction, cloud cover, etc.) and on other site conditions should also be entered in the notes. Notes should also include instrument field identification number and environmental settings. Graphite pencils or waterproof ballpoint pens should be used. Erasing is not acceptable; use a single-strike-through and initial it. The notekeeping format should conform to the *Handbook of Survey Notekeeping* by William Pafford. A survey work drawing with grid lines and at the scale of the topographic map should be prepared for all survey field work. Field notebooks will be available on site.

The following terms are defined to clarify discussion in this SOP:

- North American Datum (NAD) -The standard geodetic datum on the North American continent.
- National Geodetic Vertical Datum (NGVD) - The vertical-control datum used (1929 or later) by the National Geodetic Survey for vertical control.
- Horizontal Control - Horizontal location of an object from surveyed corners or other features on permanent land monuments in the immediate site area. Will be based on North American Datum (NAD) 1983 and state plane grid systems.
- Vertical Control - Vertical location of an object compared to the adjacent ground surface.
- Bench Mark - Precisely determined elevation above or below sea level. May also have horizontal control (northing, easting) determined for location.

III. Surveying

Horizontal Survey

Horizontal angular measurements shall be made with a 20-second or better theodolite or transit. When using a 20-second instrument the horizontal angles shall be turned four times (two each direct and inverted) with the mean of the fourth angle being within 5 seconds of the mean of the second angle. When using a 10-second or better instrument the angles shall be doubled (once each direct and inverted), with the mean of the second angle within 5 seconds of the first angle. The minimum length of any traverse courses shall be 300 feet.

Distance measurements shall be made with a calibrated steel tape corrected for temperature and tension or a calibrated electronic distance meter (EDM). When using an EDM the parts per million (PPM), curvature and refraction corrections shall be made. Vertical angle measurements used for distance slope corrections shall be recorded to the nearest 20 seconds of arc deviation from the horizontal plane. Horizontal locations will be surveyed to within 0.05-foot of the true location.

Horizontal traverse stations shall be established and referenced for future use. All stations shall be described in the field notes with sufficient detail to facilitate their recovery at a later date. The station shall consist of a permanent mark scribed on facilities such as sidewalks, curbs, concrete slabs, or iron rod and cap.

The horizontal location will be referenced to NAD83 and the appropriate state plane grid system.

Some horizontal coordinates will be measured using Geographic Positioning System (GPS) equipment. This approach will be used in particular for determining the coordinates of surface-water and sediment sampling locations, and may be used also for determining the locations of piezometers and monitoring wells. The GPS survey will be performed by staff trained in the use of the equipment and will conform to guidance provided by the manufacturer.

Vertical Survey

When practical, vertical control will be referenced to the National Geodetic Vertical Datum (NGVD) of 1929, obtained from a permanent benchmark. If practical, level circuits should close on a known benchmark other than the starting benchmark. The following criteria shall be met in conducting the survey:

- Instruments shall be pegged weekly or after any time it is dropped or severely jolted.
- Foresight and backsight distances shall be reasonably balanced and shall not be greater than 250 feet in length.
- No side shot shall be used as a beginning or ending point in another level loop.
- Rod readings shall be made to 0.01-foot and estimated to 0.005-foot.

- Elevations shall be adjusted and recorded to 0.01-foot.

Temporary benchmarks (TBMs) shall be established and referenced for future use. All TBMs shall be described in the field notes with sufficient detail to facilitate their recovery at a later date. The TBMs shall consist of a permanent mark scribed on facilities such as sidewalks, curbs, concrete slabs, etc. or spikes set in the base of trees (not power poles), or tops of anchor bolts for transmission line towers, etc. (Horizontal traverse stations will not be considered as a TBM but may be used as a permanent turning point.)

Traverse Computations and Adjustments

Traverses will be closed and adjusted in the following manner:

- Step One—Coordinate closures will be computed using unadjusted bearings and unadjusted field distances.
- Step Two—Coordinate positions will be adjusted (if the traverse closes within the specified limits) using the compass rule.
- Step Three—Final adjusted coordinates will be labeled as "adjusted coordinates." Field coordinates should be specifically identified as such.
- Step Four—The direction and length of the unadjusted error of closure, the ratio of error, and the method of adjustment shall be printed with the final adjusted coordinates.

Level Circuit Computations and Adjustments

Level circuits will be closed and adjusted in the following manner:

- For a single circuit, elevations will be adjusted proportionally, provided the raw closure is within the prescribed limits for the circuit.
- In a level net where the elevation of a point is established by more than one circuit, the method of adjustment should consider the length of each circuit, the closure of each circuit, and the combined effect of all the separate circuit closures on the total net adjustments.

Piezometer and Monitoring-Well Surveys

Piezometer and monitoring-well locations will be surveyed only after the installation of the protective casing, which is set in concrete. The horizontal plane survey accuracy is <u>+0.05-</u>foot and is measured to any point on the protective-casing cover. The vertical plane survey must be accurate to <u>+</u>0.01-foot. The following two elevations will be measured at piezometers and monitoring wells:

- Top of the piezometer or well riser (not on the protective casing), preferably on the north side
- Ground surface, preferably on the north side of the well

If no notch or mark exists, the point at which the elevation was measured on the inner casing shall be described so that water-level measurements may be taken from the same location.

Grid Surveys

Selected soil boring locations may be located by the survey crew after the soil borings are complete. The selected borings will be staked in the field by the field team leader. The stake will be marked with the boring number for reference. The horizontal plane survey accuracy is ± 1 foot and is measured to any point on the ground surface immediately adjacent to the stake.

Exhibit A

STANDARDS FOR MODIFIED THIRD-ORDER PLANE SURVEYS

Traverse

Max Number of bearing courses between azimuth checks	30
Astronomical bearings: standard error of results	6"
Azimuth closure at azimuth checkpoint not to exceed	20" $\sqrt{N}$
Standard error of the mean for length measurements	1 in 50,000
Position closure per loop in feet before azimuth adjustment	1:10,000

Leveling

Levels error of closure per loop in feet	0.05 $\sqrt{M}$

N = the number of stations for carrying bearing
M = the distance in miles

Appendix C

Laboratory DoD ELAP Accreditation Letters

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

VISTA ANALYTICAL LABORATORY
1104 Windfield Way
El Dorado Hills, CA 95762
Bahar Amiri 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
Perfluorononaoic 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

Accredited Laboratory

A2LA has accredited

VISTA ANALYTICAL LABORATORY

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*).

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.