Naval Facilities Engineering Command Northwest
Silverdale, Washington

Final

Sampling and Analysis Plan Phase 2 Site Inspection Ault Field

Naval Air Station Whidbey Island
Oak Harbor, Washington

November 2019

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SAP Worksheet #1—Title and Signature Page

Naval Facilities Engineering Command Northwest
Silverdale, Washington

Final

Sampling and Analysis Plan
Phase 2 Site Inspection
Ault Field

Naval Air Station Whidbey Island
Oak Harbor, Washington

November 2019

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

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

Approval Signatures:

____
TBD
Naval Facilities Engineering Command Atlantic
Quality Assurance Officer

Other Approval Signatures:

____
Kendra Leibman
Naval Facilities Engineering Command Northwest
Remedial Project Manager

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

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Executive Summary

The Department of the Navy (Navy), Naval Facilities Engineering Command (NAVFAC) Northwest has contracted CH2M HILL, Inc. (CH2M) to conduct a Phase 2 Site Inspection (SI) specific to known or suspected releases of per- and polyfluoroalkyl substances (PFAS) to the environment at Naval Air Station (NAS) Whidbey Island, Ault Field, in Oak Harbor, Washington in Island County. This Uniform Federal Policy-Sampling and Analysis Plan/Quality Assurance Project Plan (SAP) describes the inspection activities to be conducted on-Base at Ault Field in Oak Harbor. CH2M prepared this document under the NAVFAC Comprehensive Long-term Environmental Action – Navy 9000 Contract N62470-16-D-9000, Contract Task Order 4041, for submittal to NAVFAC Northwest, NAVFAC Atlantic, and the United States Environmental Protection Agency (USEPA).

Ault Field is one of three NAS Whidbey Island installations. Ault Field was commissioned September 21, 1942. Currently, Ault Field supports Navy tactical electronic attack squadrons flying the EA-18G Growler, the P-3 Orion Maritime Patrol squadrons, and two Fleet Reconnaissance squadrons flying the EP-3E Aries (“Installation Information,” 2017).

Based on the preliminary assessment (PA) (CH2M, 2018d) at Ault Field and desktop review of historical information, the following 35 potential source areas were identified as areas where PFAS may have been stored, used, or released, and require further investigation:

- 1959-1969 Landfill (Area 2)
- 1968-1970 Landfill (Area 3)
- 1976 EA-6 Crash Site
- 1981 P-3A Crash Site
- 1985 EA-6B Crash Site
- 1989 A-6 Crash Site
- 1990 A-6 Crash Site
- 2006 F-18 Crash Site
- Area 6 Landfill
- Current Fire Training Area
- Current Wastewater Treatment Plant
- Fire School Can Disposal Area (Area 30)
- Former 1966 Fire School (Area 27)
- Former Avionics Facility (Building 2547)
- Former Clover Valley Fire School (Area 29)
- Former/Current Fire Station (Building 2897)
- Former Runway Fire School (Area 31)
- Former Sewage Lagoons
- Former Wastewater Treatment Plant (Building 420)
- Gallery Golf Course
- Hangar 1 (Building 112)
- Hangar 5 (Building 386)
- Hangar 6 (Building 410)
- Hangar 7 (Building 2544)
- Hangar 8 (Building 2642)
- Hangar 9 (Building 2681)
- Hangar 10 (Building 2699)
- Hangar 11 (Building 2733)

- Hangar 12 (Building 2737)
- Hangar 14
- Hardstand Area
- Indoor Wash Rack (Building 2903)
- P-3 Wash Rack
- Pesticide Rinsate Disposal Area (Area 14)
- Runway Drainage Ditch System (Area 16)

These 35 areas are located throughout Ault Field (see **Figure 10-3**). Limited PFAS data, collected in 2015 and 2018, exists for eight of the potential source areas:

- 2015
  - Runway Drainage Ditch System (Area 16)
  - Former Runway Fire School (Area 31)
  - Hangar 5
- 2018
  - 1959-1969 Landfill (Area 2)
  - 1968-1970 Landfill (Area 3)
  - Current Fire Training Area
  - Fire School Can Disposal Area (Area 30)
  - Former Clover Valley Fire School (Area 29)

Groundwater sampling was conducted in 2015 in the northern portion of the Base near the runway at the Runway Drainage Ditch System (Area 16), Former Runway Fire School (Area 31), and Hangar 5 (Navy, 2016). Five monitoring wells were sampled in total. Groundwater samples from the Former Runway Fire School (Area 31) and Hangar 5 were collected within the shallow portion of the aquifer at approximately 30 feet below top of casing (btoc). Two wells were sampled at each location. One groundwater sample was collected from an artesian well screened within the deeper portion of the aquifer (approximately 60 feet below ground surface [bgs]) at the Runway Drainage Ditch System (Area 16) (**Figures 10-5 through 10-7**).

Analytical results from samples collected at the Runway Drainage Ditch System (Area 16) were not detected above the method detection limit (4 nanograms per liter [ng/L]) for perfluorooctanoic acid (PFOA) or perflouorooctane sulfonate (PFOS). Results from the Former Runway Fire School (Area 31) are above the USEPA Lifetime Health Advisory concentrations (70 ng/L) for PFOA and PFOS (maximum concentration of 58,500 ng/L for PFOA and 2,377 ng/L for PFOS), while samples collected at Hangar 5 are detected below the USEPA Lifetime Health Advisory for PFOA and PFOS.

Conclusions from the 2016 report suggest that groundwater within the deeper portion of the aquifer (approximately 60 feet bgs) at the central drainage ditch portion of Area 16 has not been impacted by PFAS; however, additional investigation at the Runway Drainage Ditch System (Area 16) was recommended to assess potential PFOA and/or PFOS contamination in shallow groundwater. Additional investigation of the nature and extent of PFAS at the Former Runway Fire School (Area 31) was also recommended (Navy, 2016) but will be conducted in a Remedial Investigation (RI) as a separate, future project; therefore, Area 31 will not be further assessed as part of this SI. While the 2016 report concluded that additional investigation for PFAS in groundwater to the north and northwest of Hangar 5 was not warranted, the well network previously sampled was not sufficient to assess whether a release has occurred at or above the Lifetime Health Advisory concentrations for PFOA and/or PFOS. Based on the conceptual site model, other sampling locations may be more representative; therefore, Hangar 5 is being further assessed as part of this SI.

During early 2018, Phase 1 SI activities were performed which focused on collecting information to support the evaluation of the long-term solutions for two residential parcels (Residences 1 and 2) near (one east and one southwest of) Ault Field where PFAS have been detected in drinking water above the USEPA Lifetime Health Advisory for PFOA and/or PFOS (Navy, 2019). Field activities conducted during the Phase 1 SI were focused on defining potential pathways for PFAS migration between on-Base release areas and the residential parcels. In the eastern portion of the Base (east of the runway near the eastern boundary of the Base between the runway drainage ditches and Residence 1), Phase 1 SI activities included installation of six new on-Base groundwater monitoring wells and one new off-Base potential alternative water supply well. Groundwater samples were collected within the intermediate and deep zones of the aquifer from all but one (dry upon arrival) newly installed wells at depths ranging from 45 to 155 feet btoc (CH2M, 2018a).

In the southwestern portion of the Base, Phase 1 SI activities were conducted near the 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), Current Fire Training Area, the Fire School Can Disposal Area (Area 30), and the Former Clover Valley Fire School (Area 29) and extended toward the southwestern fence line toward Residence 2. Phase 1 SI activities included installation of four new wells (three on-Base groundwater monitoring wells and one off-Base potential alternative water supply well). Fifteen groundwater samples (four from new wells and 11 from existing wells) were collected within the intermediate and deep zones of the aquifer at depths ranging from 56 to 106.75 feet btoc. Six additional groundwater samples were collected from existing monitoring wells downgradient of the Current Fire Training Area and 1959-1969 Landfill (Area 2), within the shallow portion of the aquifer at depths ranging from nine to 16 feet btoc (CH2M, 2018a).

The results of the Phase 1 groundwater investigation in the east portion of Ault Field (discussed in **Worksheet #10** and shown on **Figure 10-10**) identified one well east of the runway near the Base boundary sampled in the intermediate and deep zones of the aquifer with detected concentrations of PFOA and/or PFOS well below the Lifetime Health Advisory; all others in this area were non-detect (Navy, 2019).

The results from the Phase 1 groundwater investigation in the southwestern portion of Ault Field (discussed in **Worksheet #10** and shown on **Figure 10-11**) include wells sampled within the shallow, intermediate, and deep zones of the aquifer. Groundwater samples were collected from six existing wells downgradient of the Current Fire Training Area and 1959-1969 Landfill (Area 2) within the shallow portion of the aquifer. Results from these samples confirmed the presence of PFOA and/or PFOS above the Lifetime Health Advisory in all six wells. Additional groundwater samples were collected from 15 wells (14 existing monitoring wells and one newly installed off-Base potential alternative water supply well) within the intermediate and deep zones of the aquifer. Results confirmed the presence of PFOA and/or PFOS in eight of the 15 wells sampled; four of which are above the Lifetime Health Advisory in monitoring wells downgradient of the 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), and Current Fire Training Area. The remaining seven wells are non-detect (Navy, 2019).

Aquifer testing at Residences 1 and 2 was also completed in 2018 under a SAP Addendum (CH2M, 2018c) following the initial Phase 1 field efforts. The aquifer testing was to determine the feasibility of using the newly installed wells as potential long-term solution alternative water supply wells for those residences. The results of the aquifer testing were evaluated under the Engineering Evaluation/Cost Analysis for Long-term Solutions for Ault Field and Area 6 Landfill Drinking Water (CH2M, 2018c)

As described herein, this Phase 2 SI will focus on: 1) confirming the presence or absence of PFAS in the shallow portion of the aquifer (soil/water table interface) in areas where surface releases are suspected that have not previously been investigated, or where insufficient data exists to confirm or rule out a possible surface release and 2) refining the understanding of the hydrogeologic system at Ault Field. This will include areas identified in the PA as requiring further investigation, as described in **Table 9-1.** PFAS source areas where a release has already been confirmed above the Lifetime Health Advisory will not be addressed under this SI, but rather deferred for further work under a future RI. These areas include the 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), Current Fire Training Area, and the Former Runway Fire School (Area 31). Additionally, it was determined that Area 6 Landfill will not be included with Ault Field investigations and will be addressed under separate cover.

Data collected during the Phase 2 SI will provide the framework for a future RI at the 30 potential source areas that will be investigated under this Phase 2 SI. The objectives of the Phase 2 SI are to:

- Identify the presence or absence of PFAS in the shallow portion of the aquifer at areas where surface releases are suspected that have not previously been investigated, or where the well network previously sampled was not sufficient to assess whether a surface release has occurred at or above the Lifetime Health Advisory concentrations for PFOA and/or PFOS (see **Table 9-1**)
- Identify the groundwater and surface water interaction and potential PFAS migration pathways
- Improve understanding of on-Base groundwater flow directions and potential for migration of PFAS from the potential source areas identified in the PA.

The Phase 2 SI objectives will be accomplished during four inspection stages. Before planning stages presented in this SAP, field efforts outlined in the pre-SAP Approach Plan (**Appendix A**) were conducted where wells downgradient of the PA areas were identified, and a limited water level survey was performed at existing monitoring wells. The results of the Approach Plan efforts were used to aid in the selection of existing monitoring wells and sampling (groundwater, groundwater grab, and soil) locations in Stages 1 through 4. Stages 2 and 3 will be conducted under a first field event and Stages 1 and 4 will be will be conducted under a second field event. Results of the Approach Plan efforts are summarized in **Appendix A**.

The four inspection stages are as follows (requested laboratory analytical data turn-around time [TAT] is standard unless otherwise noted):

Inspection Stage 1: Sampling of Existing Wells

This stage will focus on collecting groundwater samples from existing wells and will be conducted under a second field event.

- Conduct groundwater sampling of five existing monitoring wells in close proximity to three potential source areas (one monitoring well at the Pesticide Rinsate Disposal Area [Area 14], three wells at the Former Wastewater Treatment Plant [Building 420] and one well at the Gallery Golf Course) to assess the presence or absence of PFAS in groundwater.
- Request a 14-day TAT to assess presence/absence of PFAS and allow for determination of monitoring well construction specifications during Stage 4 (Pesticide Rinsate Disposal Area [Area 14] and the Former Waste Water Treatment Plant [Building 420]), if necessary.

Inspection Stage 2: Sampling of Areas Near or Downgradient from Hangars

This stage will focus on areas associated with potential releases or drainage from hangar facilities or other associated potential source areas in the immediate vicinity of the hangars (at or downgradient of the Indoor Wash Rack, Former Avionics Facility, Former/Current Fire Station, Hardstand Area, Hangars 1, 5 through 12, and 14, P3 Washrack, and Stormwater Outfalls 1 and 2 (part of the Runway Drainage Ditch System [Area 16]). This effort will be broken out into 2 steps:

- Step 1 will include sampling of five existing monitoring wells located downgradient of the hangar facilities area (**Figures 11-4** through **11-6**).
- Step 2 will include the installation of nine monitoring wells advanced to approximately 30 feet bgs along the taxiway to the east/northeast of the hangars, lithologic logging, collection of soil samples, and subsequent groundwater sampling of all newly installed monitoring wells (**Figure 11-6**).

- For each monitoring well location, one soil sample will be collected at the soil/water table interface. Depths targeted for analysis will be identified based on boring-specific conditions and will focus on water table interface.

Inspection Stage 3: Installation of Piezometers and Sampling of the Runway Drainage Ditch System (Area 16)

This stage will focus on areas associated with potential releases at or near the Runway Ditch System (Area 16), including the 1981 P-3A Crash Site, 1985 EA-6B Crash Site, 1989 A-6 Crash Site, 1990 A-6 Crash Site, 2006 F-18 Crash Site, Former Avionics Facility, and P3 Washrack. Stage 3 will be broken out into 2 steps and conducted under two field events:

- Step 1 - Installation of 14 soil boreholes advanced to various depths, lithologic logging, collection of soil samples, completion of the 14 boreholes as piezometers, and subsequent groundwater sampling of all newly installed piezometers. (**Figure 11-7**). Step 1 will be conducted under a first field event.
  - The 14 soil borings will be advanced, and one soil sample will be collected from each borehole at the soil/water table interface. Boreholes will then be completed as piezometers in the following manner:
- Seven clusters of dual completion sets (total of 14 piezometers) screened at two intervals (approximately 15 feet bgs and 30 feet bgs).
- Step 2 - Installation of seven stage gauges co-located with the seven sets of dual completion piezometers and deployment of data logging transducers in each piezometer **(Figure 11-7**). Installation of stage gauges and deployment of data logging transducers will be conducted under a second field event.

Inspection Stage 4: Install New Wells at On-Base Areas Where Data Gaps Exist

This stage will focus on on-Base areas where known data gaps currently exist (1976 EA-6 Crash Site, Current Wastewater Treatment Plant, Fire School Can Disposal Area [Area 30], Former 1966 Fire School [Area 27], Former Clover Valley Fire School [Area 29], and the Former Sewage Lagoons) and as informed by Stage 1 (Former Wastewater Treatment Plant [Building 420] and the Pesticide Rinsate Disposal Area [Area 14]) (**Figure 11-8 through 11-11**) and will be conducted under a second field installation event. Stages 2 and 3 will be conducted under a first field event and Stages 1 and 4 will be will be conducted under a second field event. This effort will be broken into 3 steps:

- Step 1 - Installation of 20 boreholes at various locations advanced to approximately 40 feet bgs, lithologic logging, and collection of soil and groundwater grab samples (**Figures 11-8 through 11-11)**.
  - For each boring location, one soil sample will be collected at the water table interface, and grab groundwater samples will be collected from two depths (approximately 15 feet bgs and 40 feet bgs). Depths targeted for analysis will be identified based on boring-specific conditions and will focus on air-water and lithologic interfaces. Groundwater grab samples will be submitted with a 72-hour TAT request.
- Step 2 - Installation and development of up to 20 new monitoring wells based on the presence of PFAS as confirmed by the analytical results of the grab groundwater samples (**Figure 11-12**) and collection of groundwater samples from newly installed monitoring wells.
- Step 3 - Survey of synoptic water level of wells sampled during the Phase 2 SI field effort. Surveying of well details will also be conducted for newly installed wells, piezometers, stage gauges, and existing wells sampled during Stages 1 through 3 which have no survey data available or survey data accuracy is questionable.

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

- Guidance for Quality Assurance Project Plans (USEPA, 2002)
- Uniform Federal Policy for Quality Assurance Project Plans (USEPA, 2005)

- Guidance on Systematic Planning Using the Data Quality Objectives Process (USEPA, 2006)
- Interim PFAS Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update (Navy, 2017a)

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

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

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

SAP Worksheets

Appendixes

Tables

Figures

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Acronyms and Abbreviations

±	plus or minus
%	percent
>	more than
<	less than
≤	less than or equal to
°C	degree Celsius
µg/kg	microgram(s) per kilogram
AM	Activity Manager
AFFF	aqueous film-forming foam
amu	atomic mass unit
AVOC	Airfield Vehicle Operators Course
bgs	below ground surface
btoc	below top of casing
CA	corrective action
CAS	Chemical Abstract Service
CCV	continuing calibration verification
CH2M	CH2M HILL, Inc.
CLEAN	Comprehensive Long-term Environmental Action—Navy
CSM	conceptual site model
DL	detection limit
DoD	Department of Defense
DV	data validator
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
FCR	field change request
FD	field duplicate
FTL	Field Team Leader
GW	groundwater
H&S	health and safety
HDPE	high density polyethylene
HQ	hazard quotient
HSM	Health and Safety Manager
HSP	Health and Safety Plan
ICAL	initial calibration
ICV	initial calibration verification
ID	identification
IDW	investigation-derived waste
ISC	instrument sensitivity check
LC/MS/MS	liquid chromatography – tandem mass spectrometer
LCS	laboratory control sample
LCL	lower confidence limit
LOD	limit of detection

LOQ	limit of quantitation
mg/kg	milligram(s) per kilogram
mL	milliliter(s)
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NEtFOSAA	n-ethylperfluoro-1-octancesulfonamidoacetic acid
ng/L	nanogram(s) per liter
NMeFOSAA	n-methylperfluoro-1-octanesulfonamidoacetic acid
NTR	Navy Technical Representative
PA	preliminary assessment
PAL	project action limit
PC	Project Chemist
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutane sulfonate
PFDA	perfluorodecanoic acid
PFDoA	perfluorododecanoic acid
PFHxA	perfluorohexanoic acid
PFHpA	perfluoroheptanoic acid
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PFTeDA	perfluorotetradecanoic acid
PFTrDA	perfluorotridecanoic acid
PFUnA	perfluoroundecanoic acid
PID	Photoionization Detector
PM	Project Manager
POC	point of contact
PQL	project quantitation limit
PQO	Project Quality Objective
QA	quality assurance
QAO	Quality Assurance Officer
QC	quality control
QM	Quality Manager
QSM	Quality Systems Manual
RI	remedial investigation
RPD	relative percent difference
RPM	Remedial Project Manager
RSL	regional screening level
SAP	Sampling and Analysis Plan
SBO	safe behavior observation

SI	site inspection
SME	Subject Matter Expert
SOP	standard operating procedure
SOR	Safe Observation Report
SPE	Solid Phase Extraction
SSC	Site Safety Coordinator
SSL	soil screening level
STC	Senior Technical Consultant
TAT	turn-around time
TBD	to be determined
TM	Task Manager
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency

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SAP Worksheet #2—Sampling and Analysis Plan Identifying Information

Site Name/Number: Ault Field, Oak Harbor, Naval Air Station (NAS) Whidbey Island

Operable Unit: Not Applicable (N/A)

Contractor Name: CH2M HILL, Inc. (CH2M)

Contract Number: N62470-16-D-9000, Contract Task Order 4041

Contract Title: Comprehensive Long-term Environmental Action – Navy (CLEAN) Program 9000

Work Assignment: Phase 2 Site Inspection (SI) specific to known or suspected releases of per- and polyfluoroalkyl substances (PFAS) to the environment for Naval Facilities Engineering Command (NAVFAC) northwest at Ault Field in Oak Harbor, Washington.

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

Scoping Session	Date
Project Kickoff Call with NAVFAC Northwest RPM	January 10, 2019
Follow Up Project Scoping Session with NAVFAC Northwest RPM	February 26, 2019
Follow Up Project Scoping Session with NAVFAC Northwest RPM	March 8, 2019
Restructure of Activities for Field Events	June 10, 2019
Restructure of Activities for Field Events	June 26, 2019
Restructure of Activities for Field Events	June 28, 2019

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

Document	Date
Sampling and Analysis Plan Investigation of Perfluorinated Compounds in Drinking Water, Ault Field and Outlying Landing Field Coupeville, Naval Air Station Whidbey Island, Oak Harbor and Coupeville, Washington (Navy, 2017b)	August 2017
Sampling and Analysis Plan Addendum Phase 1 Site Investigation for Per- and Polyfluoroalkyl Substances in Soil and Groundwater, Ault Field, Naval Air Station Whidbey Island, Oak Harbor, Washington (CH2M, 2018b)	February 2018

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

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

Organization Partners/Stakeholders	Connection	Date
CH2M	Contractor	2017–present
NAVFAC Atlantic	QAO	2017–present
NAVFAC Northwest – Kendra Leibman	RPM	2017-present
United States Environmental Protection Agency (USEPA) Region 10 – Chan Pongkhamsing	Technical Representative/Base Stakeholder	2018-present
Island County, Washington – Doug Kelly	Technical Representative/Base Stakeholder	2017-present

7. Lead organization: Department of the Navy (Navy) – NAVFAC Northwest
8. If any required SAP elements and required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion as follows:
   - Crosswalk table is excluded because all required information is provided in this SAP.

SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number	Email Address or Mailing Address
Kendra Leibman	RPM/Task Order Contracting Officer's Representative	NAVFAC Northwest	(360) 396-0022	kendra.leibman@navy.mil
Steve Skeehan	Navy Technical Representative (NTR)	NAVFAC Northwest	(253) 279-0212	steve.skeehan@navy.mil
Charlie Escola	NTR	NAVFAC Northwest	(503) 201-5020	charles.escola@navy.mil
TBD	NAVFAC QAO	NAVFAC Atlantic	TBD	TBD
Chan Pongkhamsing	Project Manager (PM)	USEPA Region 10	(206) 553-1806	pongkhamsing.chan@epamail.epa.gov
Doug Kelly	Environmental Health, Hydrogeologist	Island County	(360) 678-7885	d.kelly@co.island.wa.us
Jennifer Madsen	Activity Manager (AM),	CH2M	(425) 233-3293	jennifer.madsen@ch2m.com
Peter Lawson	Senior Technical Consultant (STC)	CH2M	(530) 229-3383	peter.lawson@ch2m.com
Paul Townley	Quality Manager (QM)	CH2M	(425) 233-5302	paul.townley@ch2m.com
Laura Cook	Subject Matter Expert (SME)	CH2M	(757) 671-6214	Laura.cook@ch2m.com
Janice Horton	Project Task Manager (TM)	CH2M	(360) 556-0621	janice.horton@ch2m.com
Janna Staszak	Program SAP Quality Reviewer	CH2M	(757) 671-6256	Janna.staszak@ch2m.com
Anita Dodson	Navy Program Chemist/SAP Reviewer	CH2M	(757) 671-6218	anita.dodson@ch2m.com
Tiffany Hill	Project Chemist (PC)	CH2M	(541) 768-3109	tiffany.hill@ch2m.com
TBD	Data Validator (DV)	CH2M	TBD	TBD
TBD	Field Team Leader (FTL)	CH2M	TBD	TBD
TBD	Site Safety Coordinator (SSC)	CH2M	TBD	TBD
Jonathan Thorn	Laboratory PM	Battelle Analytical Services	(781) 681-5565	thorn@battelle.org

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SAP Worksheet #4—Project Personnel Sign-Off Sheet

Name	Organization/Title/Role	Telephone Number	Signature/Email Receipt	SAP Section Reviewed	Date SAP Read
Jennifer Madsen	CH2M/AM	(425) 233-3293			
Peter Lawson	CH2M/STC	(530) 229-3383			
Paul Townley	CH2M/QM	(425) 233-5302			
Laura Cook	CH2M/SME	(757) 671-6214			
Janna Staszak	CH2M/SAP Reviewer	(757) 671-6526			
Janice Horton	CH2M/TM	(360) 556-0621			
Anita Dodson	CH2M/Navy Program Chemist/SAP Reviewer	(757) 671-6218			
Tiffany Hill	CH2M/PC	(541) 768-3109			
TBD	CH2M/DV	TBD			
Loren Kaehn	CH2M/Health and Safety Manager (HSM)	(208) 383-6212			
TBD	CH2M/FTL	TBD			
TBD	CH2M/SSC	TBD			
Jonathan Thorn	Battelle Analytical Services/Laboratory PM	(781) 681-5565			

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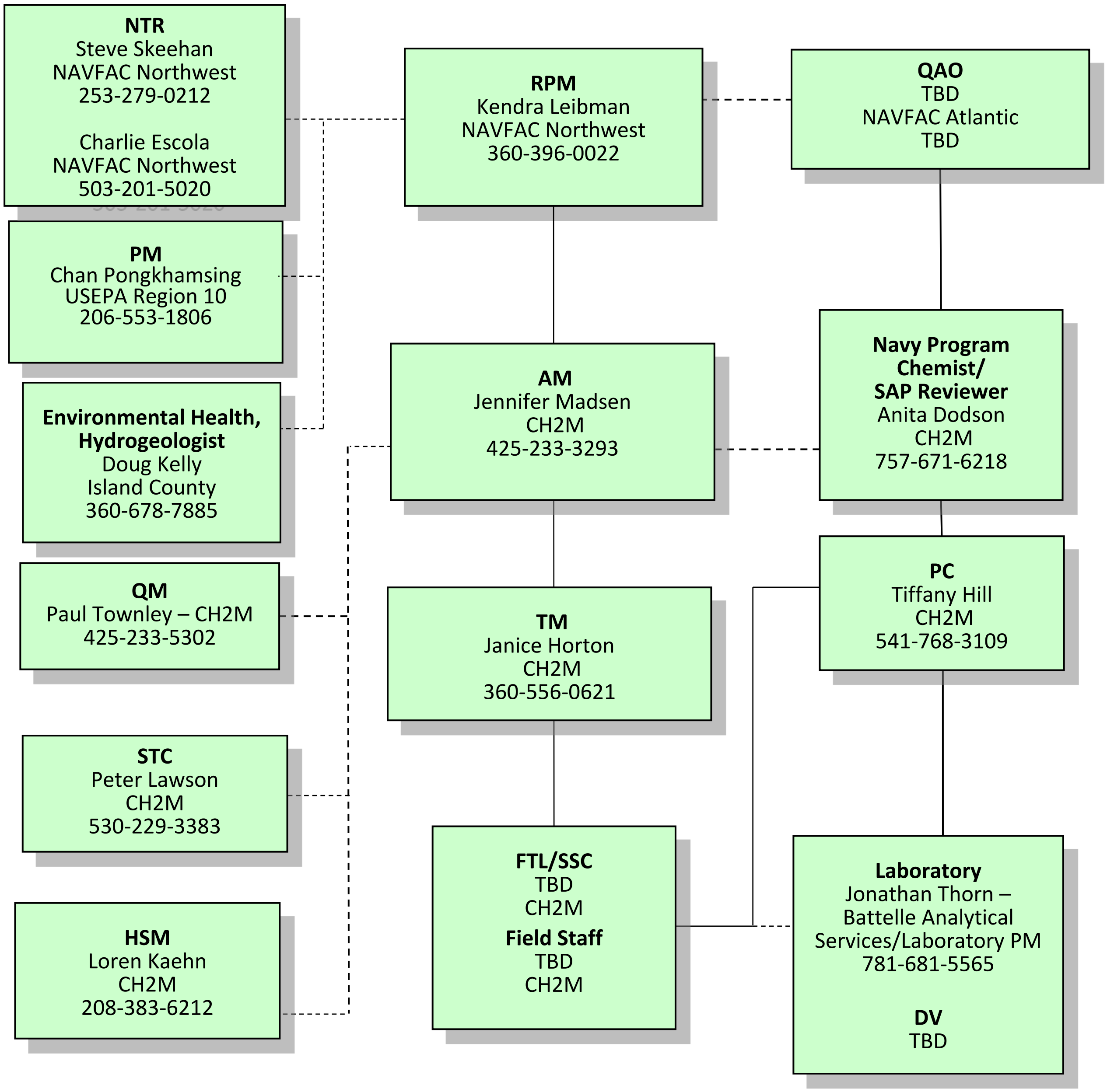
SAP Worksheet #5—Project Organizational Chart



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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure
Communication with Navy (lead agency)	NTR	Steve Skeehan	steve.skeehan@navy.mil (253) 279-0212	Primary point of contact (POC) for the Navy for the contractor during field work; oversees field work, provides base-specific information, provides coordination with NAS Whidbey Island, and can delegate communication to other internal POCs.
Communication with Navy (lead agency)	NTR	Charlie Escola	charles.escola@navy.mil (503) 201-5020	Primary POC for the Navy for the contractor during field work; oversees field work, provides base-specific information, provides coordination with NAS Whidbey Island, and can delegate communication to other internal POCs.
Communication with Navy (lead agency)	RPM	Kendra Leibman	kendra.leibman@navy.mil (360) 396-0022	Primary POC for the Navy; can delegate communication to other internal or external POCs. CH2M AM will notify the NTR and RPM by email or telephone within 24 hours for changes affecting the scope or implementation of the SAP.
Communication regarding overall project status and implementation and primary POC with RPMs and project team	CH2M AM	Jennifer Madsen	jennifer.madsen@ch2m.com (425) 233-3293	Oversees the project and will be informed of project status by the TM. If field changes are necessary, AM will work with the RPM to prepare a field change request (FCR) to be submitted to the NTR and RPM and will communicate in-field changes to the team by email within 24 hours. All data results will be communicated to appropriate team members following data receipt and review.
Technical communications for project implementation, and data interpretation	CH2M STC	Peter Lawson	peter.lawson@ch2m.com (530) 229-3383	Contact STC regarding questions/issues encountered in the field, input on data interpretation, as needed. STC will have 24 hours to respond to technical field questions as necessary. Additionally, STC will review the data as necessary prior to Base and Navy discussions and reporting review.
Quality issues	CH2M QM	Paul Townley	paul.townley@ch2m.com (425) 233-5302	Contact QM regarding quality issues during project implementation. The QM will report to the AM, NTR, and RPM.
Technical communications for project implementation, and data interpretation	CH2M SME	Laura Cook	laura.cook@ch2m.com (757) 671-6214	Contact SME regarding questions/issues encountered in the field, input on data interpretation, as needed. SME will have 24 hours to respond to technical field questions as necessary. Additionally, SME will review the data as necessary prior to Base and Navy discussions and reporting review.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure
Communication regarding items specific to Ault Field tasks and primary POC for field team	CH2M TM	Janice Horton	janice.horton@ch2m.com (360) 556-0621	Oversees the investigation task and will be informed of task status by the FTL. If field changes are necessary, TM will work with the AM to produce and FCR for the NTR and RPM and will communicate in-field changes to the team by email within 24 hours.
Health and safety (H&S)	CH2M HSM	Loren Kaehn	loren.kaehn@ch2m.com (208) 383-6212	Responsible for generation of the Health and Safety Plan (HSP) and approval of the activity hazard analyses prior to the start of fieldwork. The AM will contact the HSM as needed regarding questions/issues encountered in the field.
H&S	CH2M SSC	TBD	TBD	Responsible for the adherence of team members to the site safety requirements described in the HSP. Will report H&S incidents and near losses to the AM as soon as possible.
Stop Work Order	CH2M AM	Jennifer Madsen	jennifer.madsen@ch2m.com (425) 233-3293	Any field member can immediately stop work if an unsafe condition that is immediately threatening to human health is observed. The field staff, FTL, or SSC should notify the NTR, RPM, and the CH2M AM immediately. Ultimately, the FTL and AM can stop work for a period of time. NAVFAC Northwest can stop work at any time.
	CH2M TM	Tiffany Hill	tiffany.hill@ch2m.com (541) 768-3109	
	CH2M FTL/SSC	TBD	TBD	
	CH2M Field Team Members	TBD	TBD	
Work plan changes in field	CH2M FTL	TBD	TBD	Documentation of deviations from the work plan will be made in the field notes, and the AM will be notified immediately. Deviations will be made only with approval from the AM.
Field changes/field progress reports	CH2M FTL	TBD	TBD	Documentation of field activities and work plan deviations (made with the approval of STC and/or QAO) in field notes; provide daily progress reports to AM.
Reporting laboratory data quality issues	Battelle Analytical Services PM	Jonathan Thorn	thornj@battelle.org (781) 681-5565	All quality assurance (QA)/quality control (QC) issues with project field samples will be reported within 2 days to the PC by the laboratory.
Analytical corrective actions (CAs)	PC	Tiffany Hill	tiffany.hill@ch2m.com (541) 768-3109	Any CAs for field and analytical issues will be determined by the FTL and/or the PC and reported to the AM within 4 hours. The AM will ensure SAP requirements are met by field staff for the duration of the project.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure
Data tracking from field collection to database upload Release of analytical data	PC	Tiffany Hill	tiffany.hill@ch2m.com (541) 768-3109	Tracks data from sample collection through database upload daily. No analytical data can be released until validation of the data is completed and has been approved by the PC. The PC will review analytical results within 24 hours of receipt for release to the AM. The PC will inform the Navy CLEAN Program Chemist, who will notify the Navy QAO of any laboratory issues that would prevent the project from meeting project quality objectives or would cause significant delay in the project schedule.
Reporting data quality issues	DV	TBD	TBD	The DV reviews and qualifies analytical data as necessary. The data along with a validation narrative are returned to the PC within 7 calendar days.
Field CAs	AM, TM, and FTL	Jennifer Madsen Janice Horton TBD	Jennifer.madsen@ch2m.com (425) 233-3293 janice.horton@ch2m.com (360) 556-0621 TBD	Field and analytical issues requiring CA will be determined by the FTL and/or TM, AM on an as-needed basis. The AM will ensure SAP requirements are met by field staff for the duration of the project. The FTL will notify the AM via phone of any need for CA within 4 hours. The AM may notify the NTR and RPM of any field issues that would negatively affect schedule or the ability to meet project data quality objectives.

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SAP Worksheet #7—Personnel Responsibilities Table

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

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SAP Worksheet #8—Special Personnel Training Requirements Table

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
Review of operational procedures while traveling in active flight lines and taxiways	Airfield Vehicle Operators Course (AVOC) Training	Lloyd Potter/NAVFAC NW Public Works	TBD	FTL/CH2M	FTL/CH2M	TBD
Outlines communication procedures with flight tower while driving on flight lines and taxiways	Flightline Driver Training	Lloyd Potter/NAVFAC NW Public Works	TBD	FTL/CH2M	FTL/CH2M	TBD

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

Project Name: Ault Field Phase 2 Site Inspection **Projected Date(s) of Sampling:** August – October 2019 **AM:** Jennifer Madsen/CH2M	**Site Name:** Ault Field NAS Whidbey Island **Site Location:** Oak Harbor, Washington

Date of Session: Thursday, January 10, 2019

Scoping Session Purpose: To obtain consensus on overall objectives of the investigation at Ault Field and discuss proposed investigation scope.

Name	Title/Project Role	Affiliation	Phone #	E-mail Address
Kendra Leibman	RPM	NAVFAC Northwest	(360) 396-0022	kendra.leibman@navy.mil
Rebecca Maco	AM[s]	CH2M	(425) 233-3392	rebecca.maco@ch2m.com
Janice Horton	TM	CH2M	(360) 556-0621	janice.horton@ch2m.com
Jennifer Ulrich	Lead SAP Author/ Geologist	CH2M	(907) 792-9633	jennifer.ulrich@ch2m.com
Peter Lawson	STC/Hydrogeologist	CH2M	(530) 229-3383	peter.lawson@ch2m.com
David Butler	Hydrogeologist/ Phase 2 support	CH2M	(425) 233-3137	David.Butler@ch2m.mail.onmicrosoft.com

Notes:

[1] Rebecca Maco was the acting AM at the time of this scoping session.

Comments

The Phase 2 SI objectives and activities are based on the areas identified in the Ault Field Preliminary Assessment (PA) as potential source areas (CH2M, 2018d).

This initial scoping presentation identified five staged activities to be performed based on the findings of the PA, to address the SI objectives as presented below.

Discussion Points and Consensus Decisions

The project field team agreed to the following discussion points during this scooping session:

- SI objectives are to: 1) identify the presence or absence of PFAS in the shallow portion of the aquifer at areas where surface releases are suspected that have not previously been investigated, or where the well network previously sampled was not sufficient to assess whether a surface release has occurred at or above the Lifetime Health Advisory concentrations for perfluorooctanoic acid (PFOA) and/or perfluorooctane sulfonate (PFOS), 2) identify the groundwater and surface water interaction and potential PFAS migration pathways, and 3) Improve understanding of on-Base groundwater flow directions and potential for migration of PFAS from the potential source areas identified in the PA.
- Clarify and refine the scope and schedule to ensure elements of the planned field effort focus on the SI objectives using a five-staged approach to complete the objectives of the Phase 2 SI as follows: (1) Sampling of existing wells, 2) Sampling of Areas downgradient of Hangars, 3) Sampling of Runway Drainage Ditch System, 4) Install wells in areas of known contamination, and 5) Install new wells in areas of potential contamination).

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

- Discuss the focus of the SI and the associated inspection Stages (1 through 5) on areas where data does not exist or is insufficient to confirm presence or absence of PFAS in the shallow portion of the aquifer. It was determined that potential source areas that already have data confirming the presence of PFAS above the Lifetime Health Advisory (such as the Former Runway Fire School [Area 31]) will be moved to a future remedial investigation (RI) for additional inspections.
- The status of Area 6 Landfill and its relationship to the Ault Field Phase 2 SI was discussed. It was determined that, while there is some value for the Ault Field Phase 2 SI to understand the hydrogeology north of Area 6 Landfill, Area 6 Landfill is moving to a future RI (addressed under separate cover) and the hydrogeologic data gathered at that time can be used as needed to refine the Ault Field conceptual site model (CSM).
- The known hydrogeology of Ault Field includes several distinct groundwater flow regimes have been identified, the majority of which converge near the flight line, daylight at the runway drainage ditches, and flow toward Dugualla Bay. The hydrogeology in the extreme southwest portion of the Base is quite complex; shallow groundwater flow follows a northern trend. At depth it shifts to the south/southwest. Additional wells to better understand the hydrogeology in this area will be proposed in either this SI or the RI.
- Additional background data needs for Hangar 5, Areas 2 and 3, and the on-Base Emergency Well (Ault Field Well #1) to help refine the applicable inspection stages associated with these areas.

Action Item

The Project field team agreed to the following action items during this scoping session:

- CH2M will remove the Former Runway Fire School (Area 31) and Area 6 Landfill from the Ault Field Phase 2 SI field effort.
- CH2M will review background data for Hangar 5, Areas 2 and 3, and the on-Base Emergency Well (Ault Field Well #1) to inform further discussions regard the Phase 2 SI inspection stages associated with these areas.
- CH2M will develop Ault Field Phase 2 SI scoping presentation (scheduled for February) to gain consensus on schedule and sampling locations from Ault Field Base facilities. CH2M will provide to the NAVFAC Northwest RPM for review.
- CH2M will present the findings from the Ault Field on-Base well reconnaissance scheduled to coincide with the February Base presentation, during the next scoping session.

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

Project Name: Ault Field Phase 2 Site Inspection **Projected Date(s) of Sampling:** August – October 2019 **AM:** Jennifer Madsen/CH2M			**Site Name:** Ault Field NAS Whidbey Island **Site Location:** Oak Harbor, Washington	
Date of Session: Tuesday, February 26, 2019 **Scoping Session Purpose:** To refine the inspection stages of the investigation at Ault Field and discuss proposed investigation scope.				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
Kendra Leibman	RPM	NAVFAC Northwest	(360) 396-0022	kendra.leibman@navy.mil
Jennifer Madsen	AM	CH2M	(425) 233-3293	jennifer.madsen@ch2m.com
Janice Horton	TM	CH2M	(360) 556-0621	janice.horton@ch2m.com
Jennifer Ulrich	Lead SAP Author/Geologist	CH2M	(907) 792-9633	jennifer.ulrich@ch2m.com
Peter Lawson	STC/Hydrogeologist	CH2M	(530) 229-3383	peter.lawson@ch2m.com
Heather Perry	Hydrogeologist	CH2M	(530) 229-3276	heather.perry@ch2m.com

Comments

The pre-SAP activities discussed during this scoping session will be completed prior to field sampling to further refine the Phase 2 SI approach in the SAP. Location of wells on the ground will help determine where data gaps exist.

Discussion Points and Consensus Decisions

The project field team agreed to the following discussion points during this this scooping session:

- Discuss findings from the February site visit and presentation to the Ault Field Base facilities (that may be impacted by or require coordination with to conduct the field effort). The general schedule and proposed sampling locations were agreed to by all parties during this meeting.
- Discuss findings from the well reconnaissance performed in February. Many of the existing monitoring wells originally planned for inclusion in the Phase 2 SI SAP no longer exist and cannot be located based on the field reconnaissance. To locate and confirm viable monitoring wells to be included in the Phase 2 SI effort, CH2M proposed nonsampling field activities be performed before delivery of the Draft Ault Field Phase 2 SI SAP. These nonsampling activities will be covered under an Approach Plan, which outlines pre-SAP activities as follows: 1) a desktop evaluation (scheduled for February 25, 2019); 2) a limited water level reconnaissance to determine groundwater flow directions at existing well clusters and to identify viable, downgradient wells from potential source areas (scheduled for the week of March 11, 2019); and 3) perform flightline utility locates and reconnaissance of wells in flightline areas.
- Discuss the delivery timeframe (March 7, 2019) for the Approach Plan, which will be included as an Appendix to the Ault Field Phase 2 SI SAP.
- The 1959-1969 and 1968-1970 Landfills (Areas 2 and 3, respectively) and the Current Fire Training Area will be moved to a future RI, based on historical sampling data confirming the presence of PFAS in these areas.
- A master crosswalk will be developed and used to document the status (SI versus RI) of potential source areas identified as requiring further investigation in the PA.

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

Action Items

The Project field team agreed to the following action items during this scoping session:

- CH2M will develop the Approach Plan that outlines pre-SAP activities and provide to the NAVFAC Northwest RPM for review by March 7, 2019, before conducting pre-SAP field work.
- CH2M will remove the 1959-1969 and 1968-1970 Landfills (Areas 2 and 3, respectively) and the Current Fire Training Area from the Phase 2 SI SAP field efforts.

SAP Worksheet #9-3—Project Scoping Session Participants Sheet

<table>
<tr><td colspan="3">Project Name: Ault Field Phase 2 Site Inspection
Projected Date(s) of Sampling: August – October 2019
AM: Jennifer Madsen/CH2M</td><td colspan="2">Site Name: Ault Field NAS Whidbey Island
Site Location: Oak Harbor, Washington</td></tr>
<tr><td colspan="5">Date of Session: Friday, March 8, 2019
Scoping Session Purpose: To refine the inspection stages of the investigation at Ault Field and discuss proposed investigation scope.</td></tr>
<tr><th>Name</th><th>Title/Project Role</th><th>Affiliation</th><th>Phone #</th><th>E-mail Address</th></tr>
<tr><td>Kendra Leibman</td><td>RPM</td><td>NAVFAC Northwest</td><td>(360) 396-0022</td><td>kendra.leibman@navy.mil</td></tr>
<tr><td>Dana Ramquist</td><td>Lead Approach Plan Author</td><td>CH2M</td><td>(425) 233-3449</td><td>dana.ramquist@ch2m.com</td></tr>
<tr><td>Janice Horton</td><td>TM</td><td>CH2M</td><td>(360) 556-0621</td><td>janice.horton@ch2m.com</td></tr>
<tr><td>Jennifer Ulrich</td><td>Lead SAP Author/ Geologist</td><td>CH2M</td><td>(907) 792-9633</td><td>jennifer.ulrich@ch2m.com</td></tr>
<tr><td>Peter Lawson</td><td>STC/Hydrogeologist</td><td>CH2M</td><td>(530) 229-3383</td><td>peter.lawson@ch2m.com</td></tr>
<tr><td>Heather Perry</td><td>STC/Hydrogeologist</td><td>CH2M</td><td>(530) 229-3276</td><td>heather.perry@ch2m.com</td></tr>
</table>

Comments

- The Approach Plan scope and refinement of the SAP.
- Field work is expected to begin in August 2019.

Discussion Points and Consensus Decisions

The Project field team agreed to the following discussion points during this this scooping session:

- Discuss the Approach Plan comments and how deliverables for this document will be handled.
- Confirm the Approach Plan field effort will begin the week of March 12, 2019.
- Combine Inspections Stages 4 and 5 for clarity within the Ault Field Phase 2 SI SAP.
- The 1976 EA-6 Crash Site will be added to the Inspection Stage 4 effort, in addition to CH2M further researching historical data for the site.

Action Items

The Project field team agreed to the following action items during this scoping session:

- Approach plan comments will be provided via email by the NAVFAC Northwest RPM to CH2M. CH2M will respond to comments with the redlined document only.
- CH2M will revise the Ault Field Phase 2 SI SAP to present Inspection Stages 1 through 4 versus Stages 1 through 5.
- CH2M will revise the Ault Field Phase 2 SI SAP to include the 1976 EA-6 Crash Site to the Inspection Stage for CH2M will further review historical data for the 1976 EA-6 Crash Site.
- CH2M will update the master crosswalk to document the status of all potential source areas (**Table 9-1**).

SAP Worksheet #9-3—Project Scoping Session Participants Sheet (continued)

Table 9-1. Potential Source Areas[a] Master Crosswalk

Category	Location Name	2019 Planned action	Rationale for Further Inspection
AQUEOUS FILM-FORMING FOAM (AFFF) SPRAY TEST AREAS	Indoor Wash Rack (Building 2903)	Inspection Stage 2, Inspection Stage 3	Personnel reported that annual AFFF refractometer spray testing of fire truck hoses and nozzles may have been performed at this location in the past and that AFFF from refractometer spray testing would have been washed into floor trench drains connected to the sanitary sewer system and the Current Wastewater Treatment Plant. AFFF may have flowed out of the wash rack and into stormwater catchments on the runway apron.
EMERGENCY RESPONSE	1976 EA-6 Crash site	Inspection Stage 4	Based on the date of the aircraft crash, AFFF would likely have been used to put out any petroleum fires resulting from the impact. Despite the absence of documented usage or witness accounts, the use of AFFF at this location cannot be ruled out.
	1981 P-3A Crash site	Inspection Stage 3	Based on the date of the aircraft crash, AFFF would likely have been used to put out any petroleum fires resulting from the impact. Despite the absence of documented usage or witness accounts, the use of AFFF at this location cannot be ruled out.
	1985 EA-6B Crash site	Inspection Stage 3	An unknown amount of AFFF was used in the crash response, and likely flowed into adjacent runway drainage ditches and infiltrated the subsurface in surrounding grass-covered areas.
	1989 A-6 Crash site	Inspection Stage 3	Based on the date of the aircraft crash, AFFF would likely have been used to put out any petroleum fires resulting from the impact. Despite the absence of documented usage or witness accounts, the use of AFFF at this location cannot be ruled out.
	1990 A-6 Crash site	Inspection Stage 3	Based on the date of the aircraft crash, AFFF would likely have been used to put out any petroleum fires resulting from the impact. Despite the absence of documented usage or witness accounts, the use of AFFF at this location cannot be ruled out.
	2006 F-18 Crash site	Inspection Stage 3	Personnel reported the use of AFFF during emergency response, the amount of which was unknown. AFFF was also reportedly contained on a paved section of runway using spill containment equipment; however, it is possible that some AFFF flowed into adjacent runway drainage ditches and/or infiltrated the subsurface in surrounding grass-covered areas.

SAP Worksheet #9-3—Project Scoping Session Participants Sheet (continued)

Table 9-1. Potential Source Areas[a] Master Crosswalk

Category	Location Name	2019 Planned action	Rationale for Further Inspection
FIRE STATIONS	Former/Current Fire Station (Building 2897)	Inspection Stage 2	Fire trucks observed at the current fire station are equipped with approximately 130-gallon AFFF tanks. Personnel reported occasional leaks and spills of AFFF from fire trucks during refilling activities, as well as the testing of AFFF refractometer spray nozzles on the runway apron east of the fire station at least one time.
FIRE TRAINING AREAS	Former Clover Valley Fire School (Area 29)	Inspection Stage 4	Due to the time frame of operation, AFFF could have been used in firefighting training activities. Additionally, limited groundwater sampling conducted within the intermediate and deep zone of the aquifer was performed in this area during the 2018 Phase 1 SI work. Analytical results from that event were non-detect for PFOA and/or PFAS. However, no samples were collected within the shallow portion of the aquifer; therefore, further sampling is needed to confirm the presence or absence of PFAS within the shallow portion of the aquifer at this potential PFAS source area.
	Former 1966 Fire School (Area 27)	Inspection Stage 4	Due to the time frame of operation, AFFF could have been used in firefighting training activities.
	Former Runway Fire School (Area 31)	Future RI	Personnel confirmed the use of AFFF during weekly fire training activities at the Former Runway Fire School (Area 31). During training, fuel, water, and extinguishing agent (including AFFF) sprayed on the concrete-lined burn pad was directed through an onsite oil/water separator and discharged into adjacent drainage ditch which eventually flows into the Clover Valley Stream. An unknown amount of AFFF was used at this location during the years of operation. Groundwater data collected at the Former Runway Fire School (Area 31) during a limited groundwater investigation in 2015 confirmed the presence of PFOA and PFOS above the Lifetime Health Advisory (Navy, 2016).
	Current Fire Training Area	Future RI	Personnel confirmed the accidental release of small amounts of AFFF during fire training activities post-1999. There is no record of procedures followed during fire training activities from 1982 to 1999; however, the use of AFFF at this location can be assumed based on standard firefighting practices during the 1980s and 1990s. An unknown amount of AFFF was used at this location during the years of operation. Groundwater data collected at the Current Fire Training Area during the Ault Field Phase 1 SI confirmed the presence of PFOA and PFOS above the Lifetime Health Advisory (Navy, 2019).
HANGARS/BUILDINGS	Hangar 1 (Building 112)	Inspection Stage 2	Four hand-held AFFF/water hose systems are located in the four corners of Hangar 1 containing approximately 20 gallons of 3 percent AFFF concentrate. AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known. Due to discrepancies in as-builts and geospatial data, the specific discharge location for the Hangar 1 trench drains is not entirely known.

SAP Worksheet #9-3—Project Scoping Session Participants Sheet (continued)

Table 9-1. Potential Source Areas[a] Master Crosswalk

Category	Location Name	2019 Planned action	Rationale for Further Inspection
	Hangar 5 (Building 386)	Inspection Stage 2	Hangar 5 has an AFFF fire suppression system equipped with a 2,000-gallon polymer storage tank containing 3 percent AFFF concentrate by volume and the hangar floor trench drains are currently connected to two 20,000-gallon steel above containment tanks. It is not known whether the floor drains have always been connected to containment tanks. AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known. Additionally, limited groundwater sampling was conducted in 2015 in the northern portion of the Base near the runway at Hangar 5 (Navy, 2016). Two wells were sampled from within the shallow portion of the aquifer. Samples collected at Hangar 5 are detected below the USEPA Lifetime Health Advisory for PFOA and PFOS. While the 2016 report concluded that additional investigation for PFAS in groundwater to the north and northwest of Hangar 5 was not warranted, the well network previously sampled was not sufficient to assess whether a release has occurred at or above the Lifetime Health Advisory concentrations for PFOA and/or PFOS. Based on the CSM, other sampling locations may be more representative; therefore, additional sampling is needed to assess the presence or absence of PFAS downgradient of Hangar 5.
	Hangar 6 (Building 410)	Inspection Stage 2	Hangar 6 has an AFFF fire suppression system constructed in 2017 that is equipped with two 2,000-gallon polymer tanks (half-full) of the C6 formulation of foam, which contains PFOA. The previous fire suppression system was equipped with the old PFAS-based AFFF formulation and was reportedly transported and disposed of off-Base by the fire suppression system contractor. The current fire suppression system has a containment system in place that will divert the hangar trench drains to the containment tanks, although, prior to the current system, hangar trench drains were connected to the stormwater system. AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known. Additionally, PFAS was found in a stormwater drain near Hangar 6 (Navy et al., 2018c).
	Hangar 7 (Building 2544)	Inspection Stage 2	Hangar 7 has an AFFF fire suppression system equipped with a 1,000-gallon polymer storage tank containing 3 percent AFFF concentrate by volume. Personnel reported an accidental triggering of the AFFF fire suppression system in September 2016, resulting in the release of approximately 750 gallons of AFFF, which flowed into floor trench drains within the hangar. AFFF and water washed into the floor drains was directed to a 30,000-gallon concrete underground vault that reportedly contained overflow piping to the stormwater system which discharged to Stormwater Outfall 2. Following the discharge event, approximately 35,000 gallons of water and AFFF were reportedly pumped via pump truck and delivered to the Former Wastewater Treatment Plant (Building

SAP Worksheet #9-3—Project Scoping Session Participants Sheet (continued)

Table 9-1. Potential Source Areas[a] Master Crosswalk

Category	Location Name	2019 Planned action	Rationale for Further Inspection
			420). Personnel reported the containment tank had a crack in it, which allowed groundwater to flow into the tank creating a direct migration pathway to groundwater for approximately 1 week before an additional 30,000 gallons of AFFF and water was pumped to the Former Wastewater Treatment Plant and the vault was able to be repaired. Additionally, AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known.
	Hangar 8 (Building 2642)	Inspection Stage 2	Hangar 8 has an AFFF fire suppression system equipped with four 500-gallon, two 1,000-gallon, and two 1,200-gallon steel bladder tanks containing 3 percent AFFF concentrate by volume. There is no AFFF containment system in place, and hangar floor drains are connected directly to stormwater system which discharges at Stormwater Outfall 1. AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known.
	Hangar 9 (Building 2681)	Inspection Stage 2	Hangar 9 has an AFFF fire suppression system equipped with four 300-gallon and two 500-gallon steel bladder tanks containing 3 percent AFFF concentrate by volume. There is no AFFF containment system in place, and hangar floor drains are connected directly to stormwater system which discharges at Stormwater Outfall 2. Any AFFF not captured by hangar floor drains could have run off to nearby grass-covered areas. AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known.
	Hangar 10 (Building 2699)	Inspection Stage 2	Hangar 10 has an AFFF fire suppression system constructed in 2017 that is equipped with a 750-gallon polymer tanks of the C6 formulation of foam, which contains PFOA. The previous fire suppression system was equipped with the old PFAS-based AFFF formulation, which was reportedly transported and disposed of off-Base by the fire suppression system contractor. The current fire suppression system has a containment system in place directing the trench drains to exterior containment tanks, although it is not known whether the previous system also had containment tanks. Any AFFF not captured by hangar floor drains could have run off to nearby grass-covered areas. AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known.

SAP Worksheet #9-3—Project Scoping Session Participants Sheet (continued)

Table 9-1. Potential Source Areas[a] Master Crosswalk

Category	Location Name	2019 Planned action	Rationale for Further Inspection
	Hangar 11 (Building 2733)	Inspection Stage 2	Hangar 11 has an AFFF fire suppression system equipped with four 300-gallon and two 500-gallon steel bladder tanks containing 3 percent AFFF concentrate by volume. Reportedly, approximately 3 gallons of AFFF was accidentally released during 2014-2015 and entered the hangar floor drains which are connected to the sanitary sewer system and Current Wastewater Treatment Plant through an oil/water separator. Any AFFF not captured by hangar floor drains could have run off to nearby grass-covered areas. AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known.
	Hangar 12 (Building 2737)	Inspection Stage 2	Hangar 12 has an AFFF fire suppression system equipped with four 500-gallon steel bladder tanks containing 3 percent AFFF concentrate by volume. There is no AFFF containment system in place, and hangar floor drains are connected directly to stormwater system which discharges at Stormwater Outfall 1. Any AFFF not captured by hangar floor drains could have run off to nearby grass-covered areas. AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known.
	Hangar 14	Inspection Stage 2	Hangar 14 has an AFFF fire suppression system constructed in 2017 that is equipped with the C6 formulation of foam, which contains PFOA. The hangar floor trench drains are currently connected to an underground containment tank and any AFFF not captured by hangar floor drains could have run off to nearby grass-covered areas. AFFF systems in the hangars were reportedly tested annually; however, specific procedures followed during these events, including the use of AFFF during annual testing, are not known.
LANDFILLS	Area 6 Landfill	Future RI	Due to the timeframe of operation, PFAS-contaminated material could potentially have been disposed of at the former Area 6 Landfill and former industrial waste disposal area. Potentially contaminated biosolids from the Current Wastewater Treatment Plant have been brought to the composting facility and applied over a grass-covered area east of the wood chipping facility. Previous sampling conducted at Area 6 Landfill has confirmed the presence of PFAS above the Lifetime Health Advisory (Navy et al., 2018a and 2018b).
	1959-1969 Landfill (Area 2)	Future RI	Due to the time frame of operation, PFAS-contaminated material could potentially have been disposed of at the landfill. Groundwater data collected at the 1959-1969 Landfill (Area 2) during the Ault Field Phase 1 SI confirmed the presence of PFOA and PFOS above the Lifetime Health Advisory (Navy, 2019).
	1968-1970 Landfill (Area 3)	Future RI	Due to the time frame of operation, PFAS-contaminated material could potentially have been disposed of at the landfill. Groundwater data collected at the 1968-1970 Landfill (Area 3) during the Ault Field Phase 1 SI confirmed the presence of PFOA and PFOS above the Lifetime Health Advisory (Navy, 2019).

SAP Worksheet #9-3—Project Scoping Session Participants Sheet (continued)

Table 9-1. Potential Source Areas[a] Master Crosswalk

Category	Location Name	2019 Planned action	Rationale for Further Inspection
OTHER	P3 Wash Rack	Inspection Stage 2; Inspection Stage 3	Personnel reported that AFFF-contaminated materials from aircraft crash response activities would have been brought to a wash rack, and the P3 Wash Rack was reported as the wash rack that would most likely have been used. Any AFFF washed from planes or firefighting vehicles would have been washed into trench drains connected to the either the stormwater system or sanitary sewer system.
	Pesticide Rinsate Disposal Area (Area 14)	Inspection Stage 1; Inspection Stage 4	There are no records indicating that AFFF has ever being stored at Building 2555 or the Pesticide Rinsate Disposal Area; however, it is known that PFAS are used in several types of pesticides. During the PA, little information was uncovered about procedures and activities involving pesticides usage, both currently and historically; however, previous investigations have reported that pesticides were released directly to surface and subsurface soil at this location.
	Fire School Can Disposal Area (Area 30)	Inspection Stage 4	Approximately 150 cans of badly deteriorated horse blood-based firefighting foaming agent were found at this location, which indicates that AFFF may have also been disposed at the Fire School Can Disposal Area. Based on the deterioration of the cans, the Navy estimated that the disposal occurred sometime in the 1970s during the time when AFFF was being used by the Navy.
	Hardstand Area	Inspection Stage 3	Personnel reported that fire crash trucks stationed at the Hardstand Area during refueling could have leaked AFFF onto the ground surface, which would have flowed off the pavement into the surrounding grass-covered areas.
	Gallery Golf Course	Inspection Stage 1	Personnel reported that biosolids and sludge from the Current Wastewater Treatment Plant could have been transported to golf course for use as fill. Any PFAS remaining in biosolids could have been reintroduced into the environment at the golf course.
	Runway Drainage Ditch System (Area 16)	Inspection Stage 3	Any AFFF released in hangars without containment systems, aircraft emergency response, or wash racks would have eventually discharged into either the Strait of Juan de Fuca or the Runway Drainage Ditch System.
	Former Avionics Facility (Building 2547)	Inspection Stage 2; Inspection Stage 3	Personnel confirmed that chrome plating (known to involve PFAS-containing solutions) operations were performed at the Former Avionics Facility. Other than the knowledge that chrome plating took place at this location, little information was known about the use, storage, and disposal of PFAS-containing solutions; therefore, the release of PFAS into the environment at this location cannot be ruled out.

SAP Worksheet #9-3—Project Scoping Session Participants Sheet (continued)

Table 9-1. Potential Source Areas[a] Master Crosswalk

Category	Location Name	2019 Planned action	Rationale for Further Inspection
WASTEWATER TREATMENT PLANTS	Former Wastewater Treatment Plant (Building 420)	Inspection Stage 1; Inspection Stage 4	Approximately 65,000 gallons of AFFF and water is currently stored in two clarifier tanks at the Former Wastewater Treatment Plant. No visual signs of a release were noted during this visual sight investigation however, leakage from the clarifier tanks presents the potential for PFAS to be released into the environment. Clarifier tanks are reportedly equipped with overflow piping that discharges directly into the Strait of Juan de Fuca, although discharge from the tanks has reportedly not occurred during the time span in which the tanks have contained AFFF.
	Former Sewage Lagoons	Inspection Stage 4	Personnel reported AFFF refractometer spray testing at the Former Sewage Lagoons post 2005 of which an unknown amount of AFFF was used. Any AFFF released before 1996 in Hangar 11 would have been directed to the Former Wastewater Treatment Plant and potentially transported to the Former Sewage Lagoons through contaminated solid waste.
	Current Wastewater Treatment Plant	Inspection Stage 4	AFFF released at the Indoor Wash Rack and Hangar 11 would have been directed to the Current Wastewater Treatment Plant. Current treatment processes do not effectively remove PFAS; therefore, PFAS has likely been discharged as wastewater through the Current Wastewater Treatment Plant outfall into the Strait of Juan de Fuca. PFAS could have also been transported through solid waste as biosolids to the composting facility at Area 6 Landfill.

Notes:

[a] Potential Source Areas (formerly Potential PFAS Release Areas) identified in the Final Ault Field PA (CH2M, 2018d) - 35 Potential Source Areas were identified in the Final Ault Field PA. Five of these Potential Source Areas are being deferred to a future RI due to the confirmed presence of PFAS above the Lifetime Health Advisory. The remaining 30 Potential Source Areas will be addressed under the Ault Field Phase 2 SI.

Potential source area to be addressed under future RI.

Approach Plan - Preliminary SAP field work to refine includes: desktop evaluation, water level survey, ground truth wells, and conduct utility locates. Field efforts do not include sampling. Actions completed: Week of March 11, 2019 and April 15, 2019

Inspection Stage 1 - Sampling of existing wells

Inspection Stage 2 - Sampling of Areas Near or Downgradient from Hangars

Inspections Stage 3 - Installation of Piezometers and Sampling of the Runway Drainage Ditch System (Area 16)

Inspection Stage 4 - Install New Wells at On-Base Areas Where Data Gaps Exist

SAP Worksheet #9-4—Project Scoping Session Participants Sheet

<table>
<tr><td colspan="3">Project Name: Ault Field Phase 2 Site Inspection
Projected Date(s) of Sampling: August – October 2019
AM: Jennifer Madsen/CH2M</td><td colspan="2">Site Name: Ault Field NAS Whidbey Island
Site Location: Oak Harbor, Washington</td></tr>
<tr><td colspan="5">Date of Session: Monday, June 10, 2019
Scoping Session Purpose: Reduce the activities to be performed under inspection Stages 2 and 3 of the investigation at Ault Field.</td></tr>
<tr><th>Name</th><th>Title/Project Role</th><th>Affiliation</th><th>Phone #</th><th>E-mail Address</th></tr>
<tr><td>Kendra Leibman</td><td>RPM</td><td>NAVFAC Northwest</td><td>(360) 396-0022</td><td>kendra.leibman@navy.mil</td></tr>
<tr><td>Jennifer Madsen</td><td>AM</td><td>CH2M</td><td>(425) 233-3293</td><td>jennifer.madsen@ch2m.com</td></tr>
<tr><td>Janice Horton</td><td>TM</td><td>CH2M</td><td>(360) 556-0621</td><td>janice.horton@ch2m.com</td></tr>
<tr><td>Heather Perry</td><td>STC/Hydrogeologist</td><td>CH2M</td><td>(530) 229-3276</td><td>heather.perry@ch2m.com</td></tr>
</table>

Comments

This scoping session identified the need to reduce the number of borehole installation locations under Stage 2, piezometer installation locations under Stage 3, and removal of surface water and sediment sampling under Stage 3, because of budget constraints.

Discussion Points and Consensus Decisions

The Project field team agreed to the following discussion points during this scoping session:

- Prioritization of sample locations is preferred; however, presence or absence of PFAS needs to be confirmed at places that may not be as high priority. Therefore Stage 1 and Stage 4 activities will not be removed from the SAP.
- Under Stage 2, the groundwater flow directions and understanding of presence or absence of PFAS is key. To retain Stage 2 activities and reduce cost, the borehole spacing will be increased to reduce the number of boreholes along the taxiway.
- Under Stage 3, surface water and sediment sampling will be removed. This type of sampling will aid in understanding the surface water and groundwater interaction that can be addressed under a future RI. In addition, the number of nested piezometer installation locations will be reduced, retaining only those along flight line drainage ditches, and one location at the flight line intersection. The retained piezometer installation locations previously proposed as triple completion clusters will be reduced to dual completion clusters. The deeper, triple completion cluster may be addressed under a future RI.

Action Items

The Project field team agreed to the following action items during this scoping session:

- The NAVFAC Northwest RPM will send CH2M a reduced list of Stage 2 and Stage 3 locations.
- CH2M will revise the Preliminary Draft SAP per the reduced scope.

SAP Worksheet #9-5—Project Scoping Session Participants Sheet

Project Name: Ault Field Phase 2 Site Inspection **Projected Date(s) of Sampling:** August – October 2019 **AM:** Jennifer Madsen/CH2M			**Site Name:** Ault Field NAS Whidbey Island **Site Location:** Oak Harbor, Washington	
Date of Session: Wednesday, June 26, 2019 **Scoping Session Purpose:** To discuss the activities to be performed under inspection Stages 2 and 3 considering current budget constraints.				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
Kendra Leibman	RPM	NAVFAC Northwest	(360) 396-0022	kendra.leibman@navy.mil
Jennifer Madsen	AM	CH2M	(425) 233-3293	jennifer.madsen@ch2m.com
Janice Horton	TM	CH2M	(360) 556-0621	janice.horton@ch2m.com

Comments

This scoping session identified options to further reduce Phase 2 SI activities because of budget constraints.

Discussion Points and Consensus Decisions

The Project field team agreed to the following discussion points during this scoping session:

- Two field events will be needed to complete all Stages.
- The initial focus of the Phase 2 SI activities will be on the apron and airfield (Stage 2 and Stage 3). Stage 1 and Stage 4 are expected to occur during a second field event.
- Under Stage 3, stage gauge installation and transducer deployment will not be performed during the initial field event and are expected to occur during a second field event along with Stages 1 and 4. Stages 2 and 3 will be conducted under a first field event and Stages 1 and 4 will be will be conducted under a second field event.

Action Items

The Project field team agreed to the following action item during this scoping session:

- CH2M will review remaining budgets available to perform only Stage 2 and Stage 3 in 2019, including removing stage gauge installations and transducer deployments from the first field event.

SAP Worksheet #9-6—Project Scoping Session Participants Sheet

Project Name: Ault Field Phase 2 Site Inspection **Projected Date(s) of Sampling:** August – October 2019 **AM:** Jennifer Madsen/CH2M			**Site Name:** Ault Field NAS Whidbey Island **Site Location:** Oak Harbor, Washington	
Date of Session: Friday, June 28, 2019 **Scoping Session Purpose:** To reduce the activities to be performed under inspection Stage 2 during the first field event of the investigation at Ault Field.				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
Kendra Leibman	RPM	NAVFAC Northwest	(360) 396-0022	kendra.leibman@navy.mil
Jennifer Madsen	AM	CH2M	(425) 233-3293	jennifer.madsen@ch2m.com
Janice Horton	TM	CH2M	(360) 556-0621	janice.horton@ch2m.com

Comments

This scoping session identified the need to reduce the work to be performed under Stage 2 because of budget constraints.

Discussion Points and Consensus Decisions

The Project field team agreed to the following discussion points during this this scooping session:

- Stages 2 and 3 would be performed under an initial field event in Fall 2019.
- Under Stage 2, boreholes with groundwater grab sampling will be removed, and replaced with installation of nine monitoring wells along the taxiway. One soil sample will be collected at the soil/water table interface during drilling with no groundwater grab samples to be collected during drilling. Standard TAT will be used for analysis of all samples collected under Stage 2.
- Stages 1 and 4 will be retained in the SAP. Stages 2 and 3 will be conducted under a first field event and Stages 1 and 4 will be will be conducted under a second field event.

Action Items

The Project field team agreed to the following action item during this scoping session:

- CH2M will revise the Preliminary Draft SAP per the reduced scope.

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SAP Worksheet #10—Conceptual Site Model

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

Table 10-1. Site Description and Background
NAS Whidbey Island, Oak Harbor, Washington

Site Name	Ault Field, NAS Whidbey Island, Oak Harbor, Washington (**Figures 10-1 and 10-2**)
Study Area Description	Ault Field is located on Whidbey Island near Oak Harbor, Washington, and is one of three NAS Whidbey Island installations. Ault Field was commissioned September 21, 1942, as part of NAS Whidbey Island. The areas to be investigated are located within the shallow portion of the aquifer throughout Ault Field, in close proximity to potential source areas with suspected source releases identified in the PA as requiring further investigation, or where the well network previously sampled was not sufficient to assess whether a surface release has occurred at or above the Lifetime Health Advisory concentrations for PFOA and/or PFOS.
Potential Sources	Based on findings in the PA, there are 35 potential source areas with suspected surface releases at Ault Field requiring further investigation: 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), 1976 EA-6 Crash Site, 1981 P-3A Crash Site, 1985 EA-6B Crash Site, 1989 A-6 Crash Site, 1990 A-6 Crash Site, 2006 F-18 Crash Site, Area 6 Landfill, Current Fire Training Area, Current Wastewater Treatment Plant, Fire School Can Disposal Area (Area 30), Former 1966 Fire School (Area 27), Former Avionics Facility (Building 2547), Former Clover Valley Fire School (Area 29), Former/Current Fire Station (Building 2897), Former Runway Fire School (Area 31), Former Sewage Lagoons, Former Wastewater Treatment Plant (Building 420), Gallery Golf Course, Hangar 1 (Building 112), Hangar 5 (Building 386), Hangar 6 (Building 410), Hangar 7 (Building 2544), Hangar 8 (Building 2642), Hangar 9 (Building 2681), Hangar 10 (Building 2699), Hangar 11 (Building 2733), Hangar 12 (Building 2737), Hangar 14, Hardstand Area, Indoor Wash Rack (Building 2903), P-3 Wash Rack, Pesticide Rinsate Disposal Area (Area 14), and the Runway Drainage Ditch System (Area 16) (**Figure 10-3**). Note that potential source areas that have previously been investigated and at which the presence of PFAS has been confirmed within the shallow portion of the aquifer or where PFAS has been detected above the Lifetime Health Advisory in the intermediate and deep aquifer zones will not be addressed under this SI, but rather deferred for further work under a future RI. These areas include the 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), the Current Fire Training Area, and the Former Runway Fire School (Area 31). Additionally, it was determined that Area 6 Landfill will not be included with Ault Field investigations and will be addressed under separate cover (**Figure 10-3**).
Study Area Investigation History	A voluntary off-Base drinking water sampling program was conducted November 2016 to April 2019 in four phases. Off-Base drinking water wells were sampled to assess impacts to private drinking water wells. Two parcels (referred to as Residence 1 and Residence 2) exceeded the project action limits (PALs) (**Figure 10-4**). On-Base groundwater investigation at Ault Field for PFAS is limited. In 2015, three areas where AFFF may have been stored, handled, or released at Ault Field (Hangar 5, the Runway Drainage Ditch System [Area 16] and Former Runway Fire School [Area 31]) were investigated within the shallow portion of the aquifer (Navy, 2016). Sample results from the two groundwater wells sampled in the Runway Drainage Ditch System (Area 16) south of where the runways intersect indicated no presence of PFOS or PFOA above the method detection limit. Results from the two groundwater wells sampled near Hangar 5 indicated detectable traces of PFOS (maximum concentration of 35 nanograms per liter [ng/L]) and PFOA (maximum concentration of 7 ng/L), and results from the two groundwater wells sampled at the Former Runway Fire School (Area 31) (located within proximity of, and drains to the runway drainage system) indicated the presence of PFOS (maximum concentration of 2,370 ng/L) and PFOA (maximum concentration of 58,500 ng/L) above the EPA Lifetime Health Advisory (Navy, 2016) (**Figures 10-5 through 10-7)**. The Phase 1 SI was conducted in early 2018. This effort focused on collecting information to support the evaluation of the long-term solutions for two residential parcels (Residences 1 and 2) near Ault Field where PFOA and/or PFOS have been detected in drinking water above the Lifetime Health Advisory. Field activities conducted during the Phase 1 SI were focused on areas between suspected PFAS release areas and the residential parcels. In the east portion of the Base, Phase 1 SI activities were conducted east of the runway near the eastern boundary of the Base between the runway drainage ditches and Residence 1 (**Figure 10-8**) within the intermediate and deep zones of the aquifer. In the southwest portion of the Base, Phase 1 SI activities were conducted near the 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), Current Fire Training Area, the Former Clover Valley Fire School (Area 29), and the Fire School Can Disposal Area (Area 30) and extended toward the southwestern fence line toward Residence 2 (**Figure 10-9**) within the shallow, intermediate, and deep zones of the aquifer.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site Description and Background
NAS Whidbey Island, Oak Harbor, Washington

<table>
<tr><td></td><td colspan="2">The Phase 1 SI groundwater investigation in the eastern portion of Ault Field identified one on-Base well east of the runway near the Base boundary with detected concentrations of PFOA and/or PFOS well below the Lifetime Health Advisory; all other on-Base wells in this area were non-detect (Navy, 2019) (Figure 10-10).

The Phase 1 groundwater investigation in the southwestern portion of Ault Field confirmed the presence of PFOA and/or PFOS in eight of the 14 wells sampled in the intermediate and deep zones of the aquifer; four of which are above the Lifetime Health Advisory (Figure 10-11). The concentrations of PFAS in the remaining seven wells are non-detect (Navy, 2019). The sampled wells are in close proximity to the following PSAs:
• 1959-1969 Landfill (Area 2)
• 1968-1970 Landfill (Area 3)
• Current Firefighting School
• Former Clover Valley Fire School (Area 29)
• The Fire School Can Disposal Area (Area 30)

Phase 1 groundwater results from the six existing wells within the shallow portion of the aquifer in close proximity to the Current Fire Training Area and 1959-1969 Landfill (Area 2) confirmed the presence of PFOA and/or PFOS in all wells sampled; all of which are above the Lifetime Health Advisory (Figure 10-11).

The presence of PFAS in groundwater within the shallow portion of the aquifer has been confirmed at the 1959-1969 Landfill (Area 2), Area 6 Landfill, the Current Fire Training Area, and the Former Runway Fire School (Area 31).

The presence of PFAS in groundwater above the Lifetime Health Advisory within the intermediate and deep zones of the aquifer has been confirmed at the 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), Area 6 Landfill, the Current Fire Training Area, and the Former Runway Fire School (Area 31).

The presence of PFAS in surface soil (0 to 1 foot below ground surface [bgs]) has been confirmed (0.163 nanogram per gram) at one location (SB606-0001) near the eastern boundary of the Base between the runway drainage ditches and Residence 1. The presence of PFAS in surface soil at other areas on-Base is unknown.</td></tr>
<tr><td>Current Use</td><td colspan="2">The area surrounding Ault Field is a low-density residential area. Potable water is primarily supplied by private or community drinking water wells or the City of Oak Harbor. Currently, Ault Field supports Navy tactical electronic attack squadrons flying the EA-18G Growler, the P-3 Orion Maritime Patrol squadrons, and two Fleet Reconnaissance squadrons flying the EP-3E Aries (“Installation Information,” 2017).</td></tr>
<tr><td rowspan="2">Site Conditions</td><td>Physical Characteristics</td><td>Whidbey Island, including the entire proposed sampling area, lies within the Puget Lowland, a topographic and structural depression between the Olympic Mountains and the Cascade Range.</td></tr>
<tr><td>Geology and Hydrogeology</td><td>The surface soil in the vicinity of Ault Field primarily consists of artificial fill, post-glacial deposits, glaciomarine drift, and glacial deposits. Artificial fill, consisting of coarse- or fine-grained material, underlies the runway areas. Post-glacial deposits, consisting of peaty sand and silt, are generally found in the low-lying marshy areas (Navy, 1994).

Central Portion of Ault Field Adjacent to Runway: Ault Field is located in a valley, with elevated areas to the south, northeast, and east of the field. In the northeast portion of the facility, near the Former Runway Fire School (Area 31) it is inferred that groundwater flows to the southwest, toward the runway area. Across the remainder of the Base, east of the runway, groundwater generally flows to the northeast, and east toward Clover Valley Stream, Clover Valley Lagoon, and Dugualla Bay. West of the runway, there is likely a component of flow to the west toward the Strait of Juan de Fuca. The 1994 RI Report (Navy, 1994) identified a confined aquifer beneath the Runway Drainage Ditch System (Area 16) at a depth of approximately 20 to greater than 150 feet bgs and consisting of fine to medium sand with some silt. Clay and silt of the Everson glaciomarine drift forms the overlying confining layer. A single, unconfined aquifer was identified beneath the Former Runway Fire School (Area 31), interpreted to be the same as that encountered in the Runway Drainage Ditch System (Area 16) (specific site locations area shown on Figure 10-3), but without the glaciomarine drift that confines the aquifer (presumed to pinch out).</td></tr>
</table>

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site Description and Background
NAS Whidbey Island, Oak Harbor, Washington

		Southwest Portion of Ault Field: In the vicinity of the Current Fire Training Area, substantial thicknesses of alluvial material have been observed. Data collected during investigation activities in that area have identified several aquifer units with varying hydraulic gradients and flow directions in each unit (Navy, 2019). The spatial extent of this multi-aquifer system is unclear at this time.
Contaminants of Potential Concern		18 PFAS compounds, see **Worksheet #15** for complete list of compounds.
Nature and Extent		PFAS are known to be present in two locations in off-Base drinking water wells (Residences 1 and 2). The concentration of PFOS exceeded the Lifetime Health Advisory in a groundwater sample collected from a water supply well located off-Base in the south (Residence 2) and the concentration of PFOA exceeded the Lifetime Health Advisory in a groundwater sample collected from a water supply well located off-Base in the east (Residence 1) during the 2016-2017 voluntary sampling program (**Figure 10-4**). The source of PFAS contamination to the off-Base drinking water wells and the extent (vertical and lateral) of PFAS impacts is not currently known. **Figure 10-4** shows a summary of the sample results from Phases 1, 2, 3, and 4 of the voluntary off-Base drinking water sampling. In 2015, three areas where AFFF may have been stored, handled, or released at Ault Field were investigated within the shallow portion of the aquifer, including Hangar 5, and the Runway Drainage Ditch System (Area 16), and the Former Runway Fire School (Area 31) (Navy, 2016). The groundwater well sampled in Runway Drainage Ditch System (Area 16) south of where the runways intersect did not contain PFOS or PFOA (**Figures 10-5 through 10-7**). The two groundwater wells sampled near Hangar 5 contained detectable traces of PFOS and PFOA. However, due to limited data in this area, and because the distribution of groundwater and potential PFAS migration from Hangar 5 is not well understood, additional collection of surrounding groundwater and soil sampling data are needed to refine the CSM in this area and confirm the presence or absence of PFAS. The two groundwater wells sampled at the Former Runway Fire School (Area 31) contained PFOS and PFOA above the EPA Lifetime Health Advisory. The Phase 1 groundwater investigation conducted in 2018 focused on collecting information to support the evaluation of the long-term solutions for two residential parcels (Residences 1 and 2) near Ault Field where PFAS have been detected in drinking water above the USEPA Lifetime Health Advisory for PFOA and/or PFOS (Navy, 2019). On-Base monitoring wells installed and sampled in the eastern portion of the Base (near Residence 1), along with one newly installed off-Base well were screened within the intermediate and deep zones of the aquifer. Results from those samples confirmed the presence of PFOA and/or PFOS in one on-Base monitoring well near the eastern boundary; all others were non-detect (**Figure 10-10**). The results from the Phase 1 groundwater investigation in the southwest portion of Ault field downgradient of the 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), Current Fire Training Area, Former Clover Valley Fire School (Area 29), and the Fire School Can Disposal Area (Area 30), confirmed the presence of PFOA and/or PFOS in eight of the 14 wells sampled in the intermediate and deep zones of the aquifer; four of which are above the Lifetime Health Advisory. The remaining seven wells are non-detect (Navy, 2019). Phase 1 groundwater results from the six existing wells downgradient of the Current Fire Training Area and 1959-1969 Landfill (Area 2) within the shallow portion of the aquifer confirmed the presence of PFOA and/or PFOS in all wells; five of which are above the Lifetime Health Advisory (**Figure 10-11**).
Migration Pathways		• Leaching of PFAS in soil currently and/or historically present to groundwater • Transport via advection with groundwater flow • Potential discharge of contaminated groundwater to surface water features and sediment • Potential releases to surface and/or subsurface soil

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site Description and Background
NAS Whidbey Island, Oak Harbor, Washington

Potential Receptors/ Exposure Routes	• Groundwater: current users of drinking water (ingestion) • Soil: direct contact with soil during excavation and/or subsurface work • Surface water: ecological receptors, such as migratory birds (direct contact)
Data Needs	Soil, and groundwater sampling data are necessary to evaluate whether surface releases of PFAS-containing substances have occurred, and which media have been impacted at 30 on-Base potential source areas identified in the preliminary assessment. These areas do not include the 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), Current Fire Training Area, and the Former Runway Fire School (Area 31), which will be deferred for further work under a future RI.

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

Problem Definition, Environmental Questions, and Project Quality Objectives

As discussed in **Worksheet #10**, investigations at Ault Field began in 2015 and have continued through the present. The PA identified 35 potential source areas with suspected surface releases on-Base that warranted further investigation. Previous groundwater investigations have identified the presence of PFOS and/or PFOA in groundwater at concentrations exceeding the Lifetime Health Advisory in on-Base monitoring wells within the intermediate and deep zones of the aquifer at five previously investigated potential source areas; 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), Area 6 Landfill, the Current Fire Training Area, and the Former Runway Fire School (Area 31). Additionally, previous groundwater data confirmed the presence of PFAS within the shallow portion of the aquifer above the Lifetime Health Advisory at 1959-1969 Landfill (Area 2), the Current Fire Training Area, and the Former Runway Fire School (Area 31). As described in **Worksheet #9-1**, during the initial Phase 2 SI scoping meeting it was determined that the Former Runway Fire School (Area 31) and Area 6 Landfill would not be included in the current investigation at Ault Field; both would move to RI; however, Area 6 Landfill would be addressed under its own separate cover. Additionally, during the February 26, 2019 scoping session (**Worksheet # 9-4**), it was determined that the 1959-1969 Landfill (Area 2), 1968-1970 Landfill (Area 3), and the Current Fire Training Area would be moved to a future RI. A Phase 2 SI, focusing on the 30 remaining potential source areas with suspected surface releases, is needed to further assess the distribution and source areas of PFAS and potential PFAS transport pathways and to provide the framework/data for a potential future RI. The objectives, environmental questions, general investigation approaches, and Project Quality Objectives (PQOs) contained in this SAP are described in **Table 11-1** and are based on the USEPA *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006) and its seven-step process. The detailed sampling approach, including numbers of samples and a full list of analytes, is provided in **Worksheet #17**. Planned sample locations are shown on **Figures 11-1 through 11-11**.

What are the Project Action Limits?

The following list summarizes the PALs applicable to soil and groundwater samples at Ault Field.

- USEPA Lifetime Health Advisory for PFOA and PFOS in groundwater: 70 ng/L, unless both chemicals are detected, then 70 ng/L is the Lifetime Health Advisory for the cumulative concentration of the two chemicals. Since there is no Washington State or USEPA action limit for groundwater, this SI will use the tap water regional screening level (RSL) from USEPA's online calculator, based on a target hazard quotient (HQ) of 0.1 (PFOA = 40 ng/L, PFOS = 40 ng/L, and perfluorobutane sulfonate [PFBS] = 40,000 ng/L) for groundwater screening levels.
- USEPA RSL for PFBS in soil (residential soil RSL): 130 milligrams per kilogram (mg/kg) (based on a HQ = 0.1)
- USEPA RSL for PFOS and PFOA in soil: 0.13 mg/kg and 0.13 mg/kg (based on a HQ = 0.1) derived from the USEPA online RSL calculator for direct contact (residential exposure)[1]
- Protection of Groundwater Soil Screening Level (SSL) PAL for PFBS in soils: 13 microgram per kilogram (µg/kg)
- Protection of Groundwater SSL PALs for PFOS and PFOA in soils: 0.0378 µg/kg and 0.0172 µg/kg, derived from USEPA online RSL calculator for soil leaching to groundwater[1]

[1] https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search
Although the computation of soil screening level values for PFAS compounds do not include some chemical-specific transport properties of the constituents, these values represent generalized screening criteria for evaluation of the presence of PFAS vadose zone source areas. The soil screening level values are not intended for use in remedial action or risk assessment decision-making.

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

- PALs for PFOS, PFOA, and PFBS in soils: 0.0378 µg/kg, 0.0172 µg/kg, and 130 µg/kg derived from USEPA online RSL calculator for soil leaching to groundwater.

The laboratory limit of quantitation (LOQ) is listed as the Project Screening Level to demonstrate that the laboratory limits are sensitive enough to monitor the presence of the analytes.

PALs currently do not exist for the remaining 15 PFAS compounds for soil or groundwater. At the time of drafting this SAP, there are no USEPA RSLs or any state regulatory screening levels available. According to Navy policy, all samples will be analyzed for PFAS by liquid chromatography – tandem mass spectrometer (LC-MS/MS) compliant with DoD Quality Systems Manual (QSM) 5.1.1 Table B-15 or the most recent version of the DoD QSM for which the laboratory is Department of Defense (DoD Environmental Laboratory Accreditation Program (ELAP)-certified at the time of sampling.

For What Will the Data be Used?

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

What types of data are needed?

The types of data needed include:

- Subsurface lithology from soil borings and monitoring well installations to improve understanding of the distribution of stratigraphic units across the Base along with identification of the main water bearing units at the site. These data will be utilized to improve the overall Ault Field CSM.
- Groundwater quality data from depth-discrete groundwater grab samples to inform monitoring well construction specifications and to improve the understanding of PFAS migration in groundwater.
- Groundwater sample data from existing and newly installed monitoring wells and piezometers to improve the understanding of PFAS migration in groundwater, and to inform Stage 4 monitoring well construction specifications.
- Soil sample data from potential source areas to confirm the presence or absence of PFAS in the vadose zone and shallow groundwater.

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

- Field measurements of groundwater and surface water quality (pH, dissolved oxygen, temperature, conductivity, oxidation-reduction potential, and turbidity) during sampling of the monitoring well network (existing and new), piezometer sampling, and during surface water sampling. These data will improve understanding of the physical and geochemical properties of the groundwater and surface water across the base.
- Synoptic groundwater level surveys from existing on-Base monitoring wells, newly installed monitoring wells, newly installed piezometers, and stage gauges to improve understanding of groundwater flow directions within the aquifer system and the magnitude and nature of surface water/groundwater interaction between the runway ditches and the underlying aquifer.
- Installation of dual completion piezometers, with data logging pressure transducers to better understand the seasonality and magnitude of the surface water/groundwater interaction along the Runway Drainage Ditch System (Area 16).

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

Samples to be collected and analyzed to meet the project objectives are described in **Table 17-1** through **17-4**. The well installation methodology and sampling are included in **Worksheet #14**. Justification for individual sample and transducer locations is provided in **Worksheets #17** and **#18**. The specific target analytes and PALs are included in **Worksheet #15**.

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

Offsite laboratory analytical data will be of the quantity and quality necessary to provide technically sound and defensible assessments with respect to the aforementioned project objectives. Additionally, laboratory-specific Limits of Detection (LODs) will be less than the lifetime health advisory level for PFOA and PFOS of 70 ng/L (for the sum of the two constituents). QC sample requirements are detailed in **Worksheet #20**. For action decisions, the laboratory will follow the Measurement Performance Criteria (MPC) in **Worksheets #24** and **#28** for laboratory QC samples. These MPC are consistent with the DoD QSM (DoD, 2017) as applicable and laboratory in-house limits where the DoD QSM does not apply.

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

Field activities will be conducted in accordance with **Worksheets #14, #17, and #18**, and the project schedule outlined in **Worksheet #16**. The data will be collected following the standard operating procedures (SOPs) presented in **Worksheet #21**.

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

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

Objectives	Environmental Question	General Investigation Approach	PQOs
Identify the presence or absence of PFAS within the shallow portion of the aquifer at areas that have not previously been evaluated, or where the well network previously sampled was not sufficient to assess whether a surface release has occurred at or above the PALs (see **Table 9-1**).	Were there releases of PFAS-containing compounds to the environment from the 30 on-Base potential source areas with suspected surface releases identified in the PA as requiring further investigation?	The Phase 2 SI field activities will be accomplished using a four-staged approach as follows: ***Stage 1*** will focus on sampling of five existing wells located downgradient of three on-Base potential source areas (one monitoring well at the Pesticide Rinsate Disposal Area [Area 14], three monitoring wells at the Former Wastewater Treatment Plant [Building 420] and one well at the Gallery Golf Course) (**Figures 11-1 through 11-3**). Stage 1 will be conducted under a second field sampling event. Stages 2 and 3 will be conducted under a first field event and Stages 1 and 4 will be will be conducted under a second field event Groundwater samples will be submitted to Battelle Analytical Services for analysis of all 18 analytes listed in USEPA Method 537.1 with a 14-day TAT. ***Stage 2*** will focus on areas associated with potential releases or drainage from hangar facilities or other associated potential source areas in the immediate vicinity of the hangars (at or downgradient of the Indoor Wash Rack, Hangars 1, 5 through 12, and 14, and Stormwater Outfalls 1 and 2 (part of the Runway Drainage Ditch System [Area 16]). Stage 2 will be conducted under a first field event. This effort will be broken out into 2 steps: • Step 1 will include sampling of five existing monitoring wells located downgradient of the hangar facilities area (**Figures 11-4 and 11-5**). • Step 2 will include the installation of nine new monitoring wells (WI-AF-MW-616 through WI-AF-624) advanced to approximately 30 feet bgs along the taxiway to the east/northeast of the hangars, lithologic logging, collection of one soil sample at the soil/water table interface, and subsequent groundwater sampling of newly installed monitoring wells (**Figure 11-6**). – For each boring location, one soil sample will be collected at the soil/water table interface, Depths targeted for analysis will be identified based on boring-specific conditions and will focus on air-water and lithologic interfaces.. All samples collected during Stage 2 will be submitted to Battelle Analytical Services for analysis of all 18 analytes listed in USEPA Method 537.1 with a standard TAT. • ***Stage 3*** will focus on the Runway Drainage Ditch System (Area 16). Stage 3 will be conducted under two field events. Stage 3 will be broken out into 2 steps: • Step 1 will include installation of 14 soil boreholes (WI-AF-WT01 through WI-AF-WT14) advanced to various depths, lithologic logging, collection of soil samples, completion of the 14 boreholes as piezometers (locations PZ-01 through PZ-14) and subsequent groundwater sampling of all newly installed piezometers (**Figure 11-7**). Step 1 will be conducted under a first field event. – The 14 soil borings will be advanced, and one soil sample will be collected from each borehole at the soil/water table interface (WI-AF-WT01 through WI-AF-WT14). Boreholes will then be completed as piezometers in the following manner: ▪ Seven clusters of dual completion sets (total of 14 piezometers) screened at two intervals (approximately 15 feet bgs and 30 feet bgs) • Step 2 will include the installation of seven stage gauges co-located with the seven sets of dual completion piezometers (**Figure 11-7**). Step 2 will be conducted under a second field event. All samples collected during Stage 3 will be submitted to Battelle Analytical Services for analysis of all 18 analytes listed in USEPA Method 537.1 with a standard TAT. ***Stage 4*** will focus on on-Base areas where known data gaps currently exist (1976 EA-6 Crash Site, Current Wastewater Treatment Plant, Fire School Can Disposal Area [Area 30], Former 1966 Fire School [Area 27], Former Clover Valley Fire School [Area 29], and the Former Sewage Lagoons) and as informed by Stage 1 (Former Wastewater Treatment Plant [Building 420] and the Pesticide Rinsate Disposal Area [Area 14]) (**Figure 11-8 through 11-11**) Stage 4 will be conducted under a second field event. This effort will be broken into 3 steps:	**Stages 1, 2, 3, and 4 -** If PFOA, PFOS, or PFBS are detected in soil or groundwater at concentrations exceeding the PALs, then the area of exceedance will be considered either a PFAS vadose zone source area or an area of downgradient contamination associated with an upgradient source area, depending on the details and location of the exceedance. Further investigation of these areas will be conducted in a follow-on RI to delineate the nature and extent of PFAS contamination. **Stages 1, 2, 3, and 4 -** If PFOA, PFOS, or PFBS concentrations are not-detected or are less than the respective PALs at a particular boring or well installation location, the associated potential PFAS release area or investigation area may be considered in future RI activities. **Stages 1, 2, 3, and 4 -** Analytical data from depth-discrete groundwater grab and groundwater monitoring well samples will be used to refine the CSM with respect to the distribution of PFAS in groundwater at the on-Base potential source areas and in areas downgradient of potential release locations during future RI activities. **Stage 4 -** If PFOA, PFOS, or PFBS are detected in groundwater grab samples during Stage 4 of the SI, then a monitoring well will be installed, and groundwater samples will be collected to further assess the impact of PFAS in groundwater at that location during the SI (**Figure 11-12**). If PFOA, PFOS, or PFBS are not detected in groundwater grab samples, then no monitoring well will be installed.

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

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

Objectives	Environmental Question	General Investigation Approach	PQOs
		• Step 1 will include installation of 20 boreholes (WI-AF-BH01 through WI-AF-BH20) at various locations advanced to approximately 40 feet bgs, lithologic logging, and collection of soil and groundwater grab samples (**Figures 11-8 through 11-11)**. – For each boring location, one soil sample will be collected at the water table interface and grab groundwater samples will be collected from two depths (approximately 15 feet bgs and 40 feet bgs). Depths targeted for analysis will be identified based on boring-specific conditions and will focus on air-water and lithologic interfaces. Soil and groundwater grab samples will be submitted to Battelle Analytical Services for analysis of 18 PFAS analytes listed in USEPA Method 537.1. Soil samples will be requested with a standard TAT; groundwater grab samples will be requested with a 72-hour TAT. • Step 2 will include the installation and development of up to 20 new monitoring wells based on the presence of PFAS as confirmed by the analytical results of the grab groundwater samples (**Figure 11-12**) and collection of groundwater samples from newly installed monitoring wells. Groundwater samples collected from newly installed monitoring wells will be submitted to Battelle Analytical Services for analysis of all 18 analytes listed in USEPA Method 537.1 with a standard TAT. • Step 3 will include a synoptic water level survey of wells sampled during the Phase 2 SI field effort. Surveying in well details will also be conducted for newly installed wells, piezometers, stage gauges, and existing wells sampled during Stages 1 and 2 which have no survey data available or where existing survey data accuracy is questionable.	
Identify the groundwater and surface water interaction to determine potential PFAS migration pathways.	What is the nature and magnitude of the interaction between the groundwater and surface water systems in the vicinity of the Runway Drainage Ditch System (Area 16)? How do these conditions change seasonally?	The approach to refining the understanding of the interaction between the groundwater and surface water systems includes drilling and installing dual-completion piezometer clusters and installing associated stage gauges in the Runway Drainage Ditch System (Area 16). Synoptic groundwater level data will be collected to calculate the vertical gradients present at each piezometer cluster to determine whether the runway ditch at each location is losing surface water to the underlying aquifer or gaining water from shallow groundwater discharge into the surface water system. These data will also be used to generate revised potentiometric surface maps of the area. Fourteen (14) new piezometers will be installed at various locations under a first field installation event. Fourteen new piezometers will be installed as dual completion sets: one screened at the water table (approximately 15 feet bgs), and the other screened at approximately 30 feet bgs at each location. Lithologic logging will be performed during piezometer installation. Seven co-located stage gauges will be installed to correlate stage gauge readings with observed groundwater elevations and data logging transducers will be installed at each piezometer and stage gauge location to provide sufficient data to perform this correlation and to evaluate the effects of seasonality on groundwater/surface water interaction under a second field installation event. The objectives of Stage 3 (soil and groundwater grab sampling, and groundwater sampling of new piezometers) are outlined in the preceding Objective.	In areas where groundwater levels measured in piezometers show an upward hydraulic gradient (groundwater levels are higher than the associated stage data measured in the drainage ditches) it will be concluded that in those areas groundwater is actively discharging to surface water. In areas where groundwater levels measured in piezometers show a downward hydraulic gradient, and groundwater levels are lower than the associated stage data measured in the drainage ditches, it will be concluded that in those areas surface water is actively recharging groundwater. Data collected from the data logging pressure transducers on a quarterly basis will be used to refine the site CSM with respect to the seasonality of groundwater/surface water interaction.
Improve understanding of on-Base groundwater flow directions and potential for migration of PFAS from the potential source areas identified in the PA.	What are the groundwater flow and potential PFAS migration directions at the 30 potential source areas?	The approach to refining the understanding of groundwater flow directions at/near the 30 potential source areas will be to install new groundwater monitoring wells and piezometers and collect synoptic groundwater level data to refine the site CSM. At the completion of the groundwater monitoring well installation, synoptic groundwater level data will be collected from the following sources: • Nine new groundwater monitoring wells that will be drilled and installed on-Base and downgradient of the hangars to east/northeast of the taxiway (see **Figure 11-6**). • Up to 20 new groundwater monitoring wells that will be drilled and installed at on-Base areas where data gaps exist (**Figures 11-8 through 11-11**). • 14 new piezometers that will be drilled and installed at various locations along the Runway Drainage Ditch System (**Figures 11-7**). In addition, stage gauge readings will be recorded at the seven new stage gauge locations placed at various locations along the Runway Drainage Ditch System (**Figure 11-7**). The data will be used to update the overall CSM for the site.	Synoptic groundwater elevation data from wells in close proximity to potential source areas will be used to update the CSM for groundwater flow and PFAS transport directions.

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

Matrix: Groundwater
Analytical Group: PFAS

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

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

Matrix: Soil

Analytical Group: PFAS

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

SAP Worksheet #13—Secondary Data Criteria and Limitations Table

Secondary Data	Data Source (originating organization, report title and date)	Data Generator(s) (originating organization, data types, data generation/ collection dates)	How Data Will Be Used	Limitations on Data Use
Groundwater elevation and analytical data and geology data from monitoring within Ault Field.	Navy. 2019. *Technical Memorandum, Evaluation of Per- and Polyfluoroalkyl Substances in Groundwater, Ault Field,* Naval *Air Station Whidbey Island, Oak Harbor, Washington.* March.	Navy. Groundwater and geology. January to March 2018.	Data will be used to assist the placement of soil borings and vertical profiling locations included in this inspection.	None
Details regarding potential source areas of PFAS on-Base at Ault Field.	CH2M. 2018d. *Preliminary Assessment for Per- and Polyfluoroalkyl Substances (PFAS), Ault Field,* Naval Air Station Whidbey Island Oak Harbor and Coupeville, Washington. November.	CH2M. Geology, historical information through 2018.	Data will be used to assist the placement of soil borings and vertical profiling locations included in this inspection.	None
Groundwater sources	Navy. 2016. *Summary Report, Groundwater Sampling for Perfluorinated Compounds, Hangar 5 and Areas 16 and 31, Naval Air Station Whidbey Island, Oak Harbor, Washington* April 14.	Analytical results for PFAS in onsite groundwater monitoring wells	Identify groundwater sources	None

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SAP Worksheet #14—Summary of Project Tasks

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

Premobilization Tasks

- National Historic Preservation Act Section 106 Consultation with the State Historic Preservation Officer and/or the Advisory Council on Historic Preservation to identify possible conflicts between historic preservation objectives and the proposed activities in the clearance area shown on **Figures 11-6** through **11-11**.
- Subcontractor procurement
  - Analytical laboratories
  - DV
  - Utility locator
  - Driller
  - Vegetation Clearing
  - Investigation-derived waste (IDW) transportation and disposal contractor
- Fieldwork scheduling
- Approach Plan well reconnaissance
- AVOC Training (limited to two CH2M field personnel and one drilling subcontractor personnel)
- Flightline Driver Training (limited to two CH2M field personnel and one drilling subcontractor personnel)
- Coordination with NAS Whidbey Island for site access and IDW staging at Ault Field

Mobilization

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

Utility Locating

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

Soil Borings

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

Soil borings will be installed during Inspection Stages 2, 3, and 4 as follows:

- Inspection Stage 2, Step 1: Nine soil borings will be advanced downgradient of the hangars to a maximum depth of 30 feet bgs.
- Inspection Stage 3, Step 1: 14 soil borings will be advanced along the Runway Drainage Ditch System for piezometer well installation to a maximum depth of 30 feet bgs. One soil sample will be collected from each soil boring.

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

- Inspection Stage 4, Step 1: Up to 20 soil borings will be advanced at areas where data gaps exist (as determined in the PA or during Stage 1 of the Phase 2 SI) to a maximum depth of 40 feet bgs. One soil sample and two groundwater grab samples will be collected from each soil boring. Groundwater grab samples will be submitted for a 72-hour TAT; analytical results will determine the number and location of monitoring wells installed and the well construction specifications.

Monitoring Well/Piezometer Installation and Development

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

Monitoring wells/piezometers will be installed and developed during Inspection Stages 2, 3, and 4 as follows:

- Inspection Stage 2, Step 2: Nine new on-Base monitoring wells will be installed downgradient from the hangars (along the taxiway).
- Inspection Stage 3, Step 1: 14 piezometers will be installed and developed along the Runway Drainage Ditch System. The piezometers will be installed in clusters of seven dual-completion sets (a total of 14 piezometers). This installation will occur concurrently with the Stage 3 soil boring advancement.
- Inspection Stage 4, Step 2: Up to 20 new on-Base monitoring wells will be installed at areas where data gaps exist (as determined in the PA or during Stage 1 of the Phase 2 SI), based on the results of the Stage 4, Step 1 72-hour TAT groundwater grab sampling results.

Stage Gauge Installation

All stage gauges will be installed in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix B**.

Seven stage gauges will be installed as part of Inspection Stage 3 along the Runway Drainage Ditch System.

Soil Logging

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

Surveying

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

Sampling Tasks

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

- Soil Sampling
  - Soil sampling will be completed in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix B**. All soil samples will be sent to Battelle Analytical Serves for PFAS analysis with a standard TAT. Soil borings will be installed during the Phase 2 SI Inspection Stages 2, 3, and 4 as follows:
    - Inspection Stage 2, Step 1: Nine soil samples will be collected from areas downgradient of the hangars at the soil/ water table interface of each soil boring.
    - Inspection Stage 3: 14 soil samples will be collected from the Runway Drainage Ditch System at the soil/ water table interface of each soil boring.

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

    - Inspection Stage 4, Step 1: Up to 20 soil samples will be collected from areas where data gaps exist (as determined in the PA or during Stage 1 of the Phase 2 SI) at the soil/ water table interface of each soil boring.

- Groundwater Grab Sampling
  - Depth-discrete groundwater grab sampling will be completed as part of the Phase 2 SI field investigation in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix B**. All groundwater grab samples will be sent to Battelle Analytical Serves for PFAS analysis with a 72-hour TAT. Groundwater grab samples will be collected during the Phase 2 SI Inspection Stage 4 as follows:
    - Inspection Stage 4, Step 1: Up to 40 groundwater grab samples (one shallow [approximately 15 feet bgs] and one deep [approximately 40 feet bgs]) will be collected from each soil boring located in areas where data gaps exist (as determined in the PA or during Stage 1 of the Phase 2 SI).
- Monitoring Well/Piezometer/Spigot Sampling
  - Groundwater sampling will be completed at all new and select existing monitoring wells in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix B**. Monitoring well sampling will occur during Phase 2 SI Inspection Stages 1, 2, and 4 as follows:
    - Inspection Stage 1: Groundwater samples will be collected from up to five existing monitoring wells. Samples will be submitted to Battelle Analytical Services for PFAS analysis with a 14-day TAT to allow for determination of monitoring well construction specifications to be installed in Stage 4.
    - Inspection Stage 2, Step 1: Groundwater samples will be collected from five existing monitoring wells and nine newly installed monitoring wells at or downgradient of the hangars. Groundwater samples collected from the existing monitoring wells will be submitted to Battelle Analytical Services with a 72-hour TAT for determination of additional well placement in that area; groundwater samples collected from newly installed wells will be sent to Battelle Analytical Services for PFAS analysis with standard TAT.
    - Inspection Stage 4: Groundwater samples will be collected from up to 20 newly installed monitoring wells at areas where data gaps exist (as determined in the PA or during Stage 1 of the Phase 2 SI). Samples will be submitted to Battelle Analytical Services for PFAS analysis with standard TAT.

Stage Gauge Installation

- Seven stage gauges will be installed during Stage 3. Stage gauges will be co-located with the seven clusters of piezometers in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix B**.

Synoptic Water Level Survey

- Manual groundwater levels will be measured at all new and existing groundwater monitoring wells during the Phase 2 SI field investigation in accordance with the SOPs listed in **Worksheet #21** and provided in **Appendix B.**

Decontamination

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

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

Investigation-derived Waste Handling

- IDW will be managed in accordance with the Interim PFAS Site Guidance for NAVFAC RPMs, September 2017 Update (Navy, 2017a) and in accordance with SOPs listed in **Worksheet #21** and provided in **Appendix B**.

Analyses and Testing Tasks

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

Quality Control Tasks

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

Secondary Data

- See Worksheet #13.

Data Validation, Review, and Management Tasks

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

Documentation and Reporting

- A summary of field activities as well as a data evaluation will be documented in a Phase 2 SI Report and submitted to the NAVFAC Northwest RPM for review and approval.

Assessment and Audit Tasks

- Worksheets #31 and #32.

Demobilization

Full demobilization will occur when the project is completed, and appropriate QA/QC checks have been performed. Personnel no longer needed during 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 site to an appropriate level will be verified by the CH2M FTL.
- All equipment will be inspected, packaged, and shipped to the appropriate location.

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

Matrix: Groundwater

Analytical Group: PFAS – PFAS by LC/MS/MS Compliant with DoD QSM 5.1.1 Table B-15[1]

Analyte	Chemical Abstract Service (CAS) Number	USEPA Lifetime Health Advisory (ng/L)	RSLs Tap water HQ = 0.1 (May 2019) (ng/L)	PQL Goal[2] (ng/L)	Laboratory Limits (ng/L)			LCS and MS/MSD Recovery Limits and RPD[3] (%)		
					LOQs (ng/L)	LODs (ng/L)	DLs (ng/L)	LCL	UCL	RPD
Perfluorooctanoic acid (PFOA)	335-67-1	70	40	5	5	0.5	0.18	49	141	30
Perfluorooctane Sulfonate (PFOS)	1763-23-1	70	40	5	5	0.5	0.19	40	144	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	--	40,000	5	5	0.5	0.13	56	134	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	5	5	0.5	0.19	51	137	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	5	5	0.5	0.16	48	136	30
Perfluorohexane sulfonate (PFHxS)	355-46-4	--	--	5	5	0.4	0.11	52	128	30
Perfluorononanoic acid (PFNA)	375-95-1	--	--	5	5	1	0.26	58	122	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	5	5	0.5	0.16	59	135	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	5	5	1	0.29	64	134	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	5	5	0.5	0.18	75	131	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	5	5	0.5	0.15	42	148	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	--	5	5	1	0.25	42	158	30
N-Ethylperfluoro-1-octanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	--	5000	5000	1000	490	51	131	30
N-Methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	--	5000	5000	2000	560	50	146	30
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	5000	5000	400	200	70	130	30
4,8-dioxa-3H-perfluoronanoic acid (ADONA)	919005-14-4	--	--	5000	5000	400	180	70	130	30
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	763051-92-9	--	--	5000	5000	400	180	70	130	30
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	756426-58-1	--	--	5000	5000	400	100	70	130	30
PFOA + PFOS (calculated)[4]	--	70	--	--	--	--	--	--	--	--

Notes:

1 Analytical method is compliant with DoD QSM v. 5.1.1 Table B-15 or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification.

2 The PQL goal is equal to the laboratory LOQ.

3 Accuracy and precision limits follow laboratory in-house limits per DoD QSM v. 5.1.1, Table B-15.

4 The USEPA Lifetime Health Advisory of 0.07 µg/L is less conservative than the tap water RSLs presented in the table

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.

DL = detection limit

LCL = lower confidence limit

LCS = laboratory control sample

UCL = upper confidence limit

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

Matrix: Soil
Analytical Group: PFAS by LC/MS/MS Compliant with DoD QSM 5.1.1 Table B-15[1]

Analyte	CAS Number	USEPA Residential Soil RSL, HQ = 0.1, May 2019 (µg/kg)	Calculated Derived Residential Soil HQ = 0.1 from the USEPA RSL Calculator, May 2019 (µg/kg)[2]	Calculated Derived Soil to Groundwater from the USEPA RSL Calculator HQ = 0.1 (May 2019) (µg/kg)[3]	PQL Goal (µg/kg)[5]	Laboratory Limits (µg/L)[4]			LCS and MS/MSD Recovery Limits and RPD (%)		
						LOQs (µg/kg)	LODs (µg/kg)	DLs (µg/kg)	LCL	UCL	RPD
Perfluorooctane Sulfonate (PFOS)	1763-23-1	--	126	0.0378	5.0	5.0	1.0	0.27	50	130	30
Perfluorooctanoic acid (PFOA)	335-67-1	--	126	0.0172	5.0	5.0	1.0	0.5	56	136	30
Perfluorobutane sulfonate (PFBS)	375-73-5	130,000	126,000	13	5.0	5.0	1.0	0.36	57	145	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	--	5.0	5.0	1.0	0.33	45	135	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	--	5.0	5.0	1.0	0.44	60	128	30
Perfluorohexane sulfonate (PFHxS)	355-46-4	--	--	--	5.0	5.0	0.5	0.22	52	132	30
Perfluorononanoic acid (PFNA)	375-95-1	--	--	--	5.0	5.0	1.0	0.43	54	130	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	--	5.0	5.0	1.0	0.27	55	141	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	--	5.0	5.0	1.0	0.44	57	137	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	--	5.0	5.0	0.5	0.24	62	134	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	--	5.0	5.0	1.0	0.28	51	127	30
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	--	--	5.0	5.0	2.0	0.63	34	162	30
N-Ethylperfluoro-1-octancesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	--	--	5.0	5.0	2.0	0.57	54	124	30
N-Methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	--	--	5.0	5.0	2.5	1.12	52	146	30
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	--	5.0	5.0	2.0	0.57	70	130	30
4,8-dioxa-3H-perfluoronanoic acid (ADONA)	919005-14-4	--	--	--	5.0	5.0	1.0	0.32	70	130	30
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	763051-92-9	--	--	--	5.0	5.0	1.0	0.4	70	130	30
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	756426-58-1	--	--	--	5.0	5.0	1.0	0.45	70	130	30

Notes:

1 Analytical method is compliant with DoD QSM 5.1.1 Table B-15 or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification.

2 The Project Screening Levels were generated using the USEPA online RSL calculator for Residential Soil, HQ = 0.1 on June 6, 2019[3] The Project Screening Levels were generated using the USEPA online RSL calculator for Soil to groundwater, HQ = 0.1 on June 6, 2019

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

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

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.

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

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.

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SAP Worksheet #16—Project Schedule/Timeline Table

Activities	Organization	Dates (MM/DD/YY)		Deliverable
		Anticipated Date(s) of Initiation	**Anticipated Date of Completion**	
Draft SAP preparation	CH2M	February 2019	April 2019	Draft SAP
Navy SAP review	Navy	April 2019	May 2019	Comments
Stakeholder Review	USEPA Region 10 Island County, Washington City of Oak Harbor, Washington	June 2019	July 2019	Comments
Final SAP	CH2M	July 2019	July 2019	Final SAP
Sample Screening subcontracting	CH2M	TBD	TBD	
Monitoring Well Installation	CH2M, Subcontractor	TBD	TBD	
Groundwater Sampling	CH2M	TBD	TBD	
Analytical Data	Subcontractor	Varied turnaround times are detailed on **Worksheet #30.**		Analytical data
Data management	CH2M	TBD	TBD	
Data Validation	Subcontractor	TBD	TBD	
Reporting	CH2M	TBD	TBD	Draft and Final Technical Memorandum

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SAP Worksheet #17—Sampling Design and Rationale

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

Table 17-1. Sampling Strategy Table –Phase 2 SI: Stage 1 – Sampling of Existing Wells

Location	Matrix	Depth of Samples (feet bgs)	Analysis	Laboratory Method	Number of Samples	Sampling Strategy	Rationale
14-MW-2	GW	37.5[1,3]	PFAS	LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[2] / SOP 5-369-06	Five[1]	Groundwater will be collected from five existing groundwater wells for in-field water quality parameters and laboratory analysis of PFAS. Groundwater samples will be submitted for PFAS analysis with a 28-day TAT to allow for determination of monitoring well construction specifications to be installed in Stage 4.	This well is located downgradient of the Pesticide Rinsate Disposal Area (Area 14) (**Figure 11-1**).
MW-14		12.5[1,3]					These wells are located downgradient from the Former Wastewater Treatment Plant (Building 420) and were selected based on their proximity (**Figure 11-2**).
MW-20		10.5[1,3]					
MW-21		10[1, 3]					
Ault Field Well #1		TBD (between one and approximately 40 feet bgs) [1]				The sample collected from Ault Field Well #1 will be collected from a spigot prior to any treatment or filtering system installed by the Golf Course. The first choice (if multiple spigots exist) will be to collect the sample as close to the well as possible. Samples will be collected after 3 to 5 minutes of flushing. Groundwater samples will be submitted for PFAS analysis with a 28-day TAT.	This is an irrigation well located on the Gallery Golf Course. There is little to no information on groundwater flow, depth to water, and presence of PFAS in this portion of the Base (**Figure 11-3**).

Notes:

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

2 Analytical method is compliant with DoD QSM v. 5.1.1 Table B-15 or the most recent version of the QSM for which Battelle has DoD ELAP certification.

3 Sample depth data source: NIRIS database – accessed 3/25/19. Assumes samples will be collected from mid-screen and wells are constructed with 6-inch sump and at least 10-foot screen.

GW = groundwater

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

Table 17-2. Sampling Strategy Table –Phase 2 SI: Stage 2 – Sampling of Areas Downgradient from Hangars 1, 5 through 12, and 14

Location	Matrix	Depth of Samples (feet bgs)	Analysis	Laboratory Method	Number of Samples	Sampling Strategy	Rationale
16-26B	GW	32[1,3]	PFAS	LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[2] / SOP 5-369-06	5[1]	Groundwater will be collected from five existing groundwater wells for in-field water quality parameters and laboratory analysis of PFAS. Groundwater samples will be submitted for a standard TAT.	Samples will be collected from five existing groundwater monitoring wells near or downgradient of the on-Base Hangars identified in the PA as requiring further investigation (**Figures 11-4 and 11-5**).
H6-B3		11.5[1,4]					
MW4-B3		13.5[1,3]					
MW10-B8		10.5[1,3]					
MW15-B23		13.5[1,3]					
WI-MW-616	Soil	TBD[1]	PFAS	LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[2] / SOP 5-369-06	9[1]	1 soil sample will be collected from the water table for laboratory analysis of PFAS from each soil boring. Samples will be submitted for standard TAT.	Soil samples will be collected from nine monitoring well locations installed at areas where previous soil data does not currently exist to determine the presence of PFAS in soil at on-Base hangars identified as requiring further investigation in the PA as shown on **Figure 11-6**. Horizontal placement of the boreholes has been selected to target areas with potential releases or drainage from hangar facilities or other associated potential source areas in the immediate vicinity of the hangars (at or downgradient of the Indoor Wash Rack, Hangars 1, 5 through 12, and 14, and Stormwater Outfalls 1 and 2 (part of the Runway Drainage Ditch System [Area 16]). Depths targeted for analysis will be identified based on boring-specific conditions and will focus on the soil/ water table interface.
WI-MW-617							
WI-MW-618							
WI-MW-619							
WI-MW-620							
WI-MW-621							
WI-MW-622							
WI-MW-623							
WI-MW-624							
WI-AF-MW-616	GW	TBD (between the water table and approximately 30 feet bgs)[1]	PFAS	LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[2] / SOP 5-369-06	9[1]	Groundwater samples will be collected for laboratory analysis of PFAS from each newly installed monitoring well. Samples will be submitted for standard TAT.	Groundwater samples will be collected from newly installed monitoring wells located downgradient of the hangars.
WI-AF-MW-617							
WI-AF-MW-618							
WI-AF-MW-619							
WI-AF-MW-620							
WI-AF-MW-621							
WI-AF-MW-622							
WI-AF-MW-623							
WI-AF-MW-624							

Notes:

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

2 Analytical method is compliant with DoD QSM v. 5.1.1 Table B-15 or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification.

3 Sample depth data source: NIRIS database – accessed 3/25/19. Assumes samples will be collected from mid-screen and wells are constructed with 6-inch sump and at least 10-foot screen.

4 Sample depth data source: Well gauged during 4/18/19 well reconnaissance effort. Assumes samples will be collected from mid-screen and wells are constructed with 6-inch sump and at least 10-foot screen.

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

Table 17-3. Sampling Strategy Table –Phase 2 SI: Stage 3 – Sampling of the Runway Drainage Ditch System

Location	Matrix	Depth of Samples (feet bgs)	Analysis	Laboratory Method	Number of Samples	Sampling Strategy	Rationale
WI-AF-WT01	Soil	TBD (at the water table interface for each location) [1]	PFAS	LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[2] / SOP 5-369-06	14[1]	14 soil samples will be collected from the water table interface from each boring installed along the Runway Drainage Ditch System. Samples will be submitted for PFAS analysis with a standard TAT.	Neither the presence of PFAS nor the interaction of surface water and groundwater at the on-Base Runway Drainage Ditch System (Area 16) is well understood. Dual completion piezometers will be installed at various locations and depths within the shallow portion of the aquifer to capture aquifer data along the drainage ditch system (**Figure 11-7**). Depths targeted for analysis will be identified based on boring-specific conditions and will focus on the soil/ water table interface.
WI-AF-WT02							
WI-AF-WT03							
WI-AF-WT04							
WI-AF-WT05							
WI-AF-WT06							
WI-AF-WT07							
WI-AF-WT08							
WI-AF-WT09							
WI-AF-WT10							
WI-AF-WT11							
WI-AF-WT12							
WI-AF-WT13							
WI-AF-WT14							
WI-AF-WT01	GW	15[1]	PFAS	LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[2] / SOP 5-369-06	14[1]	14 groundwater samples will be collected from each newly installed piezometer along the Runway Drainage Ditch System (Area 16). Samples will be submitted for laboratory analysis of PFAS with a standard TAT.	Neither the presence of PFAS nor the interaction of surface water and groundwater at the on-Base Runway Drainage Ditch System (Area 16) is well understood. Dual completion piezometers will be installed at various locations and depths within the shallow portion of the aquifer to capture aquifer data along the drainage ditch system (**Figure 11-7**). Depths targeted for analysis will be identified based on boring-specific conditions and will focus on the soil/ water table interface.
WI-AF-WT02		30[1]					
WI-AF-WT03		15[1]					
WI-AF-WT04		30[1]					
WI-AF-WT05		15[1]					
WI-AF-WT06		30[1]					
WI-AF-WT07		15[1]					
WI-AF-WT08		30[1]					
WI-AF-WT09		15[1]					
WI-AF-WT10		30[1]					
WI-AF-WT11		15[1]					
WI-AF-WT12		30[1]					
WI-AF-WT13		15[1]					
WI-AF-WT14		30[1]					

Notes:

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

2 Analytical method is compliant with DoD QSM v. 5.1.1 Table B-15 or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification.

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

Table 17-4. Sampling Strategy Table –Phase 2 SI: Stage 4 –Install New Wells at On-Base Areas Where Data Gaps Exist

Location	Matrix	Depth of Samples (feet bgs)	Analysis	Laboratory Method	Number of Samples	Sampling Strategy	Rationale
WI-AF-BH01 WI-AF-BH02 WI-AF-BH03 WI-AF-BH04 WI-AF-BH05 WI-AF-BH06 WI-AF-BH07 WI-AF-BH08 WI-AF-BH09 WI-AF-BH10 WI-AF-BH11 WI-AF-BH12 WI-AF-BH13 WI-AF-BH14 WI-AF-BH15 WI-AF-BH16 WI-AF-BH17 WI-AF-BH18 WI-AF-BH19 WI-AF-BH20	Soil	TBD[1]	PFAS	LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[2] / SOP 5-369-06	20[1]	Two boreholes will be advanced in each potential PFAS release area where insufficient data exists to determine the presence or absence of PFAS in soil. 1 soil sample will be collected from the water table of each borehole for laboratory analysis of PFAS with a standard TAT.	Currently, insufficient data exists in the following potential source areas to determine the presence or absence of PFAS in soil due to a lack of existing soil data in these areas (**Figures 11-8 through 11-11**): • 1976 EA-6 Crash Site • Current Wastewater Treatment Plant • Fire School Can Disposal Area (Area 30) • Former 1966 Fire School (Area 27) • Former Clover Valley Fire School (Area 29) • Former Sewage Lagoons • Former Wastewater Treatment Plant (Building 420) • Pesticide Rinsate Disposal Area (Area 14) Depths targeted for analysis will be identified based on boring-specific conditions and will focus on collection at the water table interface and total depth to allow for determination of new monitoring well construction specifications.
WI-AF-BH01 WI-AF-BH02 WI-AF-BH03 WI-AF-BH04 WI-AF-BH05 WI-AF-BH06 WI-AF-BH07 WI-AF-BH08 WI-AF-BH09 WI-AF-BH10 WI-AF-BH11 WI-AF-BH12 WI-AF-BH13 WI-AF-BH14 WI-AF-BH15 WI-AF-BH16 WI-AF-BH17 WI-AF-BH18 WI-AF-BH19 WI-AF-BH20	GW	TBD[1]	PFAS	LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[2] / SOP 5-369-06	40[1]	2 groundwater grab samples (one 15 feet bgs and one 30 feet bgs) will be collected for laboratory analysis of PFAS from each soil boring. Groundwater grab samples will be submitted with a 72-hour TAT to allow for determination of monitoring well construction specifications.	Currently, insufficient data exists to determine the presence or absence of PFAS in groundwater due to a lack of existing monitoring wells screened within the shallow portion of the aquifer in or downgradient of these potential source areas (**Figures 11-8 through 11-11**): • 1976 EA-6 Crash Site • Current Wastewater Treatment Plant • Fire School Can Disposal Area (Area 30) • Former 1966 Fire School (Area 27) • Former Clover Valley Fire School (Area 29) • Former Sewage Lagoons • Former Wastewater Treatment Plant (Building 420) • Pesticide Rinsate Disposal Area (Area 14) Depths targeted for analysis will be identified based on boring-specific conditions and will focus on collection at the water table interface and total depth to allow for determination of new monitoring well construction specifications.

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

Table 17-4. Sampling Strategy Table –Phase 2 SI: Stage 4 –Install New Wells at On-Base Areas Where Data Gaps Exist

<table>
<tr><th>Location</th><th>Matrix</th><th>Depth of Samples (feet bgs)</th><th>Analysis</th><th>Laboratory Method</th><th>Number of Samples</th><th>Sampling Strategy</th><th>Rationale</th></tr>
<tr><td>WI-AF-MW-625</td><td rowspan="20">GW</td><td rowspan="20">TBD (between the water table and approximately 40 feet bgs) [1]</td><td rowspan="20">PFAS</td><td rowspan="20">LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[2] / SOP 5-369-06</td><td rowspan="20">up to 20[1]</td><td rowspan="20">Groundwater samples will be collected from each newly installed monitoring well for laboratory analysis of PFAS with a standard TAT.</td><td rowspan="20">Currently, insufficient data exists to determine the presence or absence of PFAS in groundwater due to a lack of existing monitoring wells screened within the shallow portion of the aquifer in or downgradient of these potential source areas (Figures 11-8 through 11-11):
• 1976 EA-6 Crash Site
• Current Wastewater Treatment Plant
• Fire School Can Disposal Area (Area 30)
• Former 1966 Fire School (Area 27)
• Former Clover Valley Fire School (Area 29)
• Former Sewage Lagoons
• Former Wastewater Treatment Plant (Building 420)
• Pesticide Rinsate Disposal Area (Area 14)
The number and depth of newly installed monitoring wells will be determined by the analytical results of the groundwater grab samples collected during Stage 4.</td></tr>
<tr><td>WI-AF-MW-626</td></tr>
<tr><td>WI-AF-MW-627</td></tr>
<tr><td>WI-AF-MW-628</td></tr>
<tr><td>WI-AF-MW-629</td></tr>
<tr><td>WI-AF-MW-630</td></tr>
<tr><td>WI-AF-MW-631</td></tr>
<tr><td>WI-AF-MW-632</td></tr>
<tr><td>WI-AF-MW-633</td></tr>
<tr><td>WI-AF-MW-634</td></tr>
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<tr><td>WI-AF-MW-641</td></tr>
<tr><td>WI-AF-MW-642</td></tr>
<tr><td>WI-AF-MW-643</td></tr>
<tr><td>WI-AF-MW-644</td></tr>
</table>

Notes:

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

2 Analytical method is compliant with DoD QSM v. 5.1.1 Table B-15 or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification.

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

Station Identification (ID)	Sample ID	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples (Identify FDs)	Sampling SOP Reference
Stage I Sampling - Sampling of Existing Wells						
MW-20	WI-A52-MW-20-MMYY	Groundwater	10.5[5]	PFAS (LC/MS/MS compliant with DoD QSM v. 5.1.1, Table B-15[1])	2 (FD)	**Worksheet #21**
	WI-A52-MW-20P-MMYY					
MW-21	WI-A52-21-MMYY		10[5]		1	
MW-14	WI-A52-MW-14-MMYY		12.5[5]		3 (MS/MSD)	
	WI-A52-MW-14-MMYY-MS					
	WI-A52-MW-14-MMYY-MSD					
Ault Field Well #1	WI-GC-WI-MMYY	Groundwater	TBD	PFAS (LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[1])	1	**Worksheet #21**
14-MW-2	WI-A14-14-MW-2-MMYY		37.5[5]		1	
Stage 2 Sampling - **Sampling of Areas Near or Downgradient from Hangars**						
16-26B	WI-A16-16-26B-MMYY	Groundwater	32[5]	PFAS (LC/MS/MS Compliant in accordance with DoD QSM v. 5.1.1, Table B-15[1])	2 (FD)	**Worksheet #21**
	WI-A16-16-26BP-MMYY					
H6-B3	WI-AF-A16-H6-B3-MMYY		11.5[6]		1	
MW4-B3	WI-AF-MW4-B3-MMYY		13.5[5]		3 (MS/MSD)	
	WI-AF-MW4-B3-MMYY-MS					
	WI-AF-MW4-B3-MMYY-MSD					
MW10-B8	WI-AF-MW10-B8-MMYY		10.5[5]		1	
MW15-B23	WI-AF-MW15-B23-MMYY		13.5[5]		1	
WI-AF-MW-616	WI-AF-MW-616-MMYY	Groundwater	TBD	PFAS (LC/MS/MS Compliant in accordance with DoD QSM v. 5.1.1, Table B-15[1])	1	**Worksheet #21**
	WI-AF-MW-616-SB-XXYY	Subsurface soil			3 (MS/MSD)	
	WI-AF-MW-616-SB-XXYY-MS					
	WI-AF-MW-616-SB-XXYY-MSD					
WI-AF-MW-617	WI-AF-MW-617-MMYY	Groundwater			2 (FD)	
	WI-AF-MW-617P-MMYY					
	WI-AF-MW-617-SB-XXYY	Subsurface soil			1	
WI-AF-MW-618	WI-AF-MW-618-MMYY	Groundwater			1	
	WI-AF-MW-618-SB-XXYY	Subsurface soil			1	
WI-AF-MW-619	WI-AF-MW-619-MMYY	Groundwater			1	
	WI-AF-MW-619-SB-XXYY	Subsurface soil			1	
WI-AF-MW-620	WI-AF-MW-620-MMYY	Groundwater			3 (MS/MSD)	
	WI-AF-MW-620-MMYY-MS					
	WI-AF-MW-620-MMYY-MSD					
	WI-AF-MW-620-SB-XXYY	Subsurface soil			1	
WI-AF-MW-621	WI-AF-MW-621-MMYY	Groundwater			1	
	WI-AF-MW-621-SB-XXYY	Subsurface soil			2 (FD)	
	WI-AF-MW-621P-SB-XXYY					
WI-AF-MW-622	WI-AF-MW-622-MMYY	Groundwater			1	
	WI-AF-MW-622-SB-XXYY	Subsurface soil			1	
WI-AF-MW-623	WI-AF-MW-623-MMYY	Groundwater			1	
	WI-AF-MW-623-SB-XXYY	Subsurface soil			1	

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

Station Identification (ID)	Sample ID	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples (Identify FDs)	Sampling SOP Reference
WI-AF-MW-624	WI-AF-MW-624-MMYY	Groundwater			1	
	WI-AF-MW-624-SB-XXYY	Subsurface soil			1	
Stage 3 Sampling - **Installation of Piezometers and Sampling of the Runway Drainage Ditch System (Area 16)**						
WI-AF-WT01	WI-AF-WT01-GW-MMYY	Groundwater	15	PFAS (LC/MS/MS Compliant in accordance with DoD QSM v. 5.1.1, Table B-15[1])	2 (FD)	**Worksheet #21**
	WI-AF-WT01-GWP-MMYY					
	WI-AF-WT01-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT02	WI-AF-WT02-GW-MMYY	Groundwater	30		3 (MS/MSD)	
	WI-AF-WT02-GW-MMYY-MS					
	WI-AF-WT02-GW-MMYY-MSD					
	WI-AF-WT02-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT03	WI-AF-WT03-GW-MMYY	Groundwater	15		1	
	WI-AF-WT03-SB-XXYY	Subsurface Soil	TBD		2 (FD)	
	WI-AF-WT03-SBP-XXYY					
WI-AF-WT04	WI-AF-WT04-GW-MMYY	Groundwater	30		1	
	WI-AF-WT04-SB-XXYY	Subsurface Soil	TBD		1	**Worksheet #21**
WI-AF-WT05	WI-AF-WT05-GW-MMYY	Groundwater	15		1	
	WI-AF-WT05-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT06	WI-AF-WT06-GW-MMYY	Groundwater	30		1	
	WI-AF-WT06-SB-XXYY	Subsurface Soil	TBD		3 (MS/MSD)	
	WI-AF-WT06-SB-XXYY-MS					
	WI-AF-WT06-SB-XXYY-MSD					
WI-AF-WT07	WI-AF-WT07-GW-MMYY	Groundwater	15		1	
	WI-AF-WT07-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT08	WI-AF-WT08-GW-MMYY	Groundwater	30		1	
	WI-AF-WT08-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT09	WI-AF-WT09-GW-MMYY	Groundwater	15		1	
	WI-AF-WT09-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT10	WI-AF-WT10-GW-MMYY	Groundwater	30		1	
	WI-AF-WT10-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT11	WI-AF-WT11-GW-MMYY	Groundwater	15		1	
	WI-AF-WT11-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT12	WI-AF-WT12-GW-MMYY	Groundwater	30		2 (FD)	
	WI-AF-WT12-GWP-MMYY					
	WI-AF-WT12-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT13	WI-AF-WT13-GW-MMYY	Groundwater	15		1	
	WI-AF-WT13-SB-XXYY	Subsurface Soil	TBD		1	
WI-AF-WT14	WI-AF-WT14-GW-MMYY	Groundwater	30		1	
	WI-AF-WT14-SB-XXYY	Subsurface Soil	TBD		1	

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

Station Identification (ID)	Sample ID	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples (Identify FDs)	Sampling SOP Reference
Stage 4 Sampling - Install New Wells at On-Base Areas Where Data Gaps Exist						
WI-AF-BH01	WI-AF-BH01-SB-XXYY	Subsurface soil	TBD	PFAS (LC/MS/MS Compliant in accordance with DoD QSM v. 5.1.1, Table B-15[1])	1	**Worksheet #21**
	WI-AF-BH01-GW-XXYY[4]	Groundwater			2 (FD)	
	WI-AF-BH01-GWP-XXYY[4]					
	WI-AF-BH01-GW-XXYY[4]				1	
WI-AF-BH02	WI-AF-BH02-SB-XXYY	Subsurface soil			1	
	WI-AF-BH02-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH02-GW-XXYY[4]				1	
WI-AF-BH03	WI-AF-BH03-SB-XXYY	Subsurface soil	TBD	PFAS (LC/MS/MS Compliant in accordance with DoD QSM v. 5.1.1, Table B-15[1])	1	**Worksheet #21**
	WI-AF-BH03-GW-XXYY[4]	Groundwater			3 (MS/MSD)	
	WI-AF-BH03-GW-XXYY-MS[4]					
	WI-AF-BH03-GW-XXYY-MSD[4]					
	WI-AF-BH03-GW-XXYY[4]				1	
WI-AF-BH04	WI-AF-BH04-SB-XXYY	Subsurface soil			1	
	WI-AF-BH04-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH04-GW-XXYY[4]				1	
WI-AF-BH05	WI-AF-BH05-SB-XXYY	Subsurface soil			1	
	WI-AF-BH05-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH05-GW-XXYY[4]				1	
WI-AF-BH06	WI-AF-BH06-SB-XXYY	Subsurface soil			1	
WI-AF-BH06	WI-AF-BH06-GW-XXYY[4]	Groundwater	TBD	PFAS (LC/MS/MS Compliant in accordance with DoD QSM v. 5.1.1, Table B-15[1])	1	**Worksheet #21**
	WI-AF-BH06-GW-XXYY[4]				1	
WI-AF-BH07	WI-AF-BH07-SB-XXYY	Subsurface soil			1	
	WI-AF-BH07-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH07-GW-XXYY[4]				1	
WI-AF-BH08	WI-AF-BH08-SB-XXYY	Subsurface soil			1	
	WI-AF-BH08-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH08-GW-XXYY[4]				2 (FD)	
	WI-AF-BH08-GWP-XXYY[4]					
WI-AF-BH09	WI-AF-BH09-SB-XXYY	Subsurface soil			1	
	WI-AF-BH09-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH09-GW-XXYY[4]				1	
WI-AF-BH10	WI-AF-BH10-SB-XXYY	Subsurface soil			2 (FD)	
	WI-AF-BH10-SBP-XXYY					
	WI-AF-BH10-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH10-GW-XXYY[4]				2 (FD)	
	WI-AF-BH10-GWP-XXYY[4]					
WI-AF-BH11	WI-AF-BH11-SB-XXYY	Subsurface soil			1	
	WI-AF-BH11-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH11-GW-XXYY[4]				1	

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

Station Identification (ID)	Sample ID	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples (Identify FDs)	Sampling SOP Reference
WI-AF-BH12	WI-AF-BH12-SB-XXYY	Subsurface soil	TBD	PFAS (LC/MS/MS Compliant in accordance with DoD QSM v. 5.1.1, Table B-15[1])	1	**Worksheet #21**
	WI-AF-BH12-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH12-GW-XXYY[4]				1	
WI-AF-BH13	WI-AF-BH13-SB-XXYY	Subsurface soil			3 (MS/MSD)	
	WI-AF-BH13-SB-XXYY-MS					
	WI-AF-BH13-SB-XXYY-MSD					
	WI-AF-BH13-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH13-GW-XXYY[4]				1	
WI-AF-BH14	WI-AF-BH14-SB-XXYY	Subsurface soil			1	
	WI-AF-BH14-GW-XXYY[4]	Groundwater			2 (FD)	
WI-AF-BH14	WI-AF-BH14-GWP-XXYY[4]	Groundwater	TBD	PFAS (LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[1])	2 (FD)	**Worksheet #21**
	WI-AF-BH14-GW-XXYY[4]				1	
WI-AF-BH15	WI-AF-BH15-SB-XXYY	Subsurface soil			1	
	WI-AF-BH15-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH15-GW-XXYY[4]				3 (MS/MSD)	
	WI-AF-BH15-GW-XXYY-MS[4]					
	WI-AF-BH15-GW-XXYY-MSD[4]					
WI-AF-BH16	WI-AF-BH16-SB-XXYY	Subsurface soil			1	
	WI-AF-BH16-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH16-GW-XXYY[4]				1	
WI-AF-BH17	WI-AF-BH17-SB-XXYY	Subsurface soil			1	
	WI-AF-BH17-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH17-GW-XXYY[4]				1	
WI-AF-BH18	WI-AF-BH18-SB-XXYY	Subsurface soil			1	
	WI-AF-BH18-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH18-GW-XXYY[4]				2 (FD)	
	WI-AF-BH18-GWP-XXYY[4]					
WI-AF-BH19	WI-AF-BH19-SB-XXYY	Subsurface soil			1	
	WI-AF-BH19-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH19-GW-XXYY[4]				1	
WI-AF-BH20	WI-AF-BH20-SB-XXYY	Subsurface soil			2 (FD)	
	WI-AF-BH20-SBP-XXYY					
	WI-AF-BH20-GW-XXYY[4]	Groundwater			1	
	WI-AF-BH20-GW-XXYY[4]				1	
WI-AF-MW-625	WI-AF-MW-625-MMYY	Groundwater	TBD	PFAS (LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[1])	1	**Worksheet #21**
WI-AF-MW-626	WI-AF-MW-626-MMYY				1	
WI-AF-MW-627	WI-AF-MW-627-MMYY				2 (FD)	
	WI-AF-MW-627P-MMYY					
WI-AF-MW-628	WI-AF-MW-628-MMYY				1	
WI-AF-MW-629	WI-AF-MW-629-MMYY				1	

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

Station Identification (ID)	Sample ID	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples (Identify FDs)	Sampling SOP Reference
WI-AF-MW-630	WI-AF-MW-630-MMYY WI-AF-MW-630-MMYY-MS WI-AF-MW-630-MMYY-MSD	Groundwater	TBD	PFAS (LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[1])	3 (MS/MSD)	**Worksheet #21**
WI-AF-MW-631	WI-AF-MW-631-MMYY	Groundwater	TBD	PFAS (LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[1])	1	**Worksheet #21**
WI-AF-MW-632	WI-AF-MW-632-MMYY				1	
WI-AF-MW-633	WI-AF-MW-633-MMYY				1	
WI-AF-MW-634	WI-AF-MW-634-MMYY				1	
WI-AF-MW-635	WI-AF-MW-635-MMYY				1	
WI-AF-MW-636	WI-AF-MW-636-MMYY				1	
WI-AF-MW-637	WI-AF-MW-637-MMYY				1	
WI-AF-MW-638	WI-AF-MW-638-MMYY WI-AF-MW-638P-MMYY				2 (FD)	
WI-AF-MW-639	WI-AF-MW-639-MMYY				1	
WI-AF-MW-640	WI-AF-MW-640-MMYY				1	
WI-AF-MW-641	WI-AF-MW-641-MMYY				1	
WI-AF-MW-642	WI-AF-MW-642-MMYY				1	
WI-AF-MW-643	WI-AF-MW-643-MMYY				1	
WI-AF-MW-644	WI-AF-MW-644-MMYY				1	
Field QC Samples						
WI-AF-QC	WI-AF-FB01-GW-MMDDYY	QC	N/A	PFAS (LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[1])	1	**Worksheet #21**
	WI-AF-FB02-GW-MMDDYY				1	
	WI-AF-FBXX-GW-MMDDYY[2]				TBD	
	WI-AF-FB01-SB-MMDDYY				1	
	WI-AF-FB02-SB-MMDDYY				1	
	WI-AF-FBXX-SB-MMDDYY[2]				TBD1	
	WI-AF-EB01-GW-MMDDYY				1	
	WI-AF-EB02-GW-MMDDYY				1	
	WI-AF-EBXX-GW-MMDDYY[2]				TBD	
	WI-AF-EB01-SB-MMDDYY				1	
	WI-AF-EB02-SB-MMDDYY				1	
	WI-AF-EBXX-SB-MMDDYY[2]				TBD	

Notes:

1 Analytical method is compliant with DoD QSM v. 5.1.1 Table B-15 or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification.

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

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

4 For the borehole samples, 2 grab groundwater samples will be collected at approximately 15 feet bgs and 30 feet bgs. Actual depths will replace "XXYY" designator in sample ID.

5 Sample depth data source: NIRIS database – accessed 3/25/19. Assumes samples will be collected from mid-screen and wells are constructed with 6-inch sump and at least 10-foot screen.

6 Sample depth data source: Well gauged during 4/18/19 well reconnaissance effort. Assumes samples will be collected from mid-screen and wells are constructed with 6-inch sump and at least 10-foot screen

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SAP Worksheet #19—Analytical SOP Requirement Table

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Containers	Sample Volume	Preservation Requirements	Maximum Holding Time[1] (Preparation/Analysis)
Groundwater	PFAS	PFAS by LC/MS/MS Compliant with DoD QSM v. 5.1 Table B-15[2]/ SOP 5-370/SOP 5-369	2 x 250 milliliters (mL) HDPE bottle	2 x 250 mL	≤10° C for up to 48 hours after sampling, upon sample receipt, then stored at laboratory ≤6° C.	14 days to extraction/ 28 days to analysis
Soil	PFAS	PFAS by LC/MS/MS Compliant with DoD QSM v. 5.1 Table B-15[2]/ SOP 5-370/SOP 5-369	One 6-ounce HDPE jar	20 grams	≤10° C for up to 48 hours after sampling, upon sample receipt, then stored at laboratory ≤6° C, but not frozen.	28 days to extraction/ 30 days to analysis

Notes:

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

[2] Analytical method is compliant with DoD QSM v. 5.1.1 Table B-15 or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification.

HDPE = high density polyethylene

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SAP Worksheet #20—Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations[1]	No. of FDs[1]	No. of MS/MSDs[1]	No. of Field Blanks[1]	No. of Equipment Blanks[1]	No. of Trip Blanks[1]	Total No. of Samples to Laboratory[1]
Stage 1 Sampling - Sampling of Existing Wells								
Groundwater	PFAS	5	1	1/1	1	2	N/A	11
Stage 2 Sampling - Sampling of Areas Near or Downgradient from Hangars								
Groundwater	PFAS	9	1	2/2	1	4	N/A	18
Subsurface Soil	PFAS	9	1	1/1	1	3	N/A	16
Stage 3 Sampling - Installation of Piezometers and Sampling of the Runway Drainage Ditch System (Area 16)								
Groundwater	PFAS	14	2	1/1	1	4	N/A	23
Subsurface soil	PFAS	14	2	1/1	1	4	N/A	23
Stage 4 Sampling - Install New Wells at On-Base Areas Where Data Gaps Exist								
Groundwater	PFAS	60	7	3/3	1	16	N/A	90
Subsurface Soil	PFAS	20	2	1/1	1	6	N/A	31

Notes:

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

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SAP Worksheet #21—Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
SOP CH2M-1	Guidelines for Logging Soil Borings Rev. Sep. 2015	CH2M	None	N	To guide staff in accurately and consistently recording the field data necessary to characterize soil borings and recovered soil samples.
SOP CH2M-2	Continuous Water Level Measurements	CH2M	Transducer and datalogger	N	Describes procedure for collecting continuous water level measurements. Only PFAS-free equipment will be used.
SOP CH2M-3	Multi RAE PID Rev. Apr. 2015	CH2M	Multi RAE PID	N	Provide general reference information for using the Multi RAE PID in the field.
SOP CH2M-4	Groundwater Sampling for Per- and Polyfluoroalkyl Substances (PFAS) Rev. Nov. 2018	CH2M	All field equipment within the sample collection area	N	Provides guidance for groundwater sample collection for samples that will be analyzed for PFAS via LC/MS/MS Compliant with DoD QSM v. 5.1.1 (or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification) for Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-5	Rotosonic Groundwater Sample Collection for Per- and Polyfluoroalkyl Substances Rev. Nov. 2018	CH2M	All field equipment within the sample collection area	N	Provides guidance for rotosonic groundwater sample collection for samples that will be analyzed for PFAS via LC/MS/MS Compliant with DoD QSM v. 5.1.1 (or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification) for Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-6	Soil Sampling for PFAS, Rev. July 2017	CH2M	All field equipment within the sample collection area	N	Provides guidance for soil sample collection for samples that will be analyzed for PFAS via LC/MS/MS Compliant with DoD QSM v. 5.1.1 (or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification) for Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-7	Management of Liquid Waste Containing Per- and Polyfluoroalkyl Substances (PFAS) Rev. Nov. 2018	CH2M	None	N	Provides guidelines for managing liquid waste containing PFAS or Navy CLEAN projects under Contract N62470-16-D-9000.
SOP CH2M-8	Non-Drinking Water Effluent Sampling for PFAS Rev. Sep. 2018	CH2M	Sampling Equipment	N	Provides guidelines for non-drinking water effluent sample collection for samples that will be analyzed for PFAS via LC/MS/MS Compliant with DoD QSM 5.1.1 Table B-15.
SOP CH2M-9	DPT Groundwater Sample Collection for PFAS Rev. Nov. 2018	CH2M	Sampling Equipment, Drilling Equipment	N	Provides guidelines for groundwater sample collection using direct-push (e.g., Geoprobe) for samples that will be analyzed for PFAS via LC/MS/MS Compliant with DoD QSM 5.1.1 Table B-15.
SOP CH2M-10	Stage Gauging. April, 2019	CH2M	Stage Gauge Installation and Equipment	Y	Describes procedure for installing stage gauges. Only PFAS-free equipment will be used.
SOP I-A-1	Planning Field Sampling Activities, Rev. Feb. 2015	NAVFAC Northwest	None	N	Establishes SOPs for planning and scheduling field sampling activities.
SOP I-A-7	IDW Management, Rev. Feb. 2015	NAVFAC Northwest	None	N	Describes activities and responsibilities of NAVFAC Northwest and its subcontractors regarding management of IDW. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.
SOP I-A-9	General Field Operation, Rev. Feb. 2015	NAVFAC Northwest	All field equipment	N	Defines organization and structure of sample collection, identification, record keeping, field measurements, and data collection.
SOP I-A-10	Monitoring/Sampling Location Recording, Rev. Feb. 2015	NAVFAC Northwest	Field logbook	N	Establishes guidelines for generating information to be recorded for each physical location where sampling is conducted.
SOP I-A-11	Sample Naming, Rev. Feb. 2015	NAVFAC Northwest	None	N	Describes the naming convention to be used for samples collected, analyzed, and reported for NAVFAC Northwest projects.
SOP I-C-01	Monitoring Well and Piezometer Installation, Rev. Mar. 2015	NAVFAC Northwest	Piezometer, drilling equipment	N	Outline the methods by which all NAVFAC NW personnel and their contractors will conduct monitoring well and piezometer installation.

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? (Y/N)	Comments
SOP I-C-02	Monitoring Well Development, Rev. Mar. 2015	NAVFAC Northwest	Pumps, monitoring equipment.	N	Describes the SOP for monitoring well development to be used by all NAVFAC NW personnel and their contractors.
SOP I-C-05	Low-Flow Groundwater Purging and Sampling, Rev. Mar. 2015	NAVFAC Northwest	Pumps, sampling equipment, monitoring equipment	N	Describes the conventional monitoring well sampling procedures to be used by all NAVFAC NW personnel and contractors.
SOP I-C-07	Aquifer Tests, Rev. Mar. 2015	NAVFAC Northwest	Pumps, monitoring equipment, calibrated meters, storage containers	N	Establish standard methods by which NAVFAC NW personnel and contractors should conduct aquifer tests.
SOP I-D-05	Water Level Measurements, Rev. Mar. 2015	NAVFAC Northwest	Interface Probe, water level indicator	N	Establish standard protocols for all NAVFAC NW field personnel for use in making water level measurements.
SOP I-D-7	Field Parameter Measurements, Rev. Mar. 2015	NAVFAC Northwest	Water quality meters N		Provides instructions for the calibration, use, and checking of instruments and equipment for field measurements. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.
SOP-I-E	Soil and Rock Classification, Rev. Mar. 2015	NAVFAC Northwest	Drilling equipment, camera, and field logbooks	N	Establishes standard protocols for all NAVFAC Northwest field personnel for use in making soil and rock classification decisions.
SOP I-G-1	Land Surveying, Rev. Aug. 2014	NAVFAC Northwest	Surveying equipment	N	Describes the methods by which NAVFAC Northwest field personnel and their contractors will conduct land surveying.
SOP III-B	Field QC Samples (Water, Soil, Sediment, Tissue), Rev. Apr. 2015	NAVFAC Northwest	Sampling equipment	N	Describes the number and types of field QC samples that will be collected during NAVFAC NW site field work.
SOP III-D	Logbooks, Rev. Apr. 2015	NAVFAC Northwest	Logbooks	N	Describes the activities and responsibilities of NAVFAC NW personnel and/or their contractors pertaining to the identification, use, and control of logbooks and associated field data records.
SOP III-E	Record Keeping, Sample Labeling, and Chain-of-Custody Procedures, Rev. Apr. 2015.	NAVFAC Northwest	Logbooks, sampling equipment, shipping equipment	N	To establish standard protocols for all NAVFAC NW field personnel and their contractors for use in maintaining field and sampling activity records, writing sample logs, labeling samples, ensuring that proper sample custody procedures are utilized, and completing chain-of-custody/analytical request forms.
SOP III-G	Sample Handling, Storage, and Shipping, Rev. Apr. 2015	NAVFAC Northwest	Samples	N	Sets forth the methods for use by NAVFAC Northwest field personnel and their contractors engaged in handling, storing, and transporting water, soil and/or sediment samples. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.
SOP III-I	Equipment Decontamination, Rev. Apr. 2015	NAVFAC Northwest	Non-disposable sampling equipment	N	Describes general methods of equipment decontamination for use by NAVFAC Northwest field personnel and their contractors during field sampling activities. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.
SOP III-J	Equipment Calibration, Operation, and Maintenance, Rev. Apr. 2015	NAVFAC Northwest	Field meters	N	Describes the activities and responsibilities of the NAVFAC Northwest personnel pertaining to the operation, calibration, and maintenance of equipment used to collect environmental data. Field activities will deviate slightly from the SOP to eliminate use of PFAS-containing materials.

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

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

Notes:

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

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

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SAP Worksheet #23—Analytical SOP References Table

Laboratory SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work (Y/N)
5-370-08	*Extraction of Poly and Perfluoroalkyl Substances from Environmental Matrices, 04/16/2019, Rev. 8*	Definitive	Soil/Groundwater/ PFAS	N/A	Battelle Analytical Services	N
5-369-06	*Analysis of Poly and Perfluoroalkyl Substances in Environment al Samples by Liquid Chromatography and Tandem Mass Spectrometry (LC-MS/MS), 05/11/2018, Rev. 6*	Definitive	Soil/Groundwater /PFAS	LC/MS/MS	Battelle Analytical Services	N
6-010-19	Sample Receipt, Custody, and Handling, 10/16/18, Rev. 19	N/A	Soil/Groundwater/ PFAS	N/A	Battelle Analytical Services	N
5-291-17	*Determination of Method Detection Limits in the Analytical La boratory, 09/20/18, Rev. 17*	N/A	Soil/Groundwater/ PFAS	N/A	Battelle Analytical Services	N

Notes:

Laboratory SOPs meet DoD QSM v. 5.1.1 (DoD, 2017) requirements (Attachment 4) for Battelle Analytical Services.

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SAP Worksheet #24—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
LC/MS/MS (PFAS)	Initial calibration (ICAL) for all analytes	At instrument set-up and after initial calibration verification (ICV) or continuing calibration verification (CCV) failure, prior to sample analysis.	The available isotopically labeled analog of an analyte (Extracted Internal Standard Analyte) are used for quantitation (except labelled 6:2 FTS) If a labeled analog is not commercially available, the Extracted Internal Standard Analyte with the closest retention time to the analyte must be used for quantitation. (Internal Standard Quantitation) S/N Ratio: ≥ 10:1 for all ions used for quantitation. For analytes having a promulgated standard, (e.g., HA levels for PFOA and PFOS), the qualitative (confirmation) transition ion must have a S/N Ratio of ≥ 3:1. The % relative standard deviation of the response factors for all analytes must be less than 20 percent. Linear or non-linear calibrations must have $r^2 \geq 0.99$ for each analyte. Analytes must be within 70 to 130 percent of their true value for each calibration standard.	If these requirements are not met for the ICAL, CA is performed and the calibration is repeated.	Analyst / Laboratory Project Manager	5-369 DoD QSM v. 5.1.1
	ICV	Once after each ICAL, analysis of a second source standard prior to sample analysis.	All reported analytes within ± 30% of true value. Internal standard area must be within 50% of L3 of the calibration curve.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.		
	Continuing Calibration Verification (CCV)	Beginning of each sample analysis sequence (if not preceded by and ICAL and ICV) analyze a mid-level standard and then after 10 injections during analysis sequence. All samples must be bracketed by the analysis of a standard.	Concentration of analytes must range from the LOQ to the mid-level calibration concentration. Analyte concentrations must be within ± 30% of their true value, labelled analogs must be within 50% of true value.	When a CCV fails to meet any of the above criteria, two additional CCVs are analyzed consecutively. If both additional CCVs pass criteria, the samples can be reported. If either of the two additional CCVs fail criteria or cannot be analyzed all samples that were analyzed after the prior acceptable CCV must be re-analyzed. If a CCV fails because a target analyte exceeded the acceptance limit defined above (over response only) and that analyte was not detected in any samples, then the samples do not need to be reanalyzed. In all other cases, the sample must be reanalyzed after and acceptable CCV has been established or justification for continuing is approved by the project manager and documented.		
	Tune Check	When the masses fall outside of the ± 0.5 atomic mass unit (amu) of the true value (as determined by the product ion formulas).	Mass assignments of tuning standard within 0.5 amu of true value.	Retune instrument and verify. If the tuning will not meet acceptance criteria, an instrument mass calibration must be performed and the tune check repeated.		
	Mass Calibration	Initially prior to use and after performing major maintenance, as required to maintain documented instrument sensitivity and stability performance.	Calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. Entire range needs to be mass calibrated.	N/A		
	Mass Spectral Acquisition Rate	Each analyte and extracted internal standard analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	N/A		

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
	Peak Asymmetry	With each calibration	First two eluting peaks in a mid-level calibration standard must have an asymmetry factor between 0.8 and 1.5.	When the asymmetry factor does not pass, perform CAs to address the issue. Modification of the standard or extract composition to more aqueous content is not permitted.		
	Calibration, Calibration Verification, and Spiking Standards	All analytes.	Standards containing both branched and linear isomers must be used when commercially available. If not available, the total response of the analyte must be integrated (i.e., accounting for peaks that are identified as linear and branched isomers) and quantitated using a calibration curve which includes the linear isomer only for that analyte (e.g., PFOA).	N/A		
LC/MS/MS (PFAS, continued)	Ion Transitions (Parent-> Product)	Prior to method implementation.	The chemical derivation of the ion transitions, both those used for quantitation and those used for confirmation, must be documented. Two transitions and the ion transition ratio per analyte shall be monitored and documented with the exception of PFBA and PFPeA. 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	Analyst / Laboratory Project Manager	5-369, 5-371, DoD QSM v. 5.1.1
	Instrument Blank	Following highest calibration point	≤1/2 the LOQ	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 acceptance criteria are not met after the highest standard which is not included in the calibration, the standard cannot be used to determine the highest concentration in samples at which carryover does not occur. If acceptance criteria are not met after sample, additional instrument blanks must be analyzed until acceptance criteria are met. Additional samples shall not be analyzed until acceptance criteria are met.		
	Instrument Sensitivity Check (ISC)	Prior to analysis and at least once every 12 hours.	Analyte concentrations must be at LOQ; concentrations must be within ±30% of their true values.	Correct problem, rerun ISC. If problem persists, repeat ICAL. No samples shall be analyzed until ISC has met acceptance criteria. ISC can serve as the initial daily CCV.		

Notes:

The specifications in this table meet the requirements of DoD QSM v. 5.1.1.

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

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
LC/MS/MS	AM	PFAS	N/A	6 Months	N/A	N/A	Analyst/supervisor	3-200-01
Balance	Verification	Weight	N/A	Daily	± 0.02 gram or ± 0.1% of calibration weight used (whichever is greater)	Refer to manufacturer's instruction manual	Analyst/supervisor	3-160-09
Balance	Calibration	Weight	N/A	Annually	Per manufacturer	Remove from service, repair, replace	Analyst/supervisor	3-160-09
Pipette	Verification	Volume	N/A	Daily	± 2% difference from true value, <1% relative standard deviation (n=3)	Remove from service, repair, replace	Analyst/supervisor	3-191-05
Pipette	Calibration	Volume	N/A	Quarterly	Per manufacturer	Remove from service, repair, replace	Analyst/supervisor	3-191-05

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SAP Worksheet #26—Sample Handling System

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

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SAP Worksheet #27—Sample Custody Requirements

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory): Samples will be collected by field team members under the supervision of the FTL. As samples are collected, they will be placed into containers and labeled. Labels will be taped to the jar to ensure they do not separate. Samples will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples 0 to 6° C (but not frozen; requirements for USEPA 537.1 are less than 10° C for the first 48 hours) until they are received by the laboratory. The chain-of-custody record will be placed into the cooler in a resealable zip-top plastic bag. Coolers will be taped up and shipped to the laboratories via FedEx overnight, with the airbill number indicated on the chain of custody (to relinquish custody). Upon delivery, the laboratory will log each cooler and report the status of the samples to CH2M. See **Worksheet #21** for SOPs containing sample custody guidance. The CH2M field team will ship all environmental samples directly to the laboratory performing the analysis. This will require shipment to Battelle Analytical Services in Norwell, Massachusetts.
Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal): Laboratory custody procedures can be found in the laboratory SOPs, which will be provided upon request.
Sample ID Procedures: Sample labels will include, at a minimum, client name, site, sample ID, date/time collected, analysis group or method, preservation, and sampler's initials. The field notes will identify the sample ID with the location and time collected and the parameters requested. The laboratory will assign each field sample a laboratory sample ID based on information in the chain of custody. The laboratory will send sample log-in forms to the CH2M PC to check that sample IDs and parameters are correct.
Chain-of-Custody Procedures: Chain-of-custody records will include, at minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information. Sample information will include sample ID. Date/time collected, number and type of containers, preservative information, analysis method, and comments. The chain-of-custody record will link location of the sample from the field notes to the laboratory receipt of the sample. The laboratory will use the sample information to populate the Laboratory Information Management Systems database for each sample.

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SAP Worksheet #28-1—Laboratory QC Sample Table

Matrix: Soil / Groundwater
Analytical Group: PFAS
Analytical Method/SOP Reference: PFAS by LC/MS/MS Compliant with DoD QSM 5.1.1 Table B-15/SOP 5-369-04

QC Sample	Frequency/Number	Method/ SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	MPC
Aqueous Sample Preparation	Each sample and associated batch QC samples.	Solid Phase Extraction (SPE) must be used unless samples are known to contain high PFAS concentrations (e.g., AFFF formulations). Inline SPE is acceptable. Samples of known high PFAS concentrations can be prepared by serial dilution instead of SPE, with documented project approval.	N/A		N/A	
Soil and Sediment Sample Preparation	Each sample and associated batch QC samples.	Entire sample received by the laboratory must be homogenized prior to subsampling.	N/A		N/A	
Sample Cleanup Procedure using ENVI-Carb or equivalent	Each sample and associated batch QC samples. Not applicable to AFFF formulation samples.	Removal of interferences from matrix.	N/A		Bias/Contamination	
Method Blank	One per prep batch of 20 or fewer samples of similar matrix; or one per day, whichever comes first	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 method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, the data must be qualified and explained in the case narrative.		Bias/ Contamination	
LCS	One per prep batch of 20 or fewer samples of similar matrix; or one per day, whichever comes first	Blank spiked with all analytes at a concentration ≥LOQ and ≤ the mid-level calibration concentration. DoD QSM v. 5.1.1 limits; (**Worksheet #15**)	Correct problem. Reprep and reanalyze the LCS and all samples in the associated preparatory batch, if sufficient sample material is available. If reanalysis cannot be performed, the data must be qualified and explained in the case narrative.	Analyst/ Laboratory Project Manager	Precision/ Accuracy/Bias	Same as Method/ SOP QC Acceptance Limits
MS/MSD	One per prep batch of 20 or fewer samples of similar matrix; or one per day, whichever comes first	Sample spiked with all analytes at a concentration ≥LOQ and ≤ the mid-level calibration concentration. DoD QSM v. 5.1.1 limits; (See **Worksheet #15** for control limits) RPD ≤ 30%	Examine the project specific requirements. Contact the client as to additional measures to be taken. For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.		Precision/ Accuracy/Bias	
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 aliquot(s) of sample at the final dilution(s) reported for sample with all analytes that have reported value of “<LOQ” in the final dilution. The spike must be at the LOQ concentration to be reported with the sample (the “<LOQ” value). When analyte concentrations are calculated as “<LOQ,” the spike must recover within 70-130% of its true value.	When analyte concentrations are calculated as “<LOQ,” and the spike recovery does not meet the 70-130% acceptance criteria, the sample, sample duplicate, and post spike sample must be reanalyzed at consecutively higher dilutions until the criteria is met.		N/A	
Extracted Internal Standard	Every field sample, spiked sample, standard, blank, and QC sample.	Added to sample prior to extraction. For aqueous samples prepared by serial dilution instead of Solid Phase Extraction, added to samples prior to analysis. Extracted Internal Standard Analyte recoveries must be within 50% to 150% of the true value.	If recoveries are acceptable for QC samples, but not field samples, the field samples must be reprepped and reanalyzed (greater dilution may be needed). If recoveries are unacceptable for the QC samples, correct the problem, and reanalyze all associated filed samples.		Precision/ Accuracy/Bias	

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

Matrix: Soil / Groundwater
Analytical Group: PFAS
Analytical Method/SOP Reference: PFAS by LC/MS/MS Compliant with DoD QSM 5.1.1 Table B-15/SOP 5-369-04

QC Sample	Frequency/Number	Method/ SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	MPC
Injected Internal Standards	Every field sample, spiked sample, standard, blank, and QC sample	Added to aliquot of sample dilutions, QC samples, and standards just prior to analysis. Peak areas must be within -50% to +50% of the area measured in the ICAL midpoint standard. On days when ICAL is not performed, the peak areas must be within -50% to +50% of the peak area measured in daily initial CCV.	If peak areas are unacceptable, analyze a second aliquot of the extract or sample if enough extract remains. If there is not enough extract, reanalyze the first aliquot. If second analysis meets acceptance criteria, report the second analysis. If it fails, either analysis may be reported with the appropriate flags.		Accuracy	
LOD verification	Quarterly for every analyte	Spike a quality system matrix at concentration 2 to 4x the DL. Must meet 3:1 signal-to-noise ratio, or for data systems that do not measure noise, results must be at least 3 standard deviations greater than the mean method blank concentration.	If verification fails, the DL determination must be repeated and a LOD verification. Alternatively pass two consecutive LOD verification at a higher spike and at the LOD at the higher concentration.		Accuracy	
LOQ verification	Quarterly for every analyte	Spike a quality system matrix at a concentration equal to or greater than the low point of the calibration curve.	Must meet laboratory-specified precision and bias limits. If LOQ fails, repeat at a higher level until limits are met.		Precision/Bias	

SAP Worksheet #29—Project Documents and Records Table

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

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SAP Worksheet #30—Analytical Services Table

Matrix	Analytical Group	Sample Locations/ID	Analytical Method	Data Package Turnaround Time	Laboratory/ Organization	Backup Laboratory/ Organization
Groundwater	PFAS	Refer to **Worksheets #18** and **#20**	LC/MS/MS Compliant with DoD QSM v. 5.1.1, Table B-15[1]	Stage 1: 14 days Stage 2: 28 days Stage 3: 28 days Stage 4: Grab sample during drilling 3 days, monitoring well sample 28 days	Battelle Analytical Services 141 Longwater Drive Suite 202 Norwell, MA 02061 POC: Jonathan Thorn (781) 681-5565	For PFAS: Vista Analytical
Soil				Stage 2, 3, 4: 28 days		

Notes:
[1] Analytical method is compliant with DoD QSM v. 5.1.1 Table B-15 or the most recent version of the DoD QSM for which Battelle has DoD ELAP certification.

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SAP Worksheet #31—Planned Project Assessments Table

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

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SAP Worksheet #32—Assessment Findings and Corrective Action Responses

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

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SAP Worksheet #32-1—Laboratory Corrective Action Form

Person initiating CA: ____ Date: ____________

Description of problem and when identified:

____
____
____
____
____

Cause of problem, if known or suspected:

____
____
____
____
____

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

____
____
____
____
____

CA implemented by: ______________________________ Date: ____________________

CA initially approved by: ______________________________ Date: ____________________

Follow-up date: ______________________________

Final CA approved by: ______________________________ Date: ____________________

Information copies to:

Anita Dodson, CH2M Navy CLEAN Program Chemist

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SAP Worksheet #32-2—Field Performance Audit Checklist

Project Responsibilities

Project No.: ______________________ Date: ______________________

Project Location: ______________________ Signature: ______________________

Team Members

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

Comments ______________________

____

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

Comments ______________________

____

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

Comments ______________________

____

Sample Collection

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

Comments ______________________

____

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

Comments ______________________

____

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

Comments ______________________

____

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

Comments ______________________

____

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

Comments ______________________

____

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

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

Yes No 7) Are photographs taken and documented?
Comments ____________________
____

Document Control

Yes No 1) Have any accountable documents been lost?
Comments ____________________
____

Yes No 2) Have any accountable documents been voided?
Comments ____________________
____

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

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

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

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

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

SAP Worksheet #32-3—Safe Observation Report

Project Observation Information					
Project Name:			**Project Manager:**		
Project #:			**Health & Safety Mgr.:**		
Office Observation Information					
Office:					
Observation Information					
Observer Name:		**Company:**		**Date & Time:**	
Position/Title of worker observed:		**Company:**			
Observation Type:	☐ Safe Behavior ☐ Safe Condition ☐ Unsafe Behavior ☐ Unsafe Condition ☐ Opportunity for Improvement ☐ Other (specify):				
Work or Task Observed:					
Describe Observation:					
Type of incident prevented?					
WPS (*see table below):	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5				
Remedial Action Taken?	☐ Not Applicable ☐ No ☐ Yes (describe):				
Further Action Needed?	☐ No Action ☐ Outstanding Action ☐ Urgent Action (describe action needed):				

SAP Worksheet #32-3—Safe Observation Report (continued)

For any incident with a WPS greater than 3, or when futher action is necessary, notify your HSM/EM and AM/Supervisor as soon as possible.

Worst Potential Severity Table

WPS	Injury -Illness	Environment	Property Damage
5	Fatality or total permanent disability	Serious offsite impact, significant remediation required	USD$> 3 million
4	Partial disability; life changing; intensive care	Significant offsite impact, some remediation required	USD$ 300K-3 million
3	Urgent treatment, surgery	Release significantly above reportable limit of some local impact	USD$ 30K-300K
2	Medical treatment to prevent deterioration	Release above reportable limit or minor impact	USD$ 3K-30k
1	Simple, immediate treatment	Small release contained onsite and no impact	USD$ less than 3K

SAP Worksheet #33—QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, and so forth)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
Field Audit Report	One during sampling event	TBD	AM CH2M	Included in project files
QA Management Report/Technical Memorandum	Once results have been assessed for data usability	To be submitted with Final Phase 2 SI Report	AM CH2M	NAVFAC Northwest RPM and will be posted in project file.

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

Data Review Input	Description[c]	Responsible for Verification or Validation	Step I/IIa/IIb[a]	Internal/ External[b]
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	FTL/CH2M	Step I	Internal
Chains-of-Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain of custody forms will be initialed by the reviewer, a copy of the chains of custody forms retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chain of custody forms will also be reviewed for adherence to the SAP by the PC.	FTL/CH2M PC/CH2M	Step I	Internal and External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the PC in the form of laboratory logins.	PC/CH2M	Step I	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the PC. Documentation will be incorporated into the case narrative, which becomes part of the final hard copy data package.	PC/CH2M	Step I	External
EDDs	EDDs will be compared against hard copy laboratory results (10 percent check). If errors are found during the 10% check, an additional 25% of the EDDs will be checked against hard copy laboratory results.	PC/CH2M	Step I	External
Case Narrative	Case narratives will be reviewed by the DV during the DV process. This is verification that they were generated and applicable to the data packages.	DV	Step I	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Laboratory QAO	Step I	Internal
Laboratory Data	The data will be verified for completeness by the PC. To ensure completeness, EDDs will be compared to the SAP. This is a verification that all samples were included in the laboratory data and that correct analyte lists were reported.	PC/CH2M	Step I	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If CAs are required, a copy of the documented CA taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and CA forms will be reviewed internally to ensure that all appropriate CAs have been taken and that CA reports are attached. If CAs have not been taken, the site manager will be notified to ensure action is taken.	AM/CH2M PC/CH2M	Step I	Internal
CA Reports	CA reports will be reviewed by the PC or AM and placed into the project file for archival at project closeout.	AM/CH2M PC/CH2M	Step I	External
Laboratory Methods	During the pre-validation check, ensure that the laboratory analyzed samples using the correct methods specified in the SAP. If methods other than those specified in the SAP were used, the reason will be determined and documented.	PC/CH2M	Step IIa	External
Target Compound List and Target Analyte list	During the pre-validation check, ensure that the laboratory reported all analytes from each analysis group as per **Worksheet #15**. If the target compound list is not correct, then it must be corrected prior to sending the data for validation. Once the checks are complete, the project manager is notified via email	PC/CH2M	Step IIa	External
Laboratory Limits (DL/LOD/LOQ)	During the pre-validation check, the laboratory limits (DL/LOD/LOQ) will be compared to those listed in the project SAP. If limits were not met, the laboratory will be contacted and asked to provide an explanation, which will then be discussed in the associated project report. Often times the cause for minor laboratory limit deviation from those presented in the SAP is due to the quarterly update of laboratory LOD.	PC/CH2M	Step IIb	External
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed. Any such discrepancies will be discussed first in the data validation narrative and will be included in the associated project report.	Laboratory QAO	Step I	Internal
Sample Chronology	Holding times from collection to extraction or analysis and from extraction to analysis will be considered during the data validation process.	DV	Step IIa and IIb	External
Raw Data	Ten percent Stage 4 review of raw data to confirm laboratory calculations. For a recalculated result, the DV attempts to re-create the reported numerical value. The laboratory is asked for clarification if a discrepancy is identified, which cannot reasonably be attributed to rounding. In general, this is outside five percent difference. Conduct a ten percent review of laboratory calculations. For a recalculated result, the DV attempts to recreate the reported numerical value. The laboratory is asked for clarification if a discrepancy is found, which cannot be reasonably attributed to rounding. If errors are found during the 10% check, an additional 20 percent of the raw data will be checked to confirm calculations. Any discrepancies will be addressed in the data validation narrative.	DV	Step IIa	External
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records. Screening data will be included in the project report.	FTL/CH2M	Step IIb	Internal

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

Data Review Input	Description[c]	Responsible for Verification or Validation	Step I/IIa/IIb[a]	Internal/ External[b]
Documentation of Method QC Results	Establish that all required QC samples were run and met limits. Any deviations will be reported in the data validation narrative.	DV	Step IIa	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run and met limits and discuss QC sampling in the associated project report.	PC/CH2M	Step IIa	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	PC/CH2M	Step I	External
Analytical data for Geotechnical Parameters	Data is for screening purposes only and will be reviewed by project chemist and project team.	PC/CH2M	Step I	Internal
Analytical data for PFAS analyzed for soil and groundwater[d]	Analytical methods and laboratory SOPs as presented in this SAP will be used to evaluate compliance against QA/QC criteria. Should adherence to QA/QC criteria yield deficiencies, data may be qualified. Data may be qualified if QA/QC exceedances have occurred. Guidance and qualifiers from *United States Department of Defense General Data Validation Guidelines* (DoD, 2018) will be applied as appropriate. As specific modules for the analytical methods in this project are published, the data validators will refer to those modules for guidance. In the meantime, if specific guidance is not given for these methods in the General Data Validation Guidelines, the data validator may adapt the guidance from *USEPA National Functional Guidelines for Superfund Organic Methods Data Review* (USEPA, 2017), may also be applicable.	DV	Step IIa and IIb	External

Notes:

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

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

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

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

SAP Worksheet #37—Usability Assessment

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

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

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

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

SAP Worksheet #37—Usability Assessment (continued)

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

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

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

Identify the personnel responsible for performing the usability assessment.

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

References

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USEPA. 2005. *Uniform Federal Policy for Quality Assurance Project Plans: Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs - Part 1: UFP-QAPP Manual.* Intergovernmental Data Quality Task Force. EPA-505-B-04-900A. Final Version 1. March.

USEPA. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4.* EPA/240/B-06/001. February.

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Figures

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Figure 10-1
Base Location Map
Naval Air Station Whidbey Island
Coupeville, Washington

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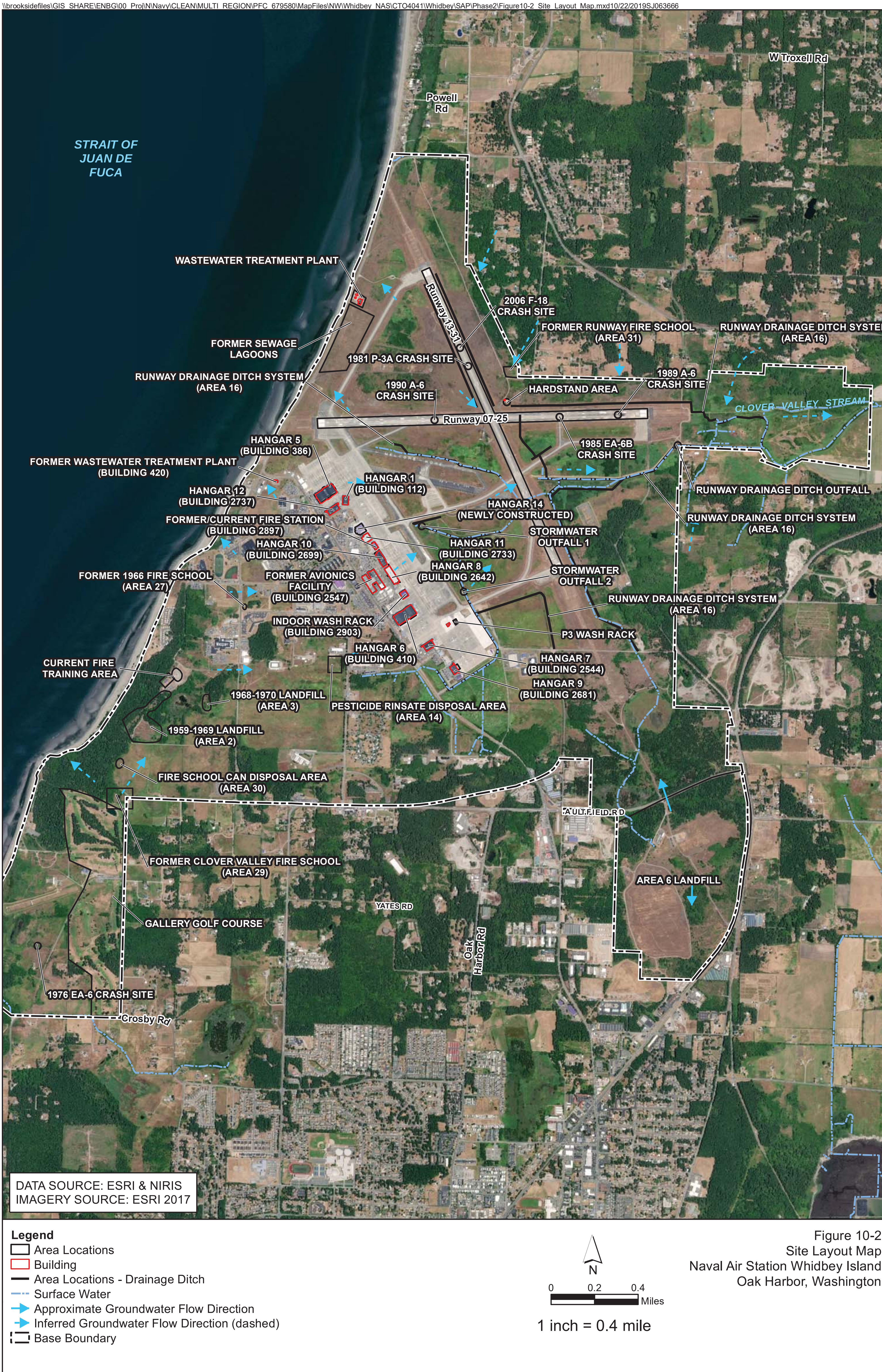

Figure 10-2
Site Layout Map
Naval Air Station Whidbey Island
Oak Harbor, Washington

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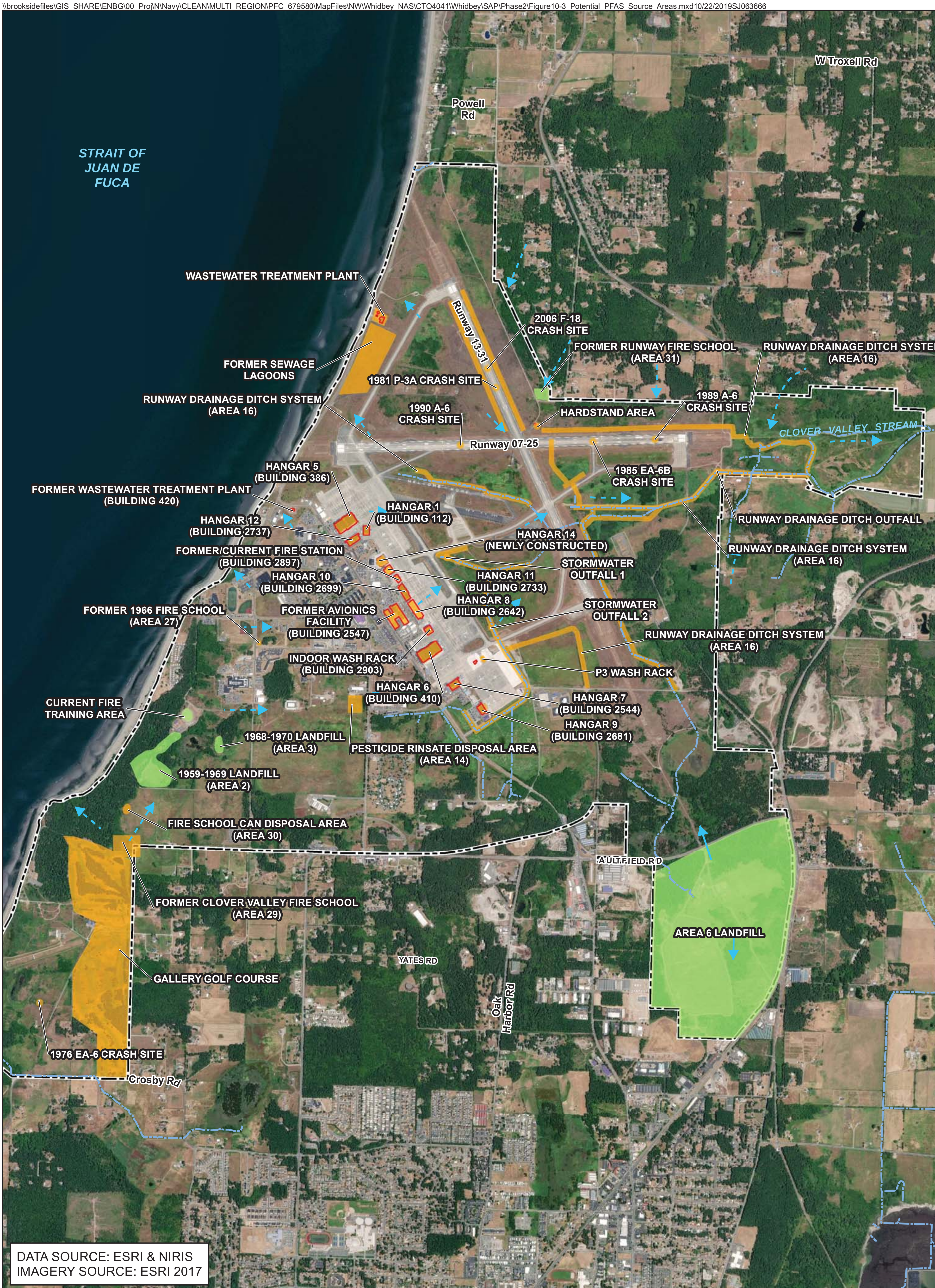

Legend

- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Building
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

N

0 0.2 0.4 Miles

1 inch = 0.4 mile

Figure 10-3
Potential PFAS Source Areas
Naval Air Station Whidbey Island
Oak Harbor, Washington

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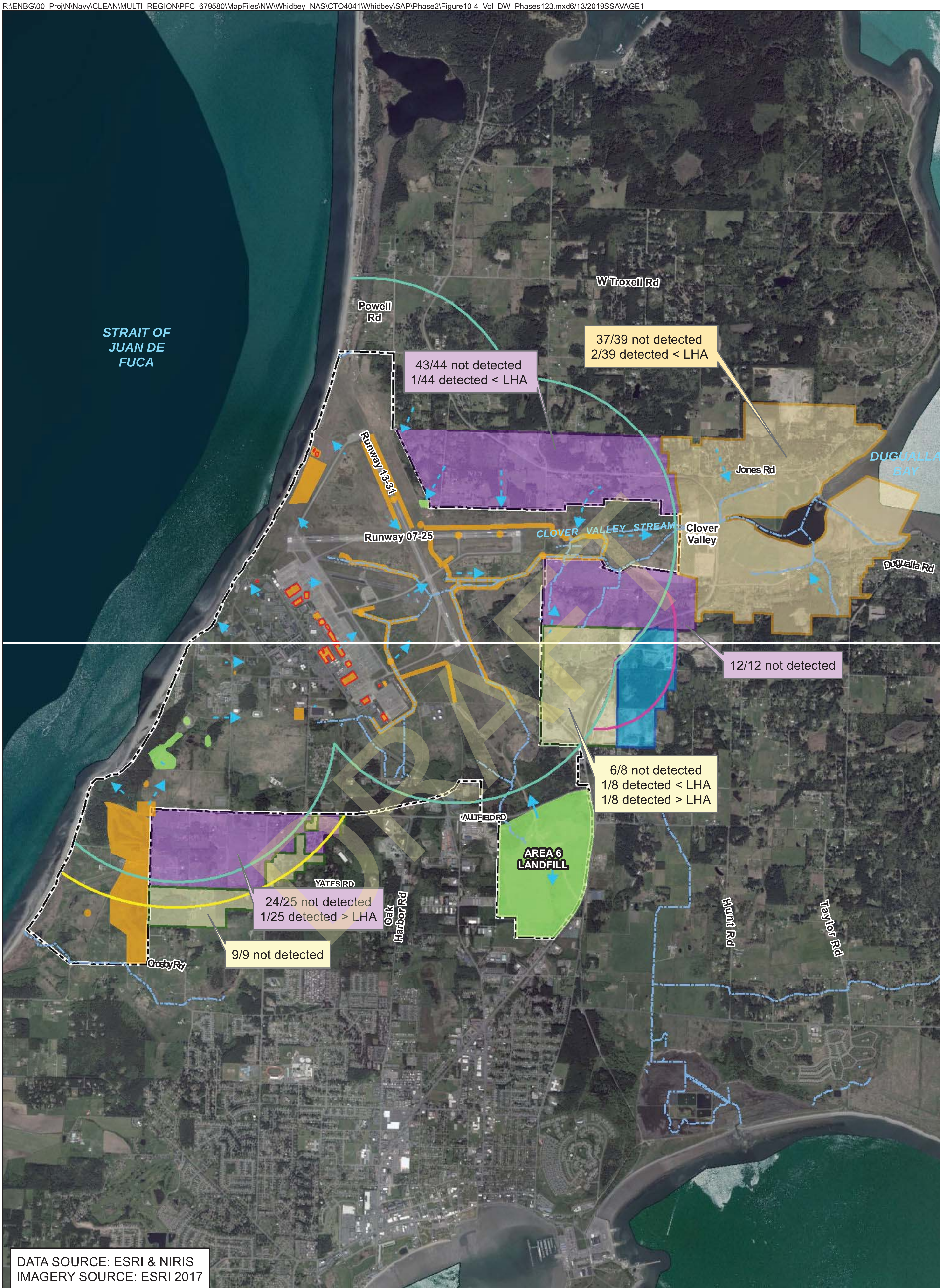

Legend

- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Building
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- 1-mile Zone
- Half-mile Step-out Downgradient (Phase 2)
- Half-mile Step-out Downgradient (Phase 3)
- Phase 1 Sampling Area
- Phase 2 Sampling Area
- Phase 3 Sampling Area
- Phase 4 Sampling Area
- Base Boundary

N

0 0.3 0.6 Miles

1 inch = 0.6 mile

Figure 10-4
Phase 1, 2, 3, and 4 Voluntary Drinking Water Sampling Program - Results Summary
Naval Air Station Whidbey Island
Oak Harbor, Washington

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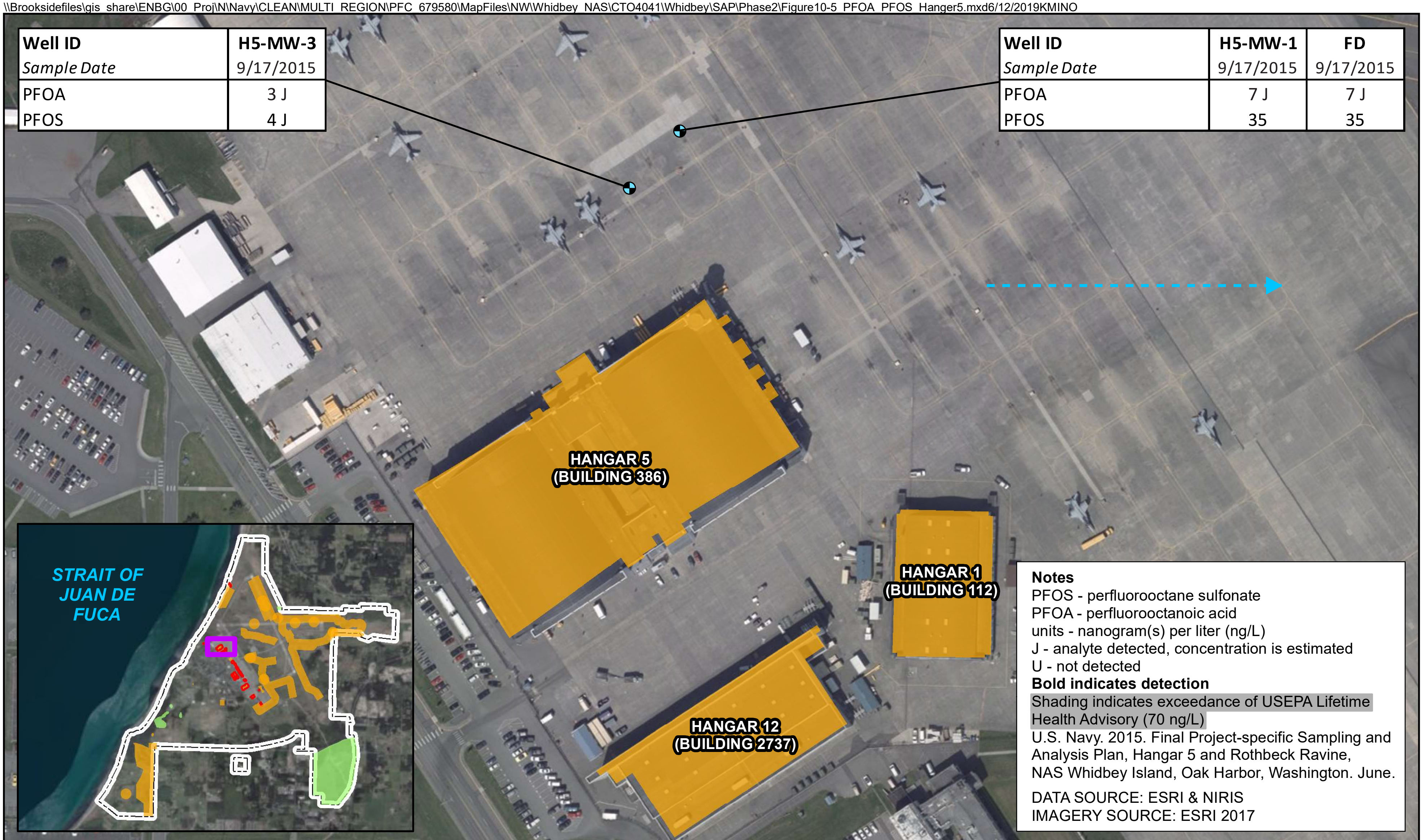

Well ID *Sample Date*	**H5-MW-3** 9/17/2015
PFOA	3 J
PFOS	4 J

Well ID *Sample Date*	**H5-MW-1** 9/17/2015	**FD** 9/17/2015
PFOA	7 J	7 J
PFOS	35	35

Notes
PFOS - perfluorooctane sulfonate
PFOA - perfluorooctanoic acid
units - nanogram(s) per liter (ng/L)
J - analyte detected, concentration is estimated
U - not detected
Bold indicates detection
Shading indicates exceedance of USEPA Lifetime Health Advisory (70 ng/L)
U.S. Navy. 2015. Final Project-specific Sampling and Analysis Plan, Hangar 5 and Rothbeck Ravine, NAS Whidbey Island, Oak Harbor, Washington. June.

DATA SOURCE: ESRI & NIRIS
IMAGERY SOURCE: ESRI 2017

Legend
- Monitoring Well Location
- Inferred Groundwater Flow Direction (dashed)
- Phase 2 SI: Potential Source Area
- Base Boundary

N

0 100 200 Feet

1 inch = 200 feet

Figure 10-5
Well Locations and PFOA and PFOS in Groundwater - Hangar 5 Area, September 2015
Naval Air Station Whidbey Island
Oak Harbor, Washington

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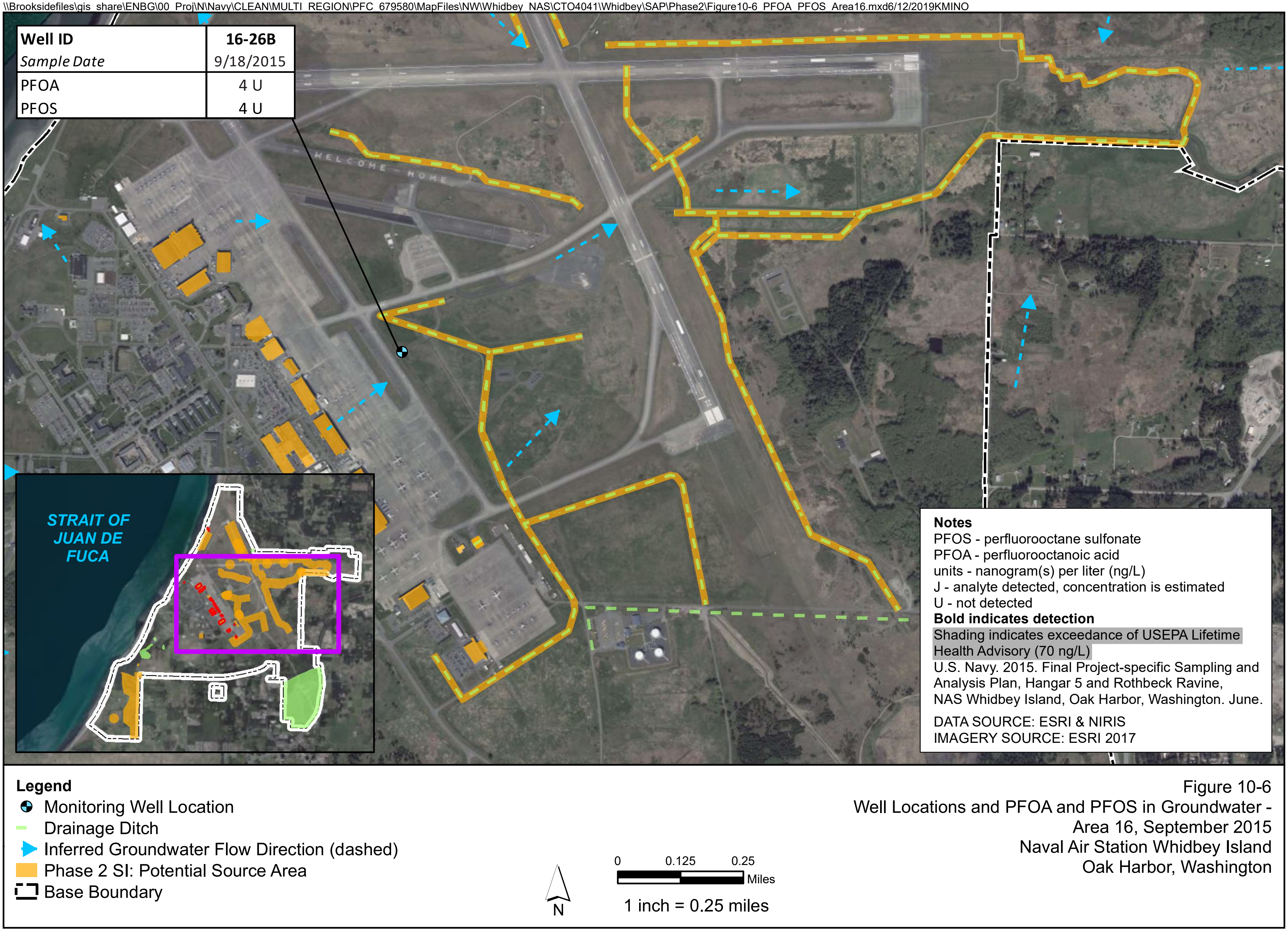

Well ID	16-26B
Sample Date	*9/18/2015*
PFOA	4 U
PFOS	4 U

Notes
PFOS - perfluorooctane sulfonate
PFOA - perfluorooctanoic acid
units - nanogram(s) per liter (ng/L)
J - analyte detected, concentration is estimated
U - not detected
Bold indicates detection
Shading indicates exceedance of USEPA Lifetime Health Advisory (70 ng/L)
U.S. Navy. 2015. Final Project-specific Sampling and Analysis Plan, Hangar 5 and Rothbeck Ravine, NAS Whidbey Island, Oak Harbor, Washington. June.

DATA SOURCE: ESRI & NIRIS
IMAGERY SOURCE: ESRI 2017

Legend
Monitoring Well Location
Drainage Ditch
Inferred Groundwater Flow Direction (dashed)
Phase 2 SI: Potential Source Area
Base Boundary

Figure 10-6
Well Locations and PFOA and PFOS in Groundwater - Area 16, September 2015
Naval Air Station Whidbey Island
Oak Harbor, Washington

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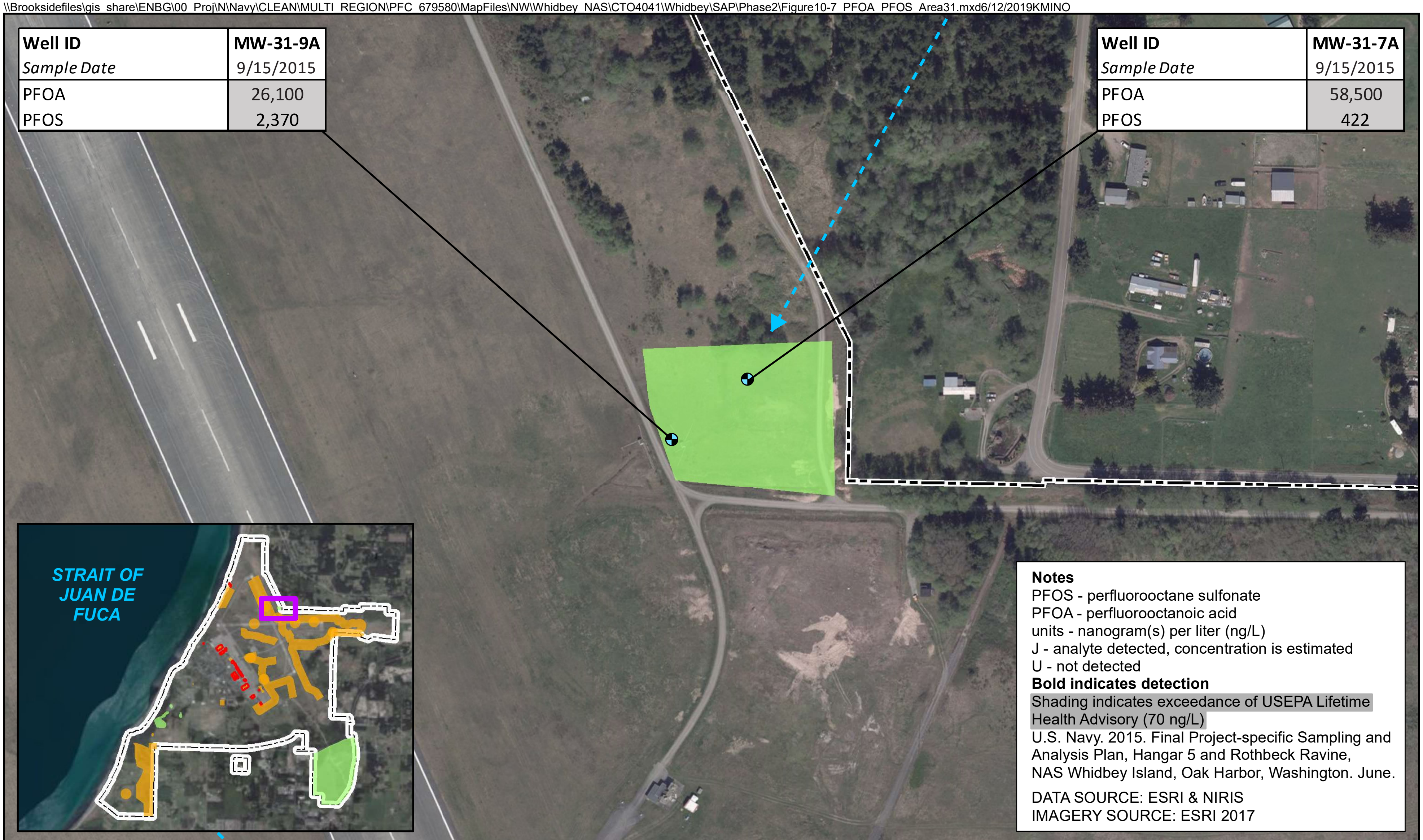

Legend

- Monitoring Well Location
- Inferred Groundwater Flow Direction (dashed)
- Future RI: Potential Source Area
- Base Boundary

N

0 125 250 Feet

1 inch = 250 feet

Figure 10-7
Well Locations and PFOA and PFOS in Groundwater - Area 31, September 2015
Naval Air Station Whidbey Island
Oak Harbor, Washington

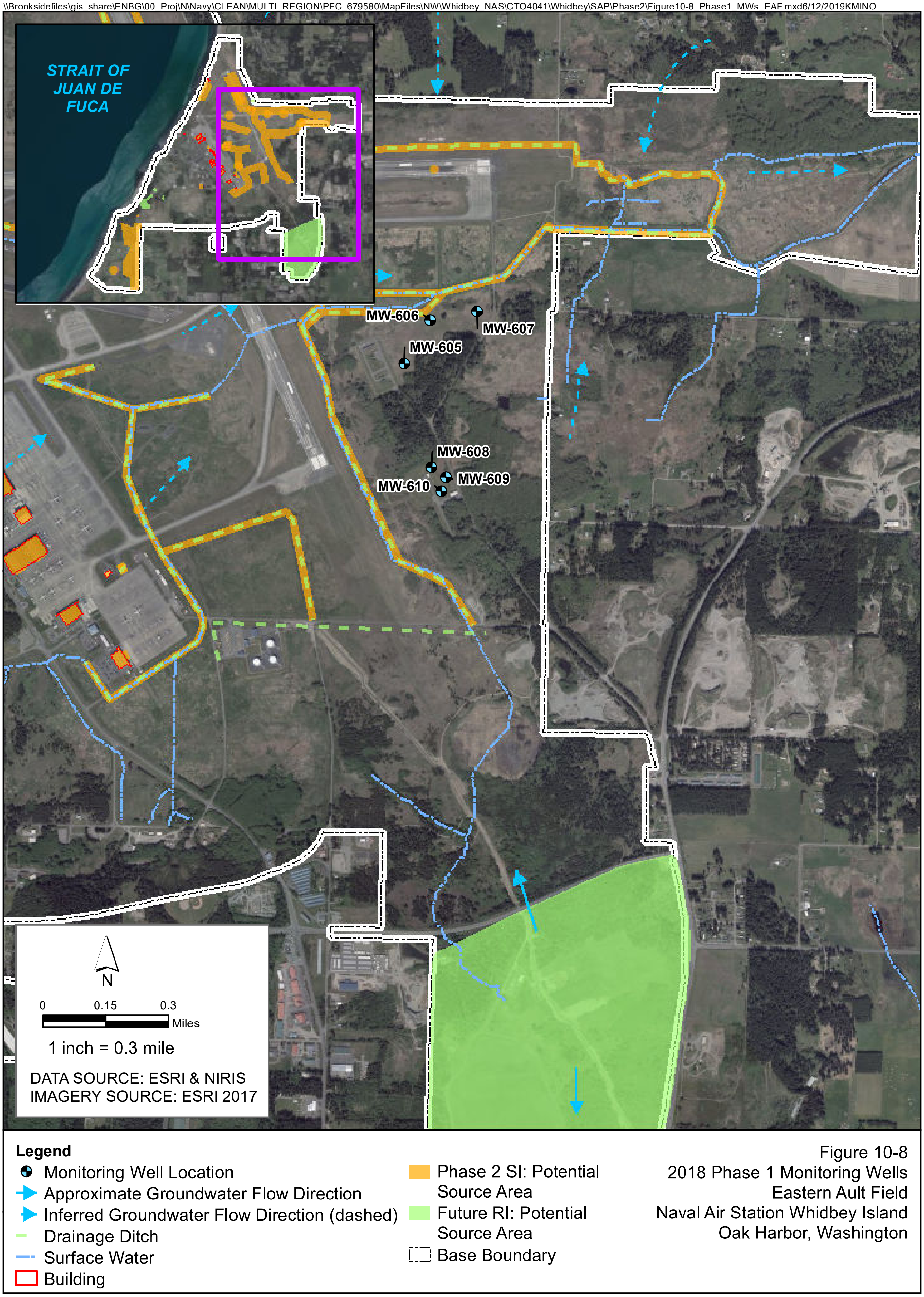

Figure 10-8
2018 Phase 1 Monitoring Wells
Eastern Ault Field
Naval Air Station Whidbey Island
Oak Harbor, Washington

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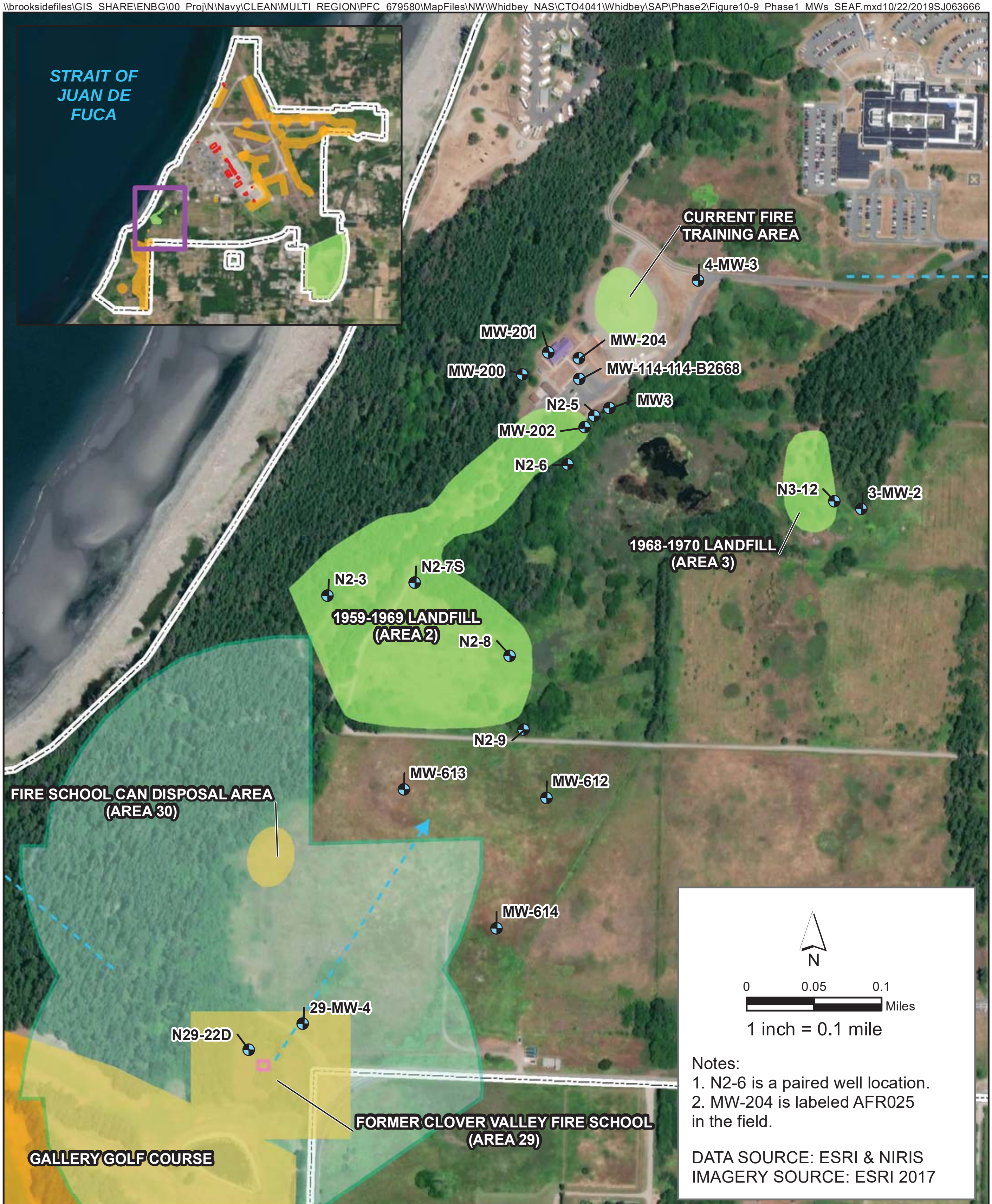

Legend

- Monitoring Well Location
- Inferred Groundwater Flow Direction (dashed)
- Building
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Mobile Turret Tower Range
- Base Boundary

Figure 10-9
2018 Phase 1 Monitoring Wells
Southwestern Ault Field
Naval Air Station Whidbey Island
Oak Harbor, Washington

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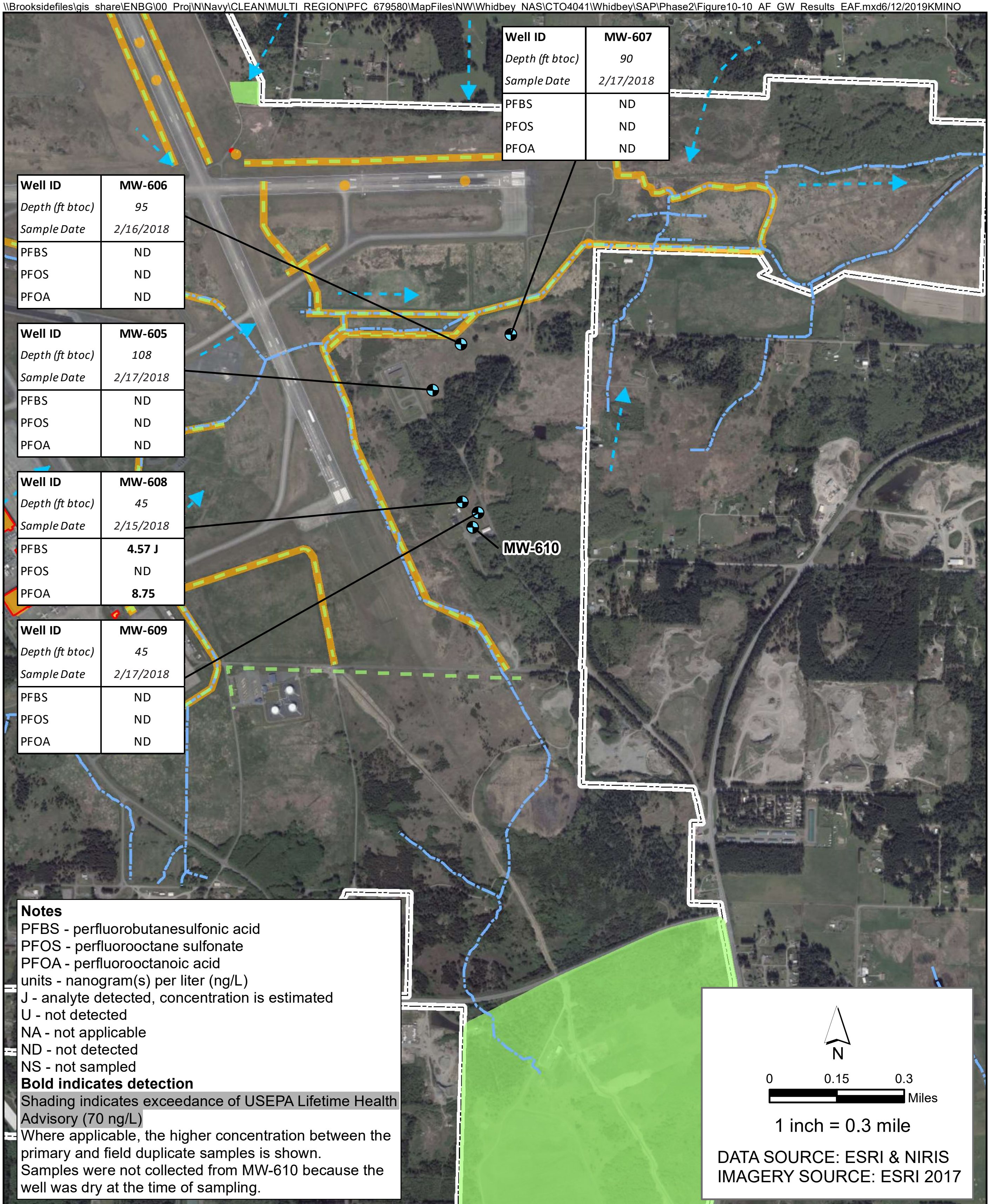

Legend

- Monitoring Well Location
- Inferred Groundwater Flow Direction (dashed)
- Drainage Ditch
- Building
- Base Boundary
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area

Figure10-10
2018 Phase 1 Sample Results
Summary Eastern Ault Field
Naval Air Station Whidbey Island
Oak Harbor, Washington

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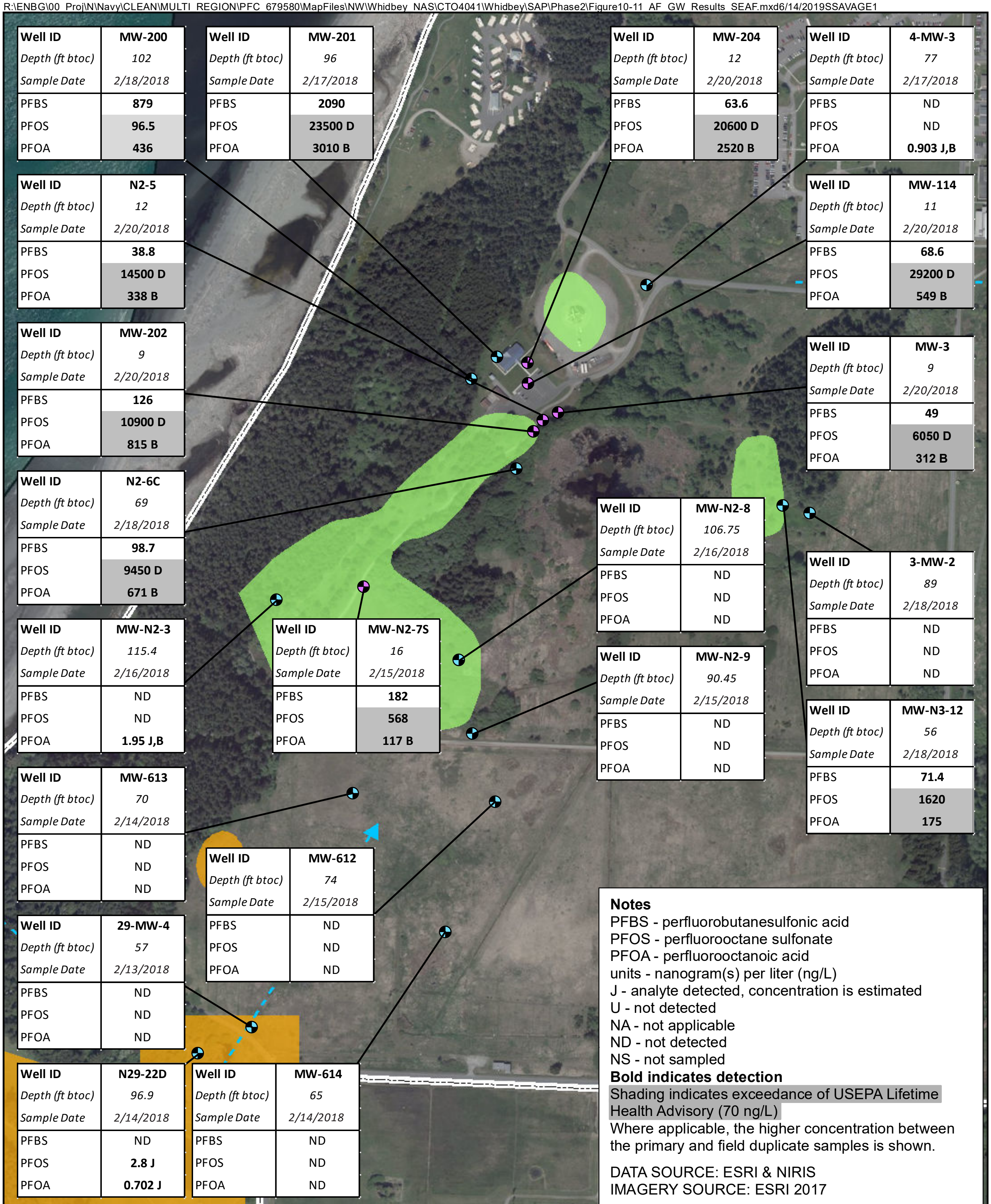


Legend

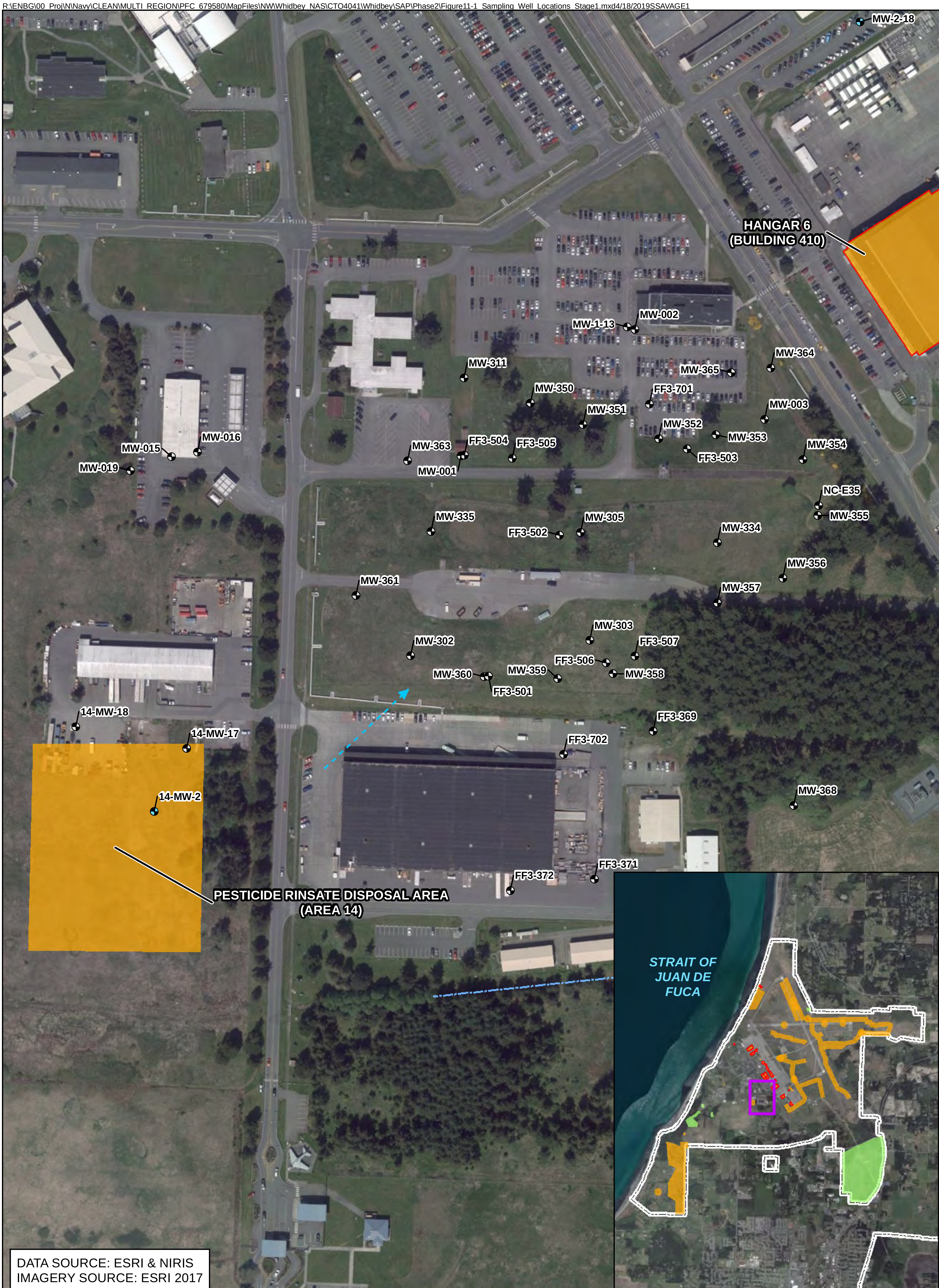
- Monitoring Well Location
- Samples Collected from Shallow Portion of Aquifer
- Inferred Groundwater Flow Direction (dashed)
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Base Boundary

N

0 0.05 0.1 Miles

1 inch = 0.1 mile

Figure 10-11
2018 Phase 1 Sample Results
Summary Southwestern Ault Field
Naval Air Station Whidbey Island
Oak Harbor, Washington



Legend

- Phase 2 SI Monitoring Well Sample Location
- Monitoring Well Location
- Surface Water
- Inferred Groundwater Flow Direction (dashed)
- Building
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Base Boundary

N

0 90 180 Feet

1 inch = 180 feet

Figure 11-1
Sampling Well Locations - Stage 1
Naval Air Station Whidbey Island
Oak Harbor, Washington

Legend
- Phase 2 SI Monitoring Well Sample Location
- Monitoring Well Location
- Surface Water
- Inferred Groundwater Flow Direction (dashed)
- Building
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Base Boundary

N

0 62.5 125 Feet

1 inch = 125 feet

Figure 11-2
Sampling Well Locations - Stage 1
Naval Air Station Whidbey Island
Oak Harbor, Washington

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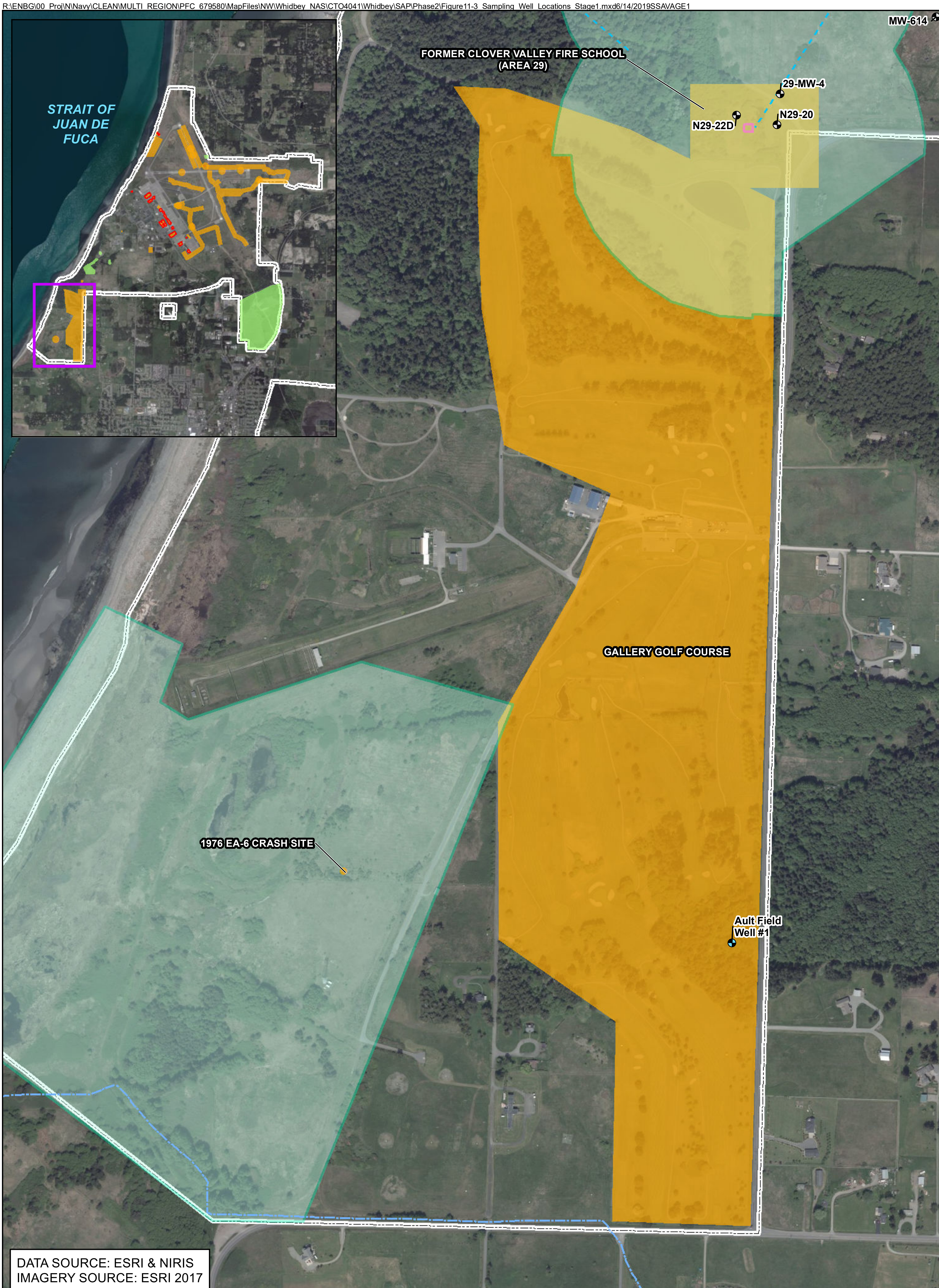

Legend

- Phase 2 SI Monitoring Well Sample Location
- Monitoring Well Location
- Surface Water
- Building
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Mobile Turret Tower Range/Machine Gun Range
- Area 29 Burn Pad
- Base Boundary

N

0 230 460 Feet

1 inch = 450 feet

Figure 11-3
Sampling Well Locations - Stage 1
Naval Air Station Whidbey Island
Oak Harbor, Washington

Figure 11-4
Sampling Well Locations - Stage 2
Naval Air Station Whidbey Island
Oak Harbor, Washington

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DATA SOURCE: ESRI & NIRIS
IMAGERY SOURCE: ESRI 2017

Legend
- Phase 2 SI Monitoring Well Sample Location
- Monitoring Well Location
- Surface Water
- Inferred Groundwater Flow Direction (dashed)
- Building
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Base Boundary

Figure 11-5
Sampling Well Locations - Stage 2
Naval Air Station Whidbey Island
Oak Harbor, Washington

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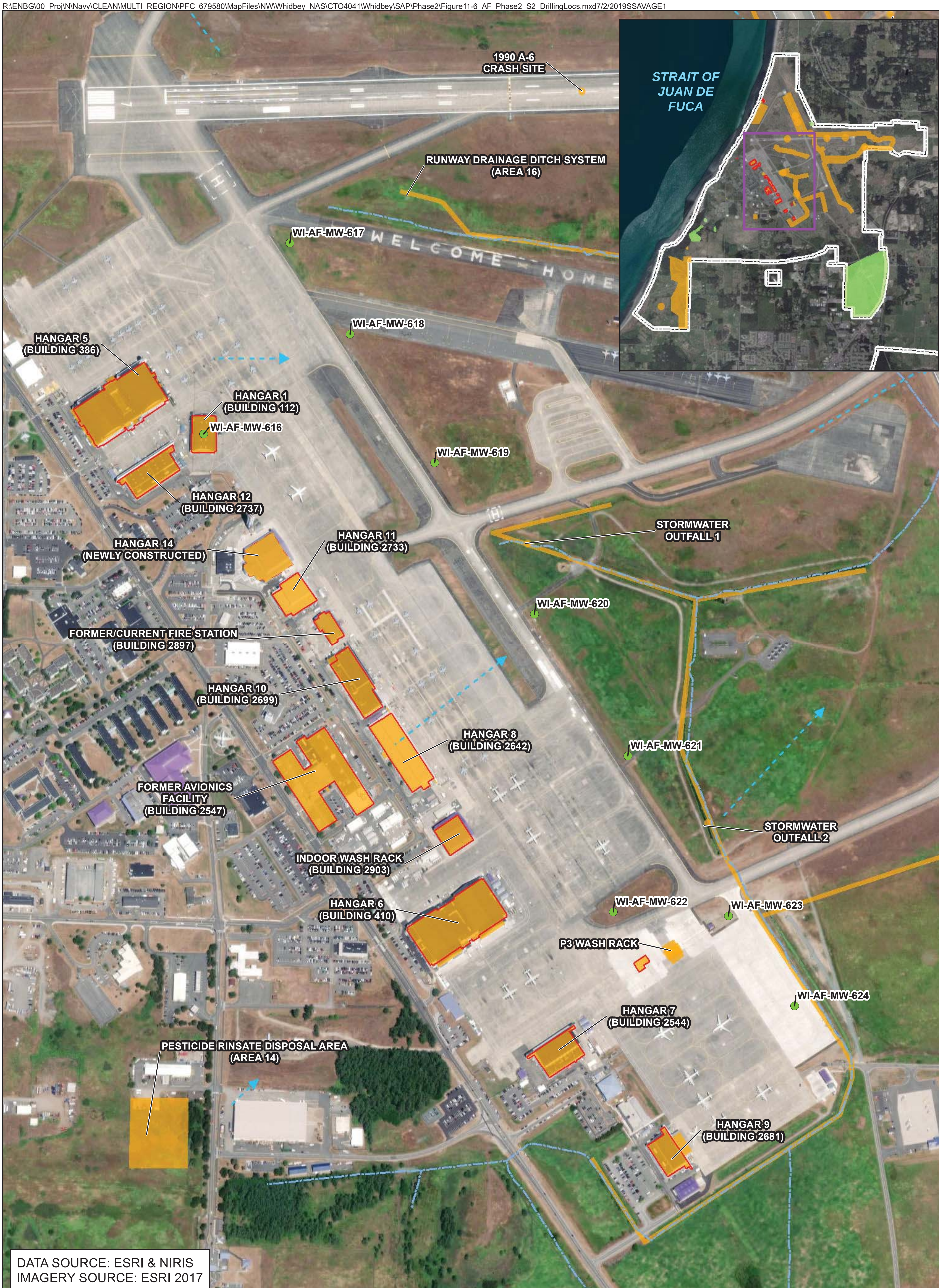

Legend

- New Monitoring Well Location
- Surface Water
- Inferred Groundwater Flow Direction (dashed)
- Building
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Base Boundary

N

0 0.05 0.1 Miles

1 inch = 0.1 mile

Figure 11-6
Ault Field Phase 2 SI; Stage 2 Monitoring Well Locations
Naval Air Station Whidbey Island
Oak Harbor, Washington

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Legend

- Staff Gage
- Dual Completion Well Cluster
- Inferred Groundwater Flow Direction (dashed)
- Surface Water
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Building
- Base Boundary

SG-01 - Stage Gauge Location
PZ-01-01 - Piezometer Well Sample Location

N

0 0.08 0.16 Miles

1 inch = 0.16 mile

Figure 11-7
Ault Field Phase 2 SI; Stage 3 Field Activity Locations
Naval Air Station Whidbey Island
Oak Harbor, Washington

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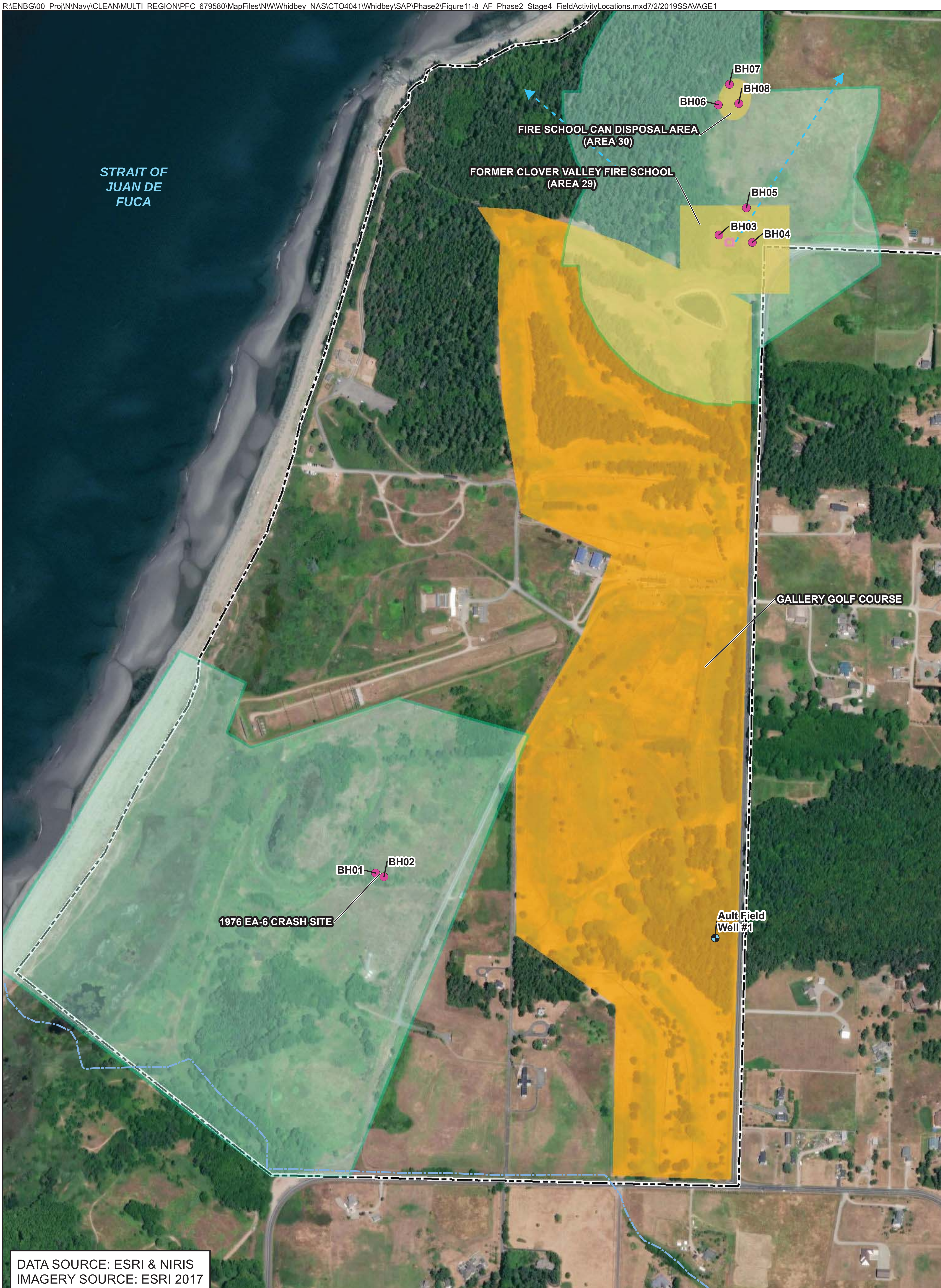

Legend

- Phase 2 SI Monitoring Well Sample Location
- Boring Location
- Surface Water
- Inferred Groundwater Flow Direction (dashed)
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Area 29 Burn Pad
- Mobile Turret Tower Range/Machine Gun Range
- Base Boundary

N

0 0.05 0.1 Miles

1 inch = 0.1 mile

Note:
Groundwater wells will be installed at the boring location if PFOA, PFOS, and/or PFBS is detected in groundwater.

Figure 11-8
Ault Field Phase 2 SI; Stage 4 Field Activity Locations
Naval Air Station Whidbey Island
Oak Harbor, Washington

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Legend

- Boring Location
- Phase 2 SI: Potential Source Area
- Future RI: Potential Source Area
- Building
- Surface Water
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

Note:
Groundwater wells will be installed at the boring location if PFOA, PFOS, and/or PFBS is detected in groundwater.

N

0 100 200 Feet

1 inch = 200 feet

Figure 11-9
Ault Field Phase 2 SI; Stage 4 Field Activity Locations
Naval Air Station Whidbey Island
Oak Harbor, Washington

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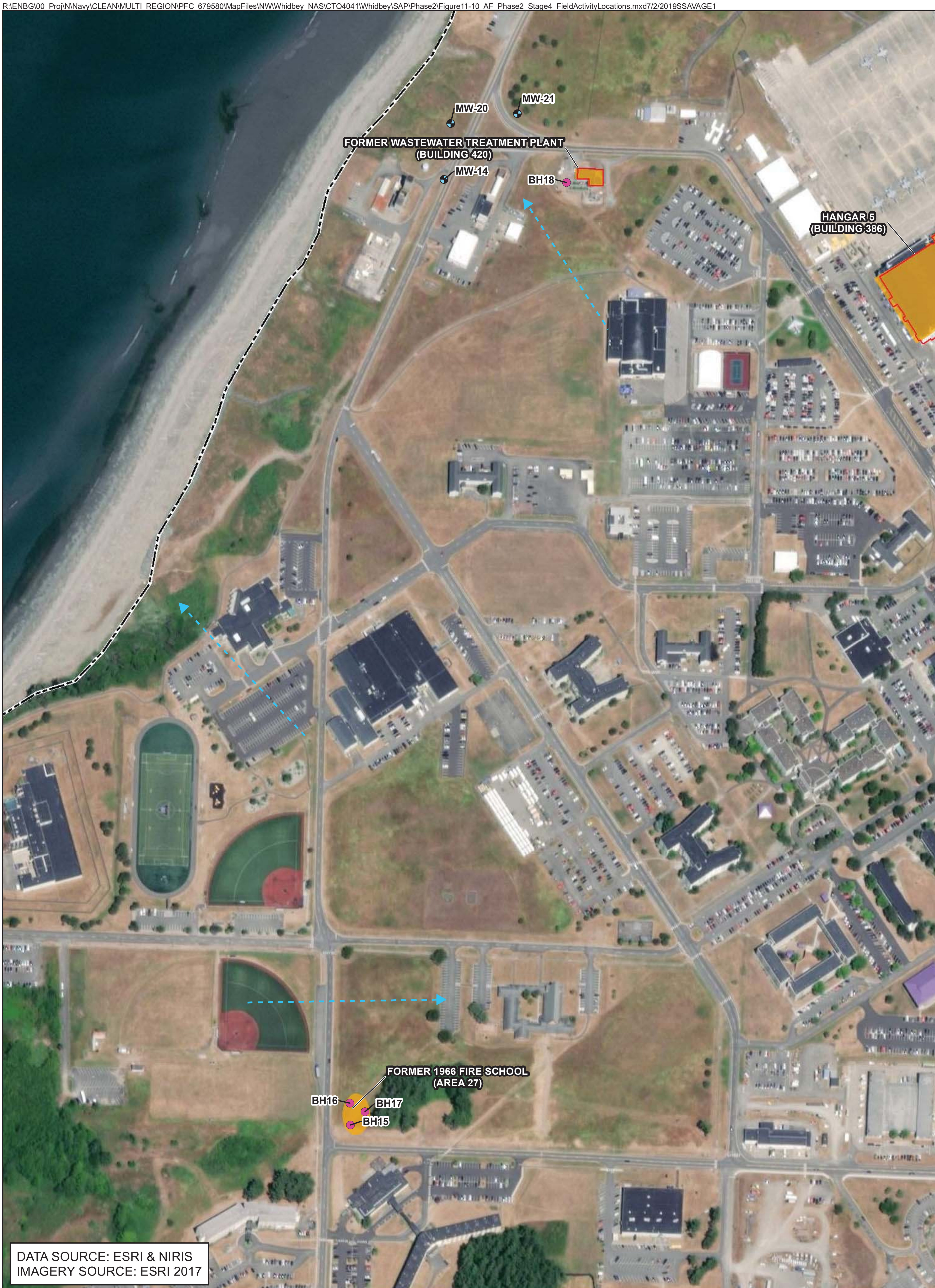

Legend

- Phase 2 SI Monitoring Well Sample Location
- Boring Location
- Surface Water
- Inferred Groundwater Flow Direction (dashed)
- Building
- Phase 2 SI: Potential Source Area
- Base Boundary

Note:
Groundwater wells will be installed at the boring location if PFOA, PFOS, and/or PFBS is detected in groundwater.

N

0 75 150 300
Feet

1 inch = 300 feet

Figure 11-10
Ault Field Phase 2 SI: Stage 4 Field Activity Locations
Naval Air Station Whidbey Island
Oak Harbor, Washington

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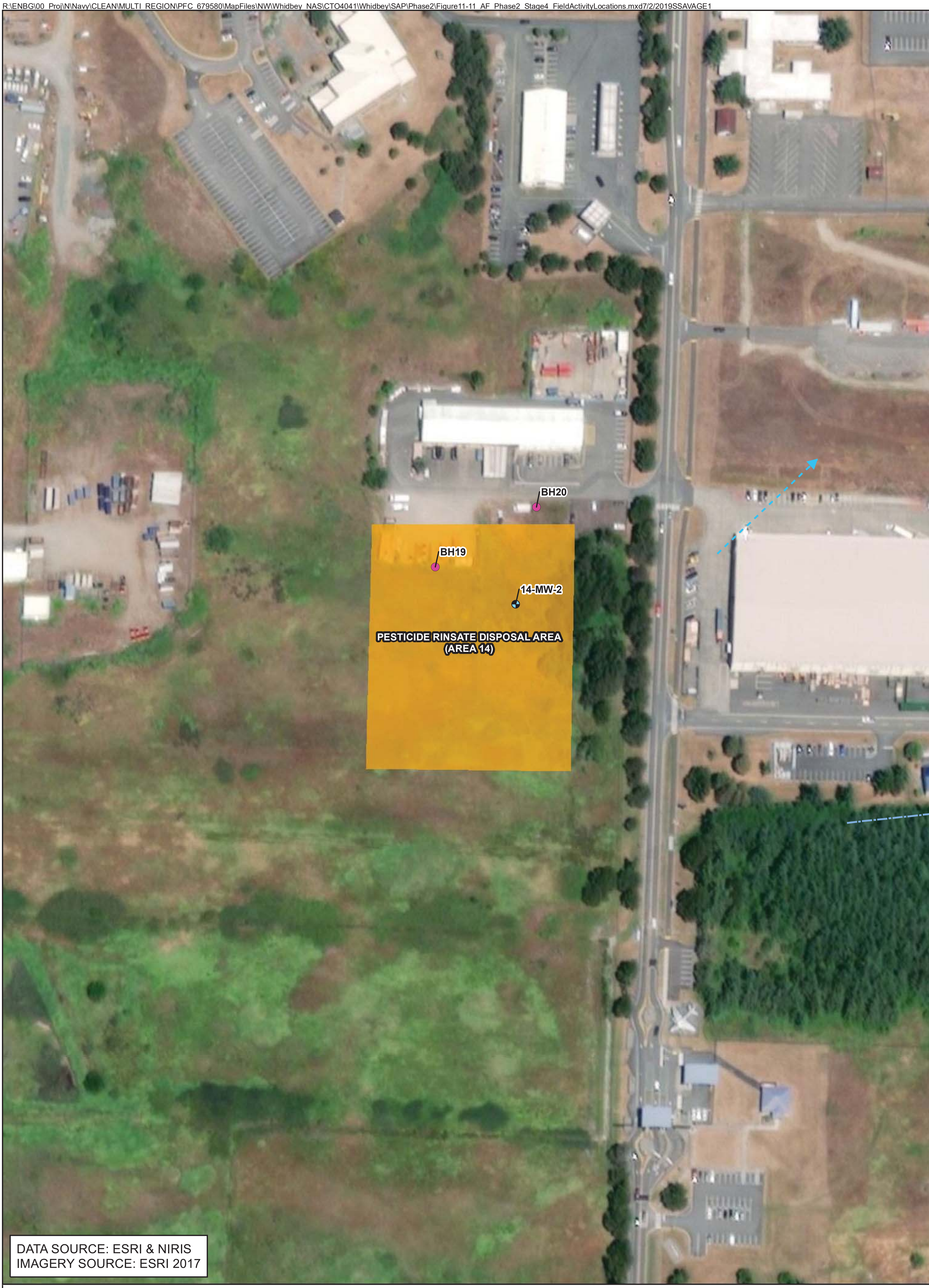


Legend

- Phase 2 SI Monitoring Well Sample Location
- Boring Location
- Surface Water
- Inferred Groundwater Flow Direction (dashed)
- Phase 2 SI: Potential Source Area
- Base Boundary

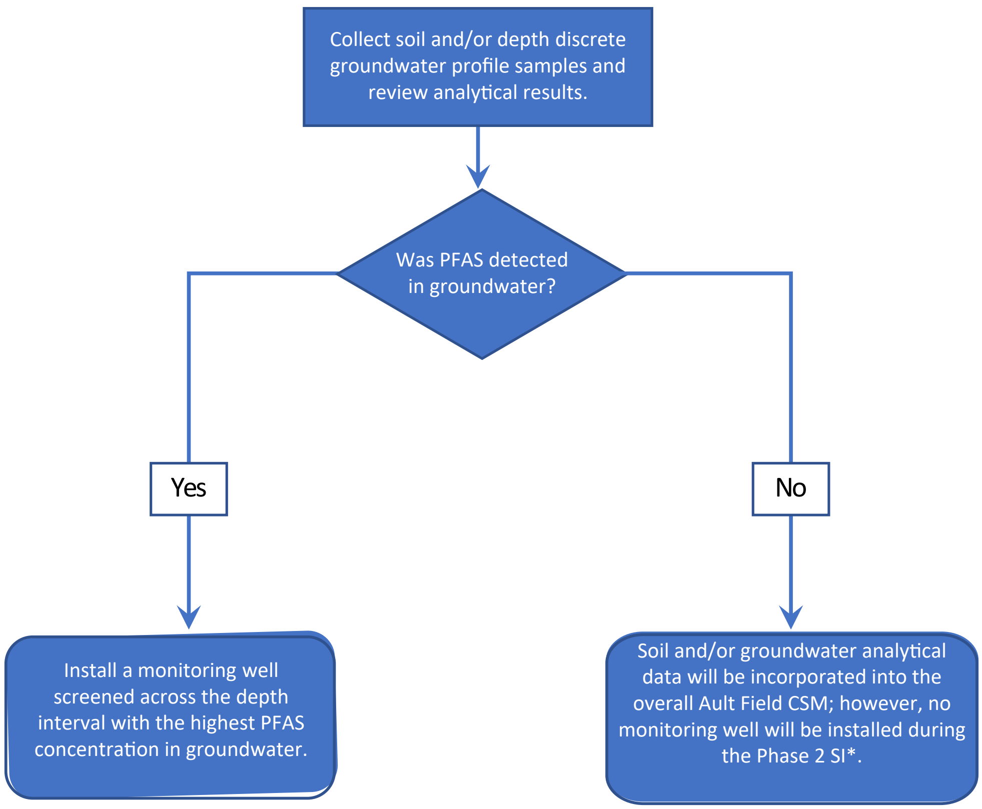
N

0 75 150 Feet

1 inch = 150 feet

Figure 11-11
Ault Field Phase 2 SI: Stage 4 Field Activity Locations
Naval Air Station Whidbey Island
Oak Harbor, Washington

Note:
Groundwater wells will be installed at the boring location if PFOA, PFOS, and/or PFBS is detected in groundwater.



NOTES:
* The potential PFAS source area may be considered during future RI activities.

Figure 11-12.
Decision Logic for Conversion of Borings to Monitoring Wells During Stage 4 Field Effort
NAS Whidbey Island
Oak Harbor, Washington

Appendix A
Approach Plan

Ault Field Pre-Phase Site 2 Inspection Approach Plan
Naval Air Station Whidbey Island

Subject	**NASWI Ault Field Pre-Phase 2 Site Inspection Approach Plan**
Attention	Kendra Leibman/NAVFAC NW
From	Peter Lawson/RDD
Date	March 7, 2019
Copies to	Jennifer Madsen/SEA, Janice Horton/SEA, Heather Perry/RDD

Introduction

The activities outlined in this Approach Plan (AP) will be conducted in support of the Ault Field Phase 2 PFAS Site Inspection (SI) activities tentatively scheduled for August and September 2019. Figure 1 is an overview of locations on Ault Field with existing wells near potential PFAS source areas. There are two objectives for the activities being conducted under this AP:

1. Conduct a groundwater level survey of existing well clusters to determine which wells are downgradient of potential PFAS source areas identified in the Ault Field Preliminary Assessment (PA) (**Table 1 and Figures 2-4**).
2. Conduct a groundwater level survey of existing well clusters in areas not associated with PA areas, or in areas where presence/absence of PFAS has been confirmed during Ault Field Phase 1 SI activities to better understand Base-wide groundwater flow direction. (**Table 2 and Figures 5-9**).

The results of the activities outlined in this AP will be used to determine specific groundwater monitoring wells to be sampled during Phase 2 SI, Stage 1, and to support selection of sample locations for Stage 4 activities. This AP will be included in the Phase 2 SI UFP-SAP as an Appendix, and the findings of activities conducted under this AP will be included in the Phase 2 SI UFP-SAP as rationale for determining Stage 1 selected wells and Stage 4 sampling locations.

Ault Field Desktop Evaluation of Existing Groundwater Monitoring Well Clusters (Former WWTP (Building 420), Northern Hangars, Former Fuel Farm (Area 13) and Pesticide Rinsate Area (Area 14), Rothboeck Ravine, Former Fuel Farm 4)

A desktop evaluation of monitoring well construction details and top-of-casing elevations was performed to identify monitoring wells to be prioritized during the groundwater level survey and in-field groundwater flow calculations. The prioritized monitoring wells are included in **Table 1** and **Figures 2-4**.

Ault Field Groundwater Level Survey and Elevation Data Collection

A groundwater level survey will be conducted for wells identified during the desktop evaluation. During the survey, groundwater levels will be recorded, abandoned or dry wells identified, and calculations of groundwater flow directions will be conducted to identify monitoring wells viable for Phase 2 SI, Stage 1 groundwater sampling, and to determine areas where no wells exist downgradient of potential PFAS release areas that would require additional investigation during Phase 2, Stage 4. Additionally, monitoring well clusters previously sampled under the Phase 1 SI will also have groundwater elevation data collected. These additional clusters are located at Areas 2, 3, and 29, Current Fire Training Area, Walker Barn Storage Area, and wells installed during the Phase 1 SI activities (MW-605 through MW-610, MW-612 through MW-614) **(Figures 7-9).** This data will be used to gain a better understanding of groundwater level information in the areas of the Base where limited groundwater flow direction data exist. Monitoring wells to be included in the groundwater level survey are included in **Table 2 and Figures 5-9.**

Table 1-Objective 1 Selected Wells

Well ID	Area	Easting	Northing	GS Elevation	TOC Elevation	TD Elevation	SI Top	SI Bottom	GW Elev	GW Elev Date	Priority
MW-2	Former WWTP (Building 420)	1191446	496711	25.85	25.85				2.51		1
MW-7 - 7	Former WWTP (Building 420)	1191604	496824	25.46	25.46				2.78		1
MW-18/ SITE 52 LOC 18	Former WWTP (Building 420)	1191195	496345.4	124.78	19.66				2.97		1
MW-17	Former WWTP (Building 420)	1191421	496449.5	121.81	121.81				2.99	11/1/95	2
MW-14	Former WWTP (Building 420)	1191688	496846.1	120.19	120.19				3.01	11/1/95	2
MW-12	Former WWTP (Building 420)	1191336	496735.1	122.04	122.04				2.19	11/1/95	2
MW-11	Former WWTP (Building 420)	1191402	496612.1	122.31	122.31				2.9	11/1/95	2
MW-102	Northern Hangars (1, 5, and 12)	1193677	495809.8	20.24	20.03	-7.23					1
MW-106	Northern Hangars (1, 5, and 12)	1193664	495773.4	19.52	19.26	-4.48					1
MW-107 - 107	Northern Hangars (1, 5, and 12)	1193703	495739.5	18.69	18.05	-3.31					1
MW-103 - 103 - B0384	Northern Hangars (1, 5, and 12)	1193549	495572.5	14.64	14.41	-1.36					1
MW3-B4	Northern Hangars (1, 5, and 12)	1193655	495795.4	20.08	19.95	1.08					1
MW5-B5	Northern Hangars (1, 5, and 12)	1193426	495761.5	17.05	123.43	-4.35					2
MW10-B8	Northern Hangars (1, 5, and 12)	1193434	495858.4	18.73	124.87	2.73					2
MW-305	Former Fuel Farm (Area 13) and Pesticide Rinsate Area (Area 14)	1194494	493018	50.31	53.05	-7.69					1
MW-303	Former Fuel Farm (Area 13) and Pesticide Rinsate Area (Area 14)	1194512	492808.2	44.41	46.85	-3.59					1
MW-302	Former Fuel Farm (Area 13) and Pesticide Rinsate Area (Area 14)	1194164	492778.2	45.13	47.86	1.6					1
MW-356	Former Fuel Farm (Area 13) and Pesticide Rinsate Area (Area 14)	1194887	492928.8	39.03	39.03	-1.27					2
MW-354	Former Fuel Farm (Area 13) and Pesticide Rinsate Area (Area 14)	1194926	493159.6	37.19	37.19	-0.81					2
MW-334	Former Fuel Farm (Area 13) and Pesticide Rinsate Area (Area 14)	1194760	492997.8	47.7	47.7	0.2					2
MW-352	Former Fuel Farm (Area 13) and Pesticide Rinsate Area (Area 14)	1194646	493199.5	30.77	33.25	2.77					2

Table 2-Objective 2 Selected Wells

Well ID	Area	Easting	Northing	GS Elevation	TOC Elevation	TD Elevation	SI Top	SI Bottom	GW Elev	GW Elev Date	Priority
MW-2-11	Former Fuel Farm 4	1196091	489826.4	58.01	60.93	30.01					1
MW-107	Former Fuel Farm 4	1196011	489758.4	65.55	68.3	33.55					1
MW-115 - 115	Former Fuel Farm 4	1196128	490157.4	38.74	38.64	28.24					1
MW-113 - 113 - B0491	Former Fuel Farm 4	1196099	490114.4	38.76	38.4	28.76					1
MW-110	Former Fuel Farm 4	1196140	489541.5	94.02	96.83	29.02					1
RR-MW-1	Rothboeck Ravine	1201493	492334.5	129.08	132.21	79.08	89.08	99.08	86.25	7/1/15	1
RR-MW-2	Rothboeck Ravine	1201517	492179.7	128.95	131.82	78.95	88.95	98.95	86.82	7/1/15	1
RR-MW-3	Rothboeck Ravine	1201475	492538.7	114.94	117.76	77.94	87.94	97.94	85.57	7/1/15	1
RR-MW-4	Rothboeck Ravine	1201306	492447.8	105.21	107.83	78.21	88.21	98.21	77.63	7/1/15	1
RR-MW-5	Rothboeck Ravine	1201292	492248.2	103.72	106.66	77.22	87.72	97.72	77.62	7/1/15	1
4-MW-3	Walker Barn Storage Area	1190041	492262.6	82.83	85.21	0.05	13.83	3.83	15.88	2/1/18	
MW-114 - 114 - B2668	Current Fire Training Area	1189577	491877.3	96.1	95.29	82.1	88.1	78.1	87.35	2/1/18	
MW-200	Current Fire Training Area	1189354	491895.1	93.86	95.92	-13.8			12.47	2/1/18	
MW-201	Current Fire Training Area	1189456	491982.3	97.53	99.65	19.28			13.02	2/1/18	
MW-202	Current Fire Training Area	1189598	491689.5	90.03	89.46	74.75			87.31	2/1/18	
MW-204	Current Fire Training Area	1189576	491958.6	97.17	96.61	78.75			87.14	2/1/18	
MW3	Current Fire Training Area	1189695	491763	89.56	89.33	76.21			87.71	2/1/18	
N2-5/ SITE 2 LOC 105	Current Fire Training Area	1189620	491758.2	91.81	92.91	73.01	84.81	74.81	87.34	2/1/18	
29-MW-4	Area 29	1188495	489353.6	94.266	96.159	30.216	42.266	32.266	38.269	2/1/18	

Table 2-Objective 2 Selected Wells

Well ID	Area	Easting	Northing	GS Elevation	TOC Elevation	TD Elevation	SI Top	SI Bottom	GW Elev	GW Elev Date	Priority
N29-22D	Area 29	1188284	489251.2	95.933	99.521	-5.687	77.933	67.93	6.801	2/1/18	
N2-9	Area 2	1189359	490504.7	86.99	87.56	-11.7	-1.01	-11.01	37.88	2/1/18	
N2-8	Area 2	1189305	490793.7	87.47	87.88	-25.91	-14.53	-24.53	31.51	2/1/18	
N2-7S	Area 2	1188933	491081	96.66	98	76.3	88.66	78.66	90.61	2/1/18	
N2-3	Area 2	1188592	491030.2	121.97	122.4	-0.83	9.97	-0.03	9.94	2/1/18	
N2-6	Area 2	1189532	491543.5	87.55	89.19	13.46	23.55	13.55	30.97	2/1/18	
N3-12	Area 3	1190575	491400	98.25	99.11	39.3	50.25	40.25	47.05	2/1/18	
3-MW-2	Area 3	1190681	491368.7	82.71	84.95	-15.39	-1.29	-11.29	28.07	2/1/18	
MW-605	Phase 1 SI Installed Wells	1200074	496011.7	30.5623	30.269	-90.331	-74.4377	-84.4377	17.079	2/1/18	
MW-606	Phase 1 SI Installed Wells	1200406	496551.2	16.337	16.112	-87.628	-73.663	-83.663	16.112	2/1/18	
MW-607	Phase 1 SI Installed Wells	1200993	496664.6	19.1533	18.895	-85.905	-80.8467	-90.8467	16.515	2/1/18	
MW-608	Phase 1 SI Installed Wells	1200421	494698.5	49.4694	49.184	-5.316	9.4694	-0.5306	18.484	2/1/18	
MW-609	Phase 1 SI Installed Wells	1200607	494571.9	53.0936	52.754	-6.946	8.0936	-1.9064	18.584	2/1/18	
MW-610	Phase 1 SI Installed Wells	1200544	494401.1	56.9908	56.717		16.9908	6.9908	18.927	2/1/18	
MW-612	Phase 1 SI Installed Wells	1189445	490240.1	87.4226	87.143	2.693	18.4226	8.4226	37.863	2/1/18	
MW-613	Phase 1 SI Installed Wells	1188888	490272.5	92.9389	92.688	14.088	28.9389	18.9389	38.048	2/1/18	
MW-614	Phase 1 SI Installed Wells	1189249	489730.1	89.3598	89.108	19.308	30.3598	20.3598	38.048	2/1/18	

Table 3 - Objective 1 Results

Well ID	Area	Easting[a]	Northing[a]	Ground Surface Elevation[a]	Top of Casing Elevation[a]	Depth to Water (feet btoc)	Total Depth (feet btoc)	Casing Stick-up (feet)[b]	Measurement Date	DEM Ground Surface Elevation (feet NAVD88)[c]	Groundwater Elevation (feet NAVD88)[d]	Total Depth Elevation (feet NAVD88)[d]	Comments
MW-2	Former Wastewater Treatment Plant (Building 420)	1191446	496711	25.85	25.85	NM	NM	NM	NM	19.48	NM	NM	Not selected for Stage 1 sampling. Well was not located, accessible, or gauged as an alternate well for this area was identified.
MW-7 - 7	Former Wastewater Treatment Plant (Building 420)	1191604	496824	25.46	25.46	NM	NM	NM	NM	18.05	NM	NM	Not selected for Stage 1 sampling. Well was not located, accessible, or gauged as an alternate well for this area was identified.
MW-11	Former Wastewater Treatment Plant (Building 420)	1191402	496612.1	122.31[e]	122.31[e]	14.54	19.53	-0.325	3/13/2019	19.89	5.03	0.04	Not selected for Stage 1 sampling. Well is not considered downgradient from potential source area based on inferred groundwater flow direction.
MW-12	Former Wastewater Treatment Plant (Building 420)	1191336	496735.1	122.04[e]	122.04[e]	13.06	18.78	-0.325	3/13/2019	19.92	6.54	0.82	Not selected for Stage 1 sampling. Well is not considered downgradient from potential source area based on inferred groundwater flow direction.
MW-14	Former Wastewater Treatment Plant (Building 420)	1191688	496846.1	120.19[e]	120.19[e]	11.38	17.67	-0.325	3/13/2019	16.89	5.19	-1.11	**Selected for Stage 1 sampling**. Inferred groundwater flow in this area is to the west/northwest. Well is downgradient from the potential source area.
MW-17	Former Wastewater Treatment Plant (Building 420)	1191421	496449.5	121.81[e]	121.81[e]	12.85	17.52	-0.325	3/13/2019	19.56	6.39	1.72	Not selected for Stage 1 sampling. Well is not considered downgradient from potential source area based on inferred groundwater flow direction.
MW-18/ SITE 52 LOC 18	Former Wastewater Treatment Plant (Building 420)	1191195	496345.4	124.78[e]	19.66[f]	19.05	23.42	2.4	3/13/2019	21.88	5.23	0.86	Not selected for Stage 1 sampling. Well is not considered downgradient from potential source area based on inferred groundwater flow direction.
MW-20	Former Wastewater Treatment Plant (Building 420)	1191710	497027.9	118.89[e]	118.89[e]	10.32	15.12	-0.2	3/15/2019	15.6	5.08	0.28	**Selected for Stage 1 sampling**. Inferred groundwater flow in this area is to the west/northwest. Well is downgradient from the potential source area.
MW-21	Former Wastewater Treatment Plant (Building 420)	1191927	497059.9	116.36[e]	116.36[e]	7.69	13.8	-0.3	3/15/2019	14.21	6.22	0.11	**Selected for Stage 1 sampling**. Inferred groundwater flow in this area is to the west/northwest. Well is downgradient from the potential source area.
MW1-B2	Northern Hangars (1, 5, and 12)	1193575	495774	19.71	125.84[e]	8.86	18.8	-0.28	3/28/2019	23.59	14.45	4.51	Not selected for Stage 2 sampling. Selected wells are considered sufficient to fulfill the Stage 1 objectives for this area.
MW3-B4	Northern Hangars (1, 5, and 12)	1193655	495795.4	20.08	19.95	6.91	22.96	-0.13	3/13/2019	23.85	16.81	0.76	Not selected for Stage 2 sampling. Selected wells are considered sufficient to fulfill the Stage 1 objectives for this area.
MW4-B3	Northern Hangars (1, 5, and 12)	1193586	495900.1	21.75	128.08[e]	6.66	17.7	-0.23	3/28/2019	25.4	18.51	7.47	**Selected for Stage 2 sampling**. This is a viable well located within the shallow portion of the aquifer and may be downgradient of the potential source area.
MW5-B5	Northern Hangars (1, 5, and 12)	1193426	495761.5	17.05	123.43[e]	5.92	17.44	-0.07	3/28/2019	20.83	14.84	3.32	Not selected for Stage 2 sampling. Selected wells are considered sufficient to fulfill the Stage 1 objectives for this area.
MW10-B8	Northern Hangars (1, 5, and 12)	1193434	495858.4	18.73	124.87[e]	4.95	14.94	-0.41	3/28/2019	22.98	17.62	7.63	**Selected for Stage 2 sampling**. This is a viable well located within the shallow portion of the aquifer and may be downgradient of the potential source area..
MW11-B11	Northern Hangars (1, 5, and 12)	1193570	495657.5	16.81	123.1[e]	7.74	14.91	-0.22	3/28/2019	20.74	12.78	5.61	Not selected for Stage 2 sampling. Selected wells are considered sufficient to fulfill the Stage 1 objectives for this area.
MW15-B23	Northern Hangars (1, 5, and 12)	1193642	495854.8	21.24	127.51[e]	7.76	18.55	-0.34	3/28/2019	24.88	16.78	5.99	**Selected for Stage 2 sampling**. This is a viable well located within the shallow portion of the aquifer and may be downgradient of the potential source area.

Table 3 - Objective 1 Results

Well ID	Area	Easting[a]	Northing[a]	Ground Surface Elevation[a]	Top of Casing Elevation[a]	Depth to Water (feet btoc)	Total Depth (feet btoc)	Casing Stick-up (feet)[b]	Measurement Date	DEM Ground Surface Elevation (feet NAVD88)[c]	Groundwater Elevation (feet NAVD88)[d]	Total Depth Elevation (feet NAVD88)[d]	Comments
MW-101-101	Northern Hangars (1, 5, and 12)	1193505	495669.3	16.55	16.24	5.69	23.82	-0.31	3/28/2019	20.62	14.62	-3.51	Not selected for Stage 2 sampling. Selected wells are considered sufficient to fulfill the Stage 1 objectives for this area.
MW-102	Northern Hangars (1, 5, and 12)	1193677	495809.8	20.24	20.03	9.75	27.57	-0.21	3/13/2019	24.3	14.34	-3.48	Not selected for Stage 2 sampling. Selected wells are considered sufficient to fulfill the Stage 1 objectives for this area.
MW-103 - 103 - B0384	Northern Hangars (1, 5, and 12)	1193549	495572.5	14.64	14.41	5.84	14.94	-0.23	3/12/2019	18.9	12.83	3.73	Not selected for Stage 2 sampling. Selected wells are considered sufficient to fulfill the Stage 1 objectives for this area.
MW-106	Northern Hangars (1, 5, and 12)	1193664	495773.4	19.52	19.26	8.33	23.28	-0.26	3/13/2019	23.25	14.66	-0.29	Not selected for Stage 2 sampling. Selected wells are considered sufficient to fulfill the Stage 1 objectives for this area.
MW-107 - 107	Northern Hangars (1, 5, and 12)	1193703	495739.5	18.69	18.05	9.29	19.27	-0.64	3/13/2019	22.91	12.98	3	Not selected for Stage 2 sampling. Selected wells are considered sufficient to fulfill the Stage 1 objectives for this area.
14-MW-2	Pesticide Rinsate Disposal Area (Area 14)	1193666	492475.8	25.58[g]	29[g]	13.84	45.79	2.35	3/29/2019	30.74	19.25	-12.7	**Selected for Stage 1 sampling**. Former Fuel Farm (Area 13) well is located at/near potential release areas based on the Preliminary Assessment description.
FF3-371	Pesticide Rinsate Disposal Area (Area 14)	1194521	492344.4	21.81	21.81	4.72	24.26	-0.47	3/28/2019	26.07	20.88	1.34	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area.
FF3-372	Pesticide Rinsate Disposal Area (Area 14)	1194358	492322.4	22.37	22.37	4.35	14.73	-0.6	3/28/2019	26.4	21.45	11.07	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area.
FF3-702	Pesticide Rinsate Disposal Area (Area 14)	1194461.46	492586.77	UNK	UNK	13.98	24.61	-0.47	3/28/2019	26.6	12.15	1.52	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area. .
MW-302	Pesticide Rinsate Disposal Area (Area 14)	1194164	492778.2	45.13	47.86	34.55	45.31	2.73	3/12/2019	50.75	18.93	8.17	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area.
MW-303	Pesticide Rinsate Disposal Area (Area 14)	1194512	492808.2	44.41	46.85	38.86	47.03	2.44	3/12/2019	49.31	12.89	4.72	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area.
MW-305	Pesticide Rinsate Disposal Area (Area 14)	1194494	493018	50.31	53.05	45.11	54.63	2.74	3/12/2019	52.56	10.19	0.67	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area.

Table 3 - Objective 1 Results

Well ID	Area	Easting[a]	Northing[a]	Ground Surface Elevation[a]	Top of Casing Elevation[a]	Depth to Water (feet btoc)	Total Depth (feet btoc)	Casing Stick-up (feet)[b]	Measurement Date	DEM Ground Surface Elevation (feet NAVD88)[c]	Groundwater Elevation (feet NAVD88)[d]	Total Depth Elevation (feet NAVD88)[d]	Comments
MW-334	Pesticide Rinsate Disposal Area (Area 14)	1194760	492997.8	47.7	47.7	42.87	50.34	2.49	3/29/2019	51.98	11.6	4.13	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area.
MW-352	Pesticide Rinsate Disposal Area (Area 14)	1194646	493199.5	30.77	33.25	NM	NM	NM	NM	33.45	NM	NM	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area.
MW-354	Pesticide Rinsate Disposal Area (Area 14)	1194926	493159.6	37.19	37.19	NM	NM	NM	NM	40.84	NM	NM	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area.
MW-356	Pesticide Rinsate Disposal Area (Area 14)	1194887	492928.8	39.03	39.03	34.14	42.15	2.34	3/29/2019	43.75	11.95	3.94	Former Fuel Farm (Area 13) well was suspected to be downgradient of Pesticide Rinsate Disposal Area (Area 14) but was not selected for Stage 1 sampling as uncertainty in groundwater flow direction remains for this area.

[a] Unless otherwise noted, survey data originated from NIRIS. Horizontal datum is Washington State Plane, North Zone, North American Datum of 1983, feet; vertical units are feet; vertical datum is unknown.
[b] PVC casing stick-up values in black font were measured relative to the well housing. Negative values indicate top of casing below ground surface, positive values indicate above ground surface. Values in red font were estimated based on the difference between ground surface and top of casing elevations from NIRIS (if not anomalous/unreliable) or the average of measured stick-ups based on well completion type (above ground or flush mount) if NIRIS elevation data are deemed anomalous/unreliable.
[c] Digitial Elevation Model (DEM) ground surface elevation was downloaded from the National Elevation Dataset: https://viewer.nationalmap.gov/basic/ (U.S. Geological Survey, 2012, USGS NED ned19_n48x50_w122x75_wa_puget_sound_2000 1/9 arc-second 2012 15 x 15 minute IMG: U.S. Geological Survey.)
[d] Because of uncertainties relating to the accuracy of the elevation survey data in NIRIS, groundwater and total depth elevations were computed using the measured depths, casing stick-up, and DEM ground surface elevation.
[e] Survey data are anomalous/unreliable.
[f] Surveyed top of casing elevation is from the Operable Unit 5 Remedial Investigation Report (ADD CITATION)
[g] Surveyed elevations are from the Operable Unit 2 Remedial Investigation Report (ADD CITATION)
Notes:
btoc = below top of casing
NAVD88 = North American Vertical Datum of 1988
NM = not measured
UNK = unknown

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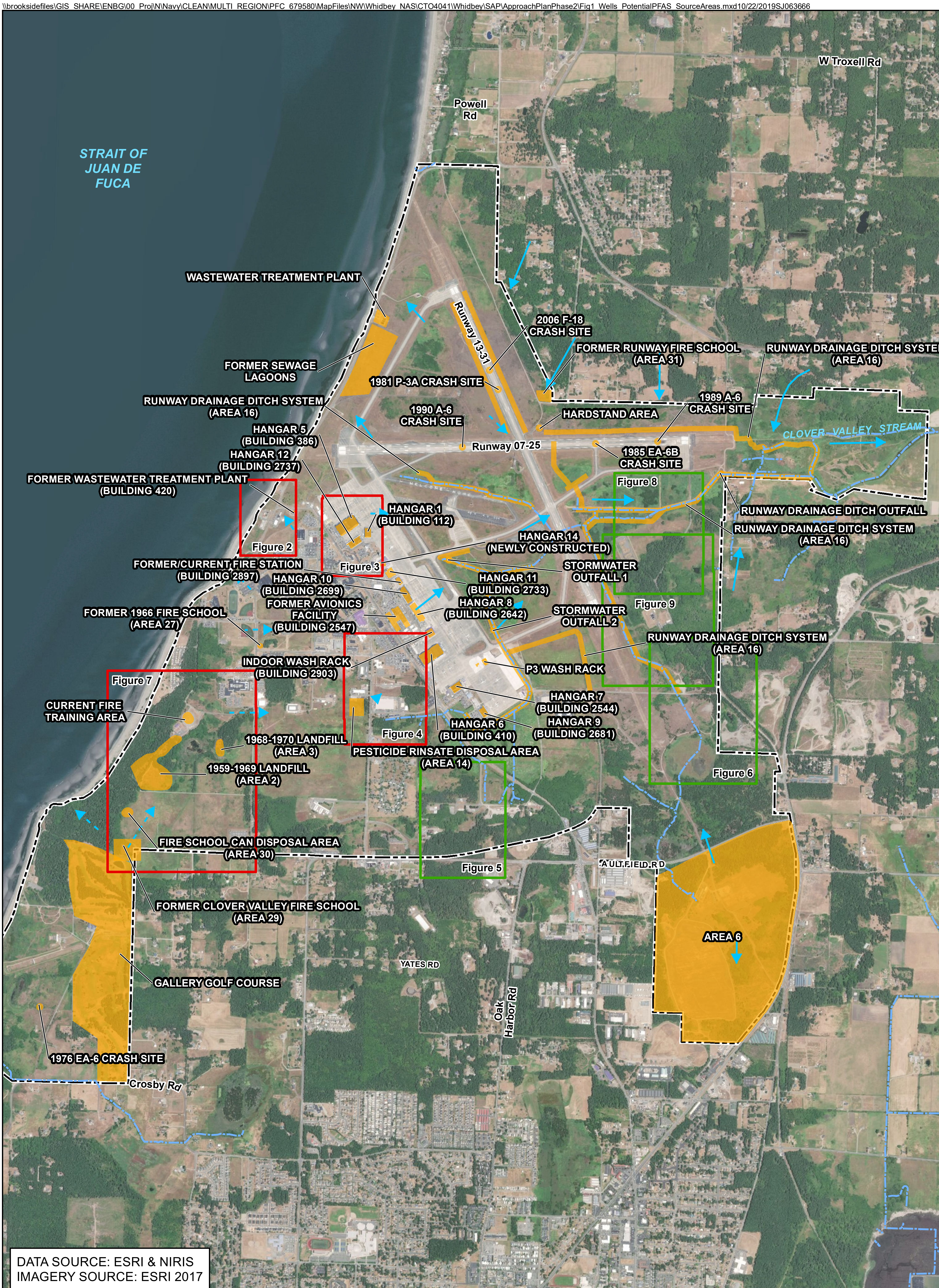

Legend

- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Wells Downgradient of PA Areas
- Wells not in PA Areas
- Potential PFAS Source Area
- Base Boundary

N

0 0.2 0.4 Miles

1 inch = 0.4 miles

Figure 1
Wells and Potential PFAS Source Areas
Naval Air Station Whidbey Island
Oak Harbor, Washington

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Legend

- Monitoring Well
- Potential PFAS Source Area
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

N

0 62.5 125 Feet

1 inch = 125 feet

Figure 2
Former WWTP(Building 420) Wells
Naval Air Station Whidbey Island
Oak Harbor, Washington

Legend

- Monitoring Well
- Potential PFAS Source Area
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

N

0 65 130 Feet

1 inch = 133.333333 feet

Figure 3
Northern Hangars Wells
Naval Air Station Whidbey Island
Oak Harbor, Washington

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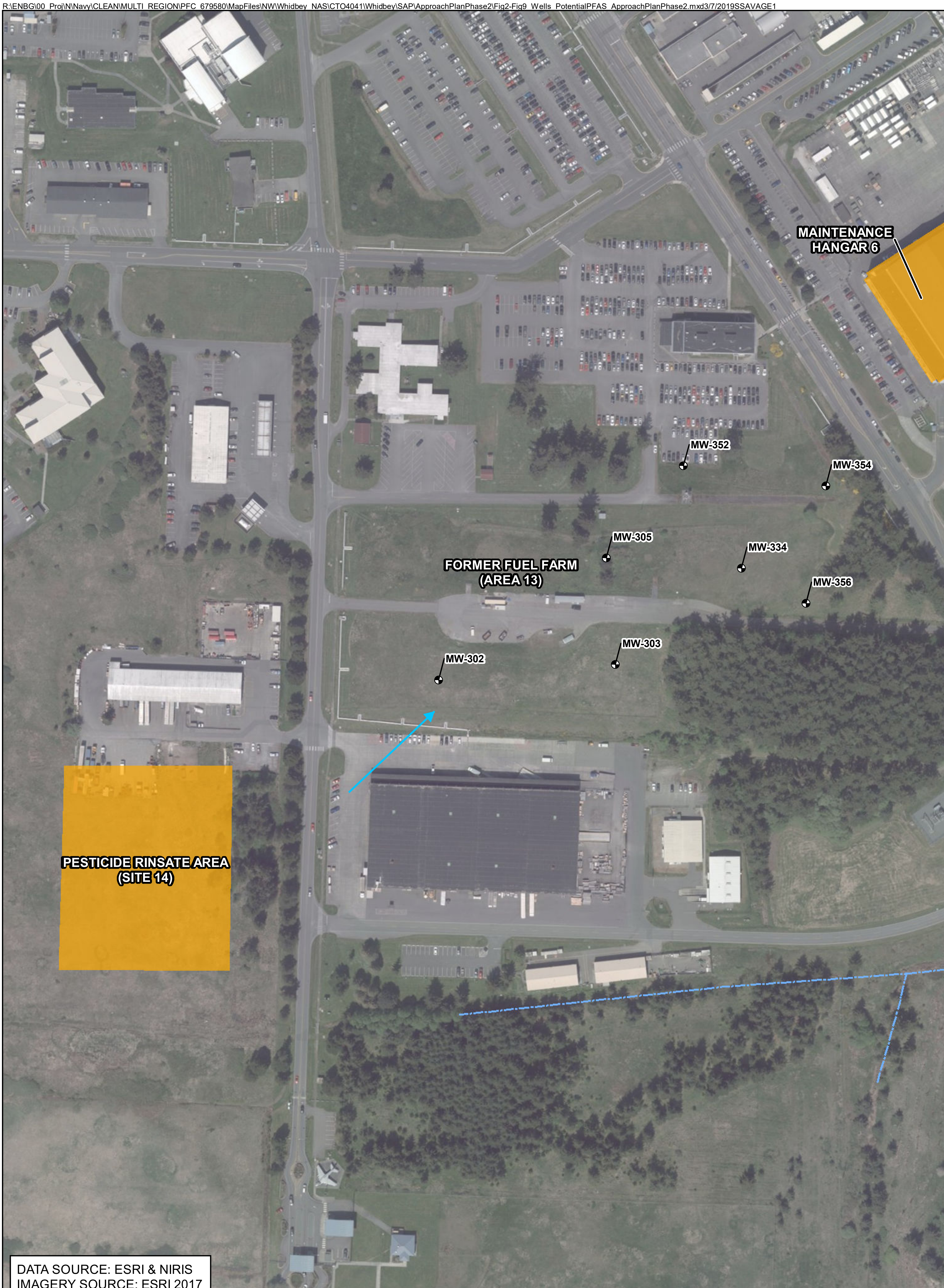

Legend
- Monitoring Well
- Potential PFAS Source Area
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

N

0 90 180 Feet

1 inch = 183.333333 feet

Figure 4
Former Fuel Farm (Area 13)
Pesticide Rinsate Area (Area 14) Wells
Naval Air Station Whidbey Island
Oak Harbor, Washington

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Legend

- Monitoring Well
- Potential PFAS Source Area
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

N

0 95 190 Feet

1 inch = 191.666667 feet

Figure 5
Former Fuel Farm 4 Wells
Naval Air Station Whidbey Island
Oak Harbor, Washington

R:\ENBG\00_Proj\N\Navy\CLEAN\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4041\Whidbey\SAP\ApproachPlanPhase2\Fig2-Fig9_Wells_PotentialPFAS_ApproachPlanPhase2.mxd3/7/2019SSAVAGE1

Legend

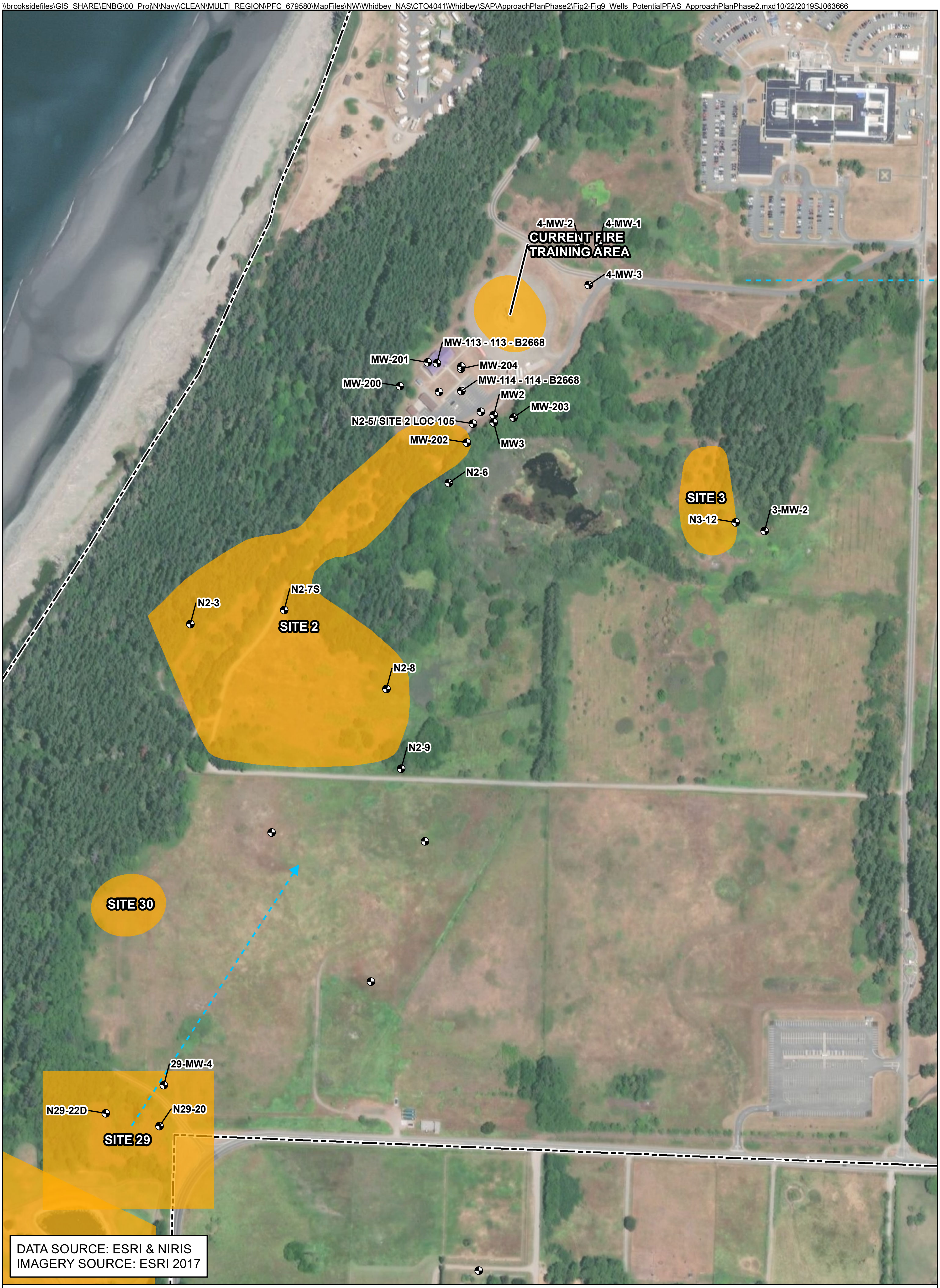
- Monitoring Well
- Potential PFAS Source Area
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

N

0 120 240 Feet

1 inch = 241.666667 feet

Figure 6
Rothboeck Canyon Wells
Naval Air Station Whidbey Island
Oak Harbor, Washington



Legend

- Monitoring Well
- Potential PFAS Source Area
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

N

0 170 340 Feet

1 inch = 333.333333 feet

Figure 7
Current Fire Training, Walker Barn Storage, Area 2, Area 3, Area 29 and Phase 1 SI Installed Wells
Naval Air Station Whidbey Island
Oak Harbor, Washington

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Legend

- Monitoring Well
- Potential PFAS Source Area
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

N

0 100 200 Feet

1 inch = 200 feet

Figure 8
Phase 1 SI Installed Wells
Naval Air Station Whidbey Island
Oak Harbor, Washington

Legend

- Monitoring Well
- Potential PFAS Source Area
- Surface Water
- Approximate Groundwater Flow Direction
- Inferred Groundwater Flow Direction (dashed)
- Base Boundary

N

0 125 250 Feet

1 inch = 250 feet

Figure 9
Phase 1 SI Installed Wells
Naval Air Station Whidbey Island
Oak Harbor, Washington

Appendix B
Standard Operating Procedures

PLANNING FIELD SAMPLING ACTIVITIES

1.0 PURPOSE

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

2.0 PROCEDURES

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

2.1 NUMBER OF SAMPLES

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

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

2.2 DURATION OF SAMPLING ACTIVITIES

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

2.3 NUMBER OF SAMPLES TO BE ANALYZED FOR VOLATILE ORGANICS

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

2.4 DECONTAMINATION WATER SOURCES

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

3.0 DOCUMENTATION

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

4.0 REFERENCES

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

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

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

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

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

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

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

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

None.

IDW MANAGEMENT

1.0 PURPOSE

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

2.0 PROCEDURES

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

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

2.1 IDW MINIMIZATION

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

2.1.1 Material Substitution

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

2.1.2 Drilling Methods

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

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

2.1.3 Decontamination Fluids

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

2.1.4 PPE and Disposable Sampling Equipment

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

2.1.5 Liners

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

2.1.6 Segregation of non-IDW

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

2.1.7 Monitoring Well Construction

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

2.1.8 Field Analytical Test Kits

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

2.2 SEGREGATION OF IDW BY MATRIX AND LOCATION

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

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

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

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

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

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

2.3 DRUM HANDLING AND LABELING

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

2.3.1 Drum Handling

The drums used for containing IDW shall be approved by the United States Department of Transportation (DOT, 49 CFR 172). The drums shall be made of steel or plastic, have a 55-gallon capacity, be completely painted or opaque, and have removable lids (i.e., 1A1 or 1A2). New steel drums are preferred over recycled drums. For short-term storage of liquid IDW prior to discharge, double-walled bulk steel or plastic storage tanks may be used. Consideration must be given to scheduling and cost-effectiveness of bulk storage, treatment, and discharge system versus longer-term drum storage.

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

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

2.3.2 Drum Labeling

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

2.3.2.1 Preprinted Labels

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

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

Painted Labels

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

2.3.2.2 Regulatory Marking and Labeling

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

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

2.4 DRUM STORAGE

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

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

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

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

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

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

2.5 DRUM INVENTORY

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

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

2.5.1 Navy Activity (Generator)/Site Name

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

2.5.2 DO Number

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

2.5.3 Drum Number

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

2.5.4 Storage Location Prior to Disposal

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

2.5.5 Origin of Contents

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

2.5.6 IDW Type

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

2.5.7 Waste Volume

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

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

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

2.5.9 Recommended or Actual Disposition of IDW Drum Contents

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

2.5.10 Generation Date

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

2.5.11 Expected Disposal Date

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

2.5.12 Actual Disposal Date

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

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

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

3.0 DOCUMENTATION

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

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

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

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

4.0 REFERENCES

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

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

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

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

5.0 ATTACHMENTS

Attachment IA71 Example Format – Quarterly IDW Drum Inventory Updates

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

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

NA = Not Applicable

GENERAL FIELD OPERATION

1.0 PURPOSE

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

2.0 PROCEDURES

2.1 MOBILIZATION/DEMOBILIZATION

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

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

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

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

2.2 SHIPPING

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

2.3 CHAIN OF COMMAND

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

2.4 SAMPLING ORGANIZATION

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

2.5 REVIEW

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

3.0 DOCUMENTATION

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

4.0 REFERENCES

None.

5.0 ATTACHMENTS

Attachment IA91 Field Equipment Checklist.

Attachment I-A-9-1
Field Equipment Checklist

General

___ 1. Health and Safety Plan

___ 2. Site base map

___ 3. Hand calculator

___ 4. Brunton compass

___ 5. Personal clothing and equipment

___ 6. Personal Protective Equipment (First Aid kit)

___ 7. Cell or radio telephone

Environmental Monitoring Equipment

___ 1. Shovels

___ 2. Keys to well caps

___ 3. pH meter (with calibrating solutions)

___ 4. pH paper

___ 5. Thermometer

___ 6. Conductivity meter (with calibrating solution)

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

___ 8. H2S, O2, combustible gas indicator

___ 9. Draeger tubes

Shipping Supplies

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

___ 2. Heavy-duty aluminum foil

___ 3. Coolers

___ 4. Ice packs

___ 5. Large zipper locking plastic bags

___ 6. Heavy-duty garbage bags

___ 7. Duct tape

___ 8. Strapping tape

___ 9. Paper towels

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

___ 11. Vermiculite

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

___ 13. Federal Express/DHL labels

Sampling Equipment

___ 1. Tool box with assorted tools (pipe wrenches, screwdrivers, socket set and driver, open and box end wrenches, hacksaw, hammer, vice grips)

___ 2. Geologic hammer

___ 3. Trowel

___ 4. Stainless steel and/or Teflon spatula

___ 5. Hand auger

___ 6. Engineer's tape

___ 7. Steel tape

___ 8. Electric water level sounder

___ 9. Petroleum Interface Probe

___ 10. Batteries

___ 11. Bailers (Teflon, stainless steel, acrylic, PVC)

___ 12. Slug test water displacement tube

___ 13. Vacuum hand pump

___ 14. Electric vacuum pump

___ 15. Displacement hand pump

___ 16. Mechanical pump (centrifugal, submersible, bladder)

___ 17. Portable generator

___ 18. Gasoline for generator

___ 19. Hose

___ 20. Calibrated buckets

___ 21. Stop watch

___ 22. Orifice plate or equivalent flow meter

___ 23. Data logger and pressure transducers

___ 24. Strip chart recorders

___ 25. Sample bottles

___ 26. 0.45-micron filters (prepackaged in holders)

___ 27. Stainless steel bowls

___ 28. SW scoop

___ 29. Peristaltic pump/tubing

___ 30. Sample tags

___ 31. SOPs, HAZWOPER training certificates, MSDs, FSP, QAPP

Decontamination Equipment

___ 1. Non-phosphate laboratory-grade detergent

___ 2. Selected high purity, contaminant free solvents

___ 3. Long-handled brushes

___ 4. Drop cloths (plastic sheeting)

___ 5. Trash container

___ 6. Galvanized tubs or equivalent (e.g., baby pools)

___ 7. Tap Water

___ 8. Contaminant free distilled/deionized water

___ 9. Metal/plastic container for storage and disposal of contaminated wash solutions

___ 10. Pressurized sprayers, H_2O

___ 11. Pressurized sprayers, solvents

___ 12. Aluminum foil

___ 13. Sample containers

___ 14. Emergency eyewash bottle

___ 15. Documentation Supplies

Documentation Supplies

___ 1. Weatherproof, bound field logbooks with numbered pages

___ 2. Daily Drilling Report forms

___ 3. Field Borehole Log forms

___ 4. Monitoring Well Installation Log forms

___ 5. Well Development Data forms

___ 6. Groundwater Sampling Log forms

___ 7. Aquifer Test Data forms

___ 8. Sample Chain-of-Custody forms

___ 9. Custody seals

___ 10. Communication Record forms

___ 11. Documentation of Change forms

___ 12. Camera and film

___ 13. Paper

___ 14. Permanent/indelible ink pens

___ 15. Felt tip markers (indelible ink)

___ 16. Munsell Soil Color Charts

MONITORING/SAMPLING LOCATION RECORDING

1.0 PURPOSE

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

2.0 PROCEDURES

2.1 SAMPLING LOCATION MARKING

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

2.2 PHOTOGRAPHIC DOCUMENTATION

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

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

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

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

2.3 MONITORING/SAMPLING LOCATION INFORMATION FORM

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

3.0 DOCUMENTATION

None.

4.0 REFERENCES

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

Attachment IA101 Example Monitoring/Sampling Location Information Form

FORM 11-1A
MONITORING/SAMPLING LOCATION SUMMARY

Installation ID:	Establishing Contract ID:	Prime Contractor Name:

Site Name:	DO/CTO:	Establishing Phase:	Date Established:

Survey Contractor:	Local System Description:

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

Location Types

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

Recorder: ______________________________ Date: __________

Checker: ______________________________ Date: __________

SAMPLE NAMING

1.0 PURPOSE

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

2.0 PROCEDURES

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

3.0 DOCUMENTATION

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

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

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

4.0 REFERENCES

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

5.0 ATTACHMENTS

None.

MONITORING WELL AND PIEZOMETER INSTALLATION

1.0 PURPOSE

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

2.0 PROCEDURES

2.1 EQUIPMENT

The following is an equipment list:

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

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

2.2 DECONTAMINATION

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

2.3 INSTRUMENT CALIBRATION

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

2.4 DRILLING AND WELL INSTALLATION PROCEDURES

2.4.1 Drilling Technique

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

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

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

2.4.2 Well Bore Drilling Operations

The procedure for well bore drilling is as follows:

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

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

2.4.3 Well Design Specifications

The general specifications for wells are as follows:

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

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

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

2.4.4 Well Installation Procedure

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

The procedure for monitoring well installation is as described below.

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

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

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

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

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

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

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

2.4.5 Well Installation Specifications

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

<u>Bentonite Seal and Grout.</u> A minimum 2-foot-thick bentonite pellet/chip seal should be placed in the annulus above the filter pack. The thickness of the seal may vary slightly based on site conditions. The thickness of the seal should be measured immediately after placement, without allowance for swelling. Bentonite Grout or cement grout should then be placed from the top of the bentonite seal to the ground surface. Bentonite grout is preferred because of potential investigation derived waste issues if too much cement grout is prepared and due to heat generated from cement grout. Bentonite grout shall be "high solids" and prepared in accordance with the manufacturer's instructions. Cement grout should consist of a mixture of Portland cement (ASTM C150) and clean water, with a ratio of no more than 7 gallons of clean water per bag of cement (1 cubic foot or 94 pounds). Additionally, 3 percent by weight of bentonite powder should be added if permitted by state regulations. The grout should be prepared in a rigid

aboveground container by first thoroughly mixing the cement with water, and then mixing in the bentonite powder. Grout mixtures should be placed, by pumping through a tremie pipe. The lower end of the tremie pipe should be kept within 5 feet of the top of the bentonite seal. Grout should be pumped through the tremie pipe until undiluted grout flows from the annular space at the ground surface. The tremie pipe should then be removed and more grout added to compensate for settling. After 24 hours, the drilling contractor should check the site for grout settlement and add more grout to fill any depression. This should be repeated until firm grout remains at the surface.

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

3.0 DOCUMENTATION

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

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

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

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

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

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

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

4.0 REFERENCES

SOP I-A-7, *IDW Management*

SOP III-I, *Equipment Decontamination*

5.0 ATTACHMENTS

None.

MONITORING WELL DEVELOPMENT

1.0 PURPOSE

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

2.0 PROCEDURE

2.1 INTRODUCTION

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

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

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

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

2.2 FACTORS AFFECTING MONITORING WELL DEVELOPMENT

2.2.1 Type of Geologic Materials

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

2.2.2 Design and Completion of the Well

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

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

2.2.3 Drilling Method

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

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

2.3 PREPARATION

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

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

Table I-C-2-1*
Casing Volume

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

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

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

* The above two volumes must be added together to obtain one unit well volume.
[a] Assumes a porosity of 40% for filter pack.

2.4 DECONTAMINATION

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

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

2.5 WELL DEVELOPMENT MONITORING

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

General

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

- Names of personnel involved

Development volume

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

Monitoring data for each sample point

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

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

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

2.6 METHODS OF MONITORING WELL DEVELOPMENT

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

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

2.6.1 Mechanical Surging and Bailing

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

Methodologies:

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

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

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

+ It affects the entire screened interval.

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

- It may cause upward movement of water in the filter pack that could disrupt the seal.

- Potential exists for damaging a screen with a tight-fitting surge block or with long surge strokes.

2.6.2 Surge Pumping

Methodologies:

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

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

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

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

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

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

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

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

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

2.7 SPECIAL SITUATIONS

2.7.1 Development of Low Yield Wells

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

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

3.0 DOCUMENTATION

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

4.0 REFERENCES

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

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

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

SOP III-I, *Equipment Decontamination*

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

Attachment I-C-2-1 Well Development Record

Attachment 1-C-2-1
Well Development Record

WELL DEVELOPMENT LOG	PROJECT		WELL NO.
	JOB NO.	SITE	PREPARED BY

METHOD		
OVERPUMPAGE __________ BAILER __________	INITIAL WATER LEVEL __________ FINAL WATER LEVEL __________	REMARKS:
SURGE BLOCK __________ AIR LIFT __________ OTHER __________	CAPACITY OF CASING (GALLONS/LINEAR FOOT) 2” = 0.16 4” = 0.65 6” = 1.47	VOLUME BETWEEN CASING AND HOLE (GALLONS/LINEAR FOOT) (ASSUMING 40% POROSITY) 2” CASING AND 6” HOLE - 0.52 2” CASING AND 8” HOLE - 0.98 4” CASING AND 10” HOLE = 1.37 4” CASING AND 12” HOLE - 2.09

Hole Diameter d_h =_____

Well Casing:

Inside Diameter d_wID =_____

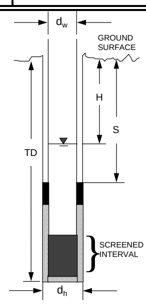
Outside Diameter d_wOD =_____

Depth to Water: H =_____

Depth to Base of Seal: S =_____

Depth to Base of Well: TD =_____

Estimated Filter Pack Porosity: P =_____



WELL VOLUME CALCULATION :

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

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

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

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

TOTAL WELL VOLUME = VT = Vc + Vf = ____ + ____ = ______ ft.^{3} x 7.48 = ______ gal.

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

* = Dissolved Oxygen

LOW-FLOW GROUNDWATER PURGING AND SAMPLING

1.0 PURPOSE

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

2.0 PROCEDURE

2.1 PURPOSE

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

2.2 PREPARATION

2.2.1 Site Background Information

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

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that may be encountered during sampling, such as excessive turbidity and low well yield. They may also indicate where dedicated pumps are placed in the water column.

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

2.2.2 Groundwater Analysis Selection

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

2.3 GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling procedures at a site should include: (1) measurement of depth to groundwater and total depth, (2) assessment of the presence or absence of an immiscible phase (if required by the project plan), (3) assessment of purge parameter stabilization, (4) purging of static water within the well and well bore, and (5) obtaining a groundwater sample. Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events.

2.3.1 Measurement of Static Water Level Elevation

The depth to water and the total depth of the well should be measured to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). Dependent upon individual project requirements, synoptic water level collection may be required prior to groundwater sampling activities. In the event that synoptic water levels **are not** collected prior to sampling activities, total depth measurements should be collected **after** purging and sampling activities to prevent the suspension of fine-grained sediment that may be present at the bottom of the well. Each well should be marked with a permanent, easily identified reference point for water level measurements whose location and elevation have been surveyed.

An electronic water level meter accurate to 0.01 foot should be used to measure the water level surface and depth of the well. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

2.3.2 Decontamination of Equipment

Each piece of non-dedicated equipment should be decontaminated prior to entering the well. Decontamination should also be conducted prior to the start of sampling at a site, even if the equipment is known to be decontaminated subsequent to its last usage. This precaution is taken to minimize the potential for cross-contamination. In addition, each piece of equipment used at the site should be decontaminated prior to leaving the site. Dedicated sampling equipment need only be decontaminated prior to installation within the well. Clean sampling equipment should not be placed directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without onsite decontamination.

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

2.3.3 Detection of Immiscible Phase Layers

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

2.3.4 Purging Equipment and Use

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

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

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

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

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

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

2.3.5 Groundwater Sampling Methodology

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

2.3.6 Sample Handling and Preservation

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

Improper sample handling may alter the analytical results of the sample. Samples should be transferred in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the Quality Assurance Project Plan.

When sampling for VOCs, water samples should be collected in vials or containers specifically designed to prevent loss of VOCs from the sample. An analytical laboratory should provide these vials, preferably by the laboratory that will perform the analysis. Groundwater from the sampling device should be collected in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment should not touch the interior of the vial. The vial should be filled above the top of the vial to form a positive meniscus with no overflow. No headspace should be present in the sample container once the container has been capped. The sample can be checked for headspace by inverting the sample bottle and tapping the side of the vial to dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that is aerated or naturally carbonated. In these cases, the investigator should note the problem to account for possible error. Field logs and laboratory analysis reports should note any headspace in the sample container(s) at the time of receipt by the laboratory, as well as at the time the sample was first transferred to the sample container at the wellhead.

2.3.6.1 Special Handling Considerations

Samples requiring analysis for organics should not be filtered. Samples should not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container.

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

2.3.6.2 Field Sampling Preservation

Samples should be preserved immediately upon collection. Ideally, sample jars contain preservatives of known concentration and volume during the initial filling of the jar to a predetermined final sample volume. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 ml of 1:1 nitric acid added to 500 ml of groundwater will produce a pH less than 2.0. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. It should be noted that introduction of preservatives will dilute samples, and may require normalization of results. Guidance for the preservation of environmental samples can be found in the EPA "Handbook for Sampling and Sample Preservation of Water and Wastewater:" (U.S. EPA 1982).

3.0 DOCUMENTATION

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

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

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

- Field observations on sampling event
- Name of collector

Figure 1-C-5-1
Groundwater Sampling Log

Project Number: ________________________ Date: ________________________

Location: ________________________ Time: ________________________

Well Number: ________________________ Climatic Conditions: ________________________

Initial Measurements: Static Water Level: ____________
Total Depth: ____________

Well Purging: Length of Saturated Zone: ____________linear feet
Volume of Water to be Evacuated: ____________gals./linear ft. x
Linear feet of Saturation x Casing Volumes* = ____________gallons
Method of Removal: ________________________
Pumping Rate: ____________ gallons/minute

Well Purge Data:

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

Sample Withdrawal Method: ________________________
Appearance of Sample: Color ________________________
Turbidity ________________________
Sediment ________________________
Other ________________________

Laboratory Analysis Parameters and Preservatives: ________________________

Number and Types of Sample Containers Used: ________________________

Sample ID(s): ________________________

Decontamination Procedures:________________________

Notes: ________________________

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

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

4.0 REFERENCES

SOP I-A-7, IDW Management

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

SOP III-I, Equipment Decontamination

SOP III-B, Field QC Samples

SOP III-D, Logbooks

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

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

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

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

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

5.0 ATTACHMENTS

None.

AQUIFER TESTS

1.0 PURPOSE

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

2.0 PROCEDURES

2.1 CONSTANT DISCHARGE AQUIFER PUMPING TESTS

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

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

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

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

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

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

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

2.1.1 Interferences and Potential Problems

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

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

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

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

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

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

2.1.2 Pumping Test Planning

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

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

2.1.3 Field Procedures

2.1.3.1 Preparation

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

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

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

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

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

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

2.1.3.2 *Step Drawdown Test*

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

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

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

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

2.1.3.3 *Constant-Discharge Pumping Test*

<u>Time Intervals</u>

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

Table I-C-7-1
Pumping Well Measurements

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

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

Table I-C-7-2
Observation Well Measurements

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

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

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

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

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

Water Chemistry Measurements

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

Test Duration

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

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

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

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

<u>Recovery</u>

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

2.1.3.4 Post Operation

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

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

2.1.4 Pumping Test Interpretation

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

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

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

2.1.5 Quality Assurance/Quality Control

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

2.2 SLUG TESTS

2.2.1 Scope and Application

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

2.2.2 Method Summary

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

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

2.2.3 Interferences and Potential Problems

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

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

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

2.2.4 Field Procedures

2.2.4.1 Preparation

Office Procedures

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

Equipment List

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

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

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

<u>Data Form</u>

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

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

2.2.4.2 Performing the Slug Test

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

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

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

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

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

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

2.2.4.3 Post Operations

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

For the electronic data logger, implement the following procedure:

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

2.2.5 Slug Test Interpretation

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

2.2.5.1 Cooper et al. Method

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

2.2.5.2 Bouwer and Rice Method

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

2.2.6 QA/QC

Similar to pumping test analysis. Refer to Section 2.1.5.

3.0 DOCUMENTATION

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

4.0 REFERENCES

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

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

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

SOP III-I, *Equipment Decontamination*

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

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

5.0 ATTACHMENTS

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

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

CONSTANT DISCHARGE PUMPING TEST/AQUIFER TEST DATA FORM

PROJECT NAME: ________ PROJECT NUMBER: ________ WELL NUMBER: ________

LOCATION: ________ DATE: ________ HYDROGEOLOGIST: ________

PUMPED WELL NO. ____ DISTANCE FROM PUMPING WELL: ____ TYPE OF TEST: ____ TEST NO. ________

MEASURING EQUIPMENT ________ TYPE AND DEPTH OF PUMP ________

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

WATER LEVEL MEASUREMENTS

1.0 PURPOSE

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

2.0 PROCEDURE

2.1 EQUIPMENT

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

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

2.2 PRELIMINARY STEPS

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

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

2. Locate the permanent reference mark at the top of the well casing. This reference point shall be scribed, notched, or otherwise noted on the top of the casing. If no such marks are present, measure depth relative to the top of the highest point of the well casing and note this fact in the field logbook. Determine from the records and record the elevation of the permanent reference point and record it in the logbook.

3. Record any observations and remarks regarding the characteristics and condition of the well, such as evidence of cracked casing or surface seals, security of the well (locked cap), evidence of tampering, missing well cap, surface water entering the well casing, etc.

2.3 OPERATION

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

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

11. Decontaminate interface probe as appropriate.

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

1. Remove the water level indicator probe from the case, turn on the sounder, and test the battery and sensitivity scale by pushing the test button. Adjust the sensitivity scale until you can hear the alarm.

2. Slowly lower the probe and cable into the well, allowing the cable reel to unwind. Continue lowering the probe until the alarm sounds. Very slowly raise and lower the probe until the point is reached where the meter just beeps. Mark the spot by grasping the cable with thumb and forefingers at the top of the casing. Record the depth to water relative to the permanent reference point. If no mark is present, use the highest point on the casing as a reference point. Withdraw the cable and record the depth.

3. Alternately, use a steel tape with an attached weight if the aquifer gradients are lower than 0.05 ft./ft. Due to the possibility of adding unknown contaminants from chalk colorants, only white chalk is permitted as a level indicator.

4. Rub chalk onto the end (first 1 foot) of the steel tape and slowly lower the chalked end into the well until the weighted end is below the water surface. (A small splash can be heard when the weighted end hits the water surface.)

5. Mark the spot on the tape by grasping the tape with the thumb and forefingers at the top of the casing as described in the subsection (2) above. Record this spot on the tape in the logbook as the "HOLD". Ensure not to retract the tape from the well until after the depth measurement (HOLD) is recorded.

6. Remove the steel tape from the well. The chalk will be wet or absent where the tape was below the water surface. Locate, read, and record this length in the logbook as the "CUT". Subtract the "CUT" length from the "HOLD" length and record the difference in the logbook. This is the depth to water table.

7. Decontaminate water level indicator or steel tape as appropriate

2.4 PRECAUTIONS

- Depending on the device used, correction factors may be required for some measurements. For example, if the water level indicator has been shortened during its repair.

- Check instrument batteries prior to each use.

- Exercise care not to break the seals at the top of the electric water level indicator probe.

- It is important to note that when measuring total well depth (bottom of casing), using an interface probe or water level indicator, the increments of measure are ticked off from the alarm sensor on the probe. On some meters there is a portion of the probe that sticks out beyond the alarm sensor. This needs to be accounted for when reading the bottom of casing measurement (i.e., added onto the reading). A potential problem arises if it is unknown whether this has been done on previous readings or not.

3.0 DOCUMENTATION

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

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

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

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

4.0 REFERENCES

SOP III-D, *Logbooks*

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

5.0 ATTACHMENTS

None.

FIELD PARAMETER MEASUREMENTS

1.0 PURPOSE

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

2.0 PROCEDURES

2.1 WATER QUALITY MEASUREMENTS

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

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

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

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

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

2.2 ORGANIC VAPORS

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

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

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

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

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

3.0 DOCUMENTATION

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

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

4.0 REFERENCES

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

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

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

FORM 11-3
FIELD MEASUREMENT DATA

Installation ID :	Contract ID :	Prime Contractor Name:

Site Name:	DO/CTO:	Phase:	Measured Date:

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

Analyte Test Type and Units of Measure

AIRVE Air Velocity - M_SEC
ALK Alkalinity - MG_L
BAL_GAS % balance gas in air space by portable gas meter - PCT
BARO_PRESS Barometric Pressure - IN_HG
BG_NMOC Background non-methane organic compounds - PPM
CACRB Calcium Carbonate - MG_L
CASING VOLUME Casing Volume Removed - GAL
CH4 Methane - PCT
CO Carbon Monoxide - PPM
CO2 Carbon Dioxide - PCT
COLOR Color - COLOR_UNITS
DO Dissolved Oxygen - MG_L
DO-C Dissolved Oxygen by Colometrics - MG_L
DO-T Dissolved Oxygen by Titration - MG_L
FE Total Iron - MG_L
FE2 Ferrous Iron - MG_L

FI Ferrous-Ferric Iron - MG_L
FI3 Ferric Iron - MG_L
FID Flame Ionization Detection - PPM
HS Hydrogen Sulfide - MG_L
LEL Lower explosive limit - PCT
MN Manganese - MG_L
MN2 Manganese, Ion (MN2+) - MG_L
NA2S2O8 Sodium Persulfate - MG_L
NM_VOC Non-methane VOCs - PPM
NO2 Nitrite - MG_L
NO3 Nitrate - MG_L
O2 Oxygen - PCT
ODOR Odor - TONU
ORP Oxidation Reduction Potential - MV
PH pH - PH or SU
PID Photoionization Detector - PPM

PRDTH Product Thickness - FT
PURGERT Purge Rate - GAL_MIN
RECOVFP Recovered Free Product – GAL
SAL Salinity - PCT
SC Specific Conductivity - MS_CM
SG_PRESS Soil gas pressure - IN_H2O
SO4 Sulfate - MG_L
STAGE Stage elevation for surface water - FT
SUL Sulfide - MG_L
TDS Total Dissolved Solids - MG_L
TEMP Temperature - DEG_C or DEG_F
TURB Turbidity - NTU
VOL_PURGED Actual Volume Purged [Prior to Sampling] - GAL
WELL_VOLUME Well Volume Removed - GAL
WTRVE Water Velocity - GAL_MIN

Recorder: ______________________________ Date: ______________

Checker: ______________________________ Date: ______________

SOIL AND ROCK CLASSIFICATION

1.0 PURPOSE

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

2.0 PROCEDURES

2.1 SOIL CLASSIFICATION

The basic purpose of the classification of soils is to thoroughly describe the physical characteristics of the sample and to classify it according to an appropriate soil classification system for the NAVFAC NW. The Unified Soil Classification System (USCS) was developed so that soils could be described on a common basis by different investigators and serves as a "shorthand" description of soil. A classification of a soil in accordance with the USCS includes not only a group symbol and name, but also a complete word description.

Describing soils on a common basis is essential so that soils described by different site qualified personnel are comparable. Site individuals describing soils, as part of NAVFAC NW site activities, must use the classification system described herein to provide the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC NW sites.

The site geologist or other qualified individual shall describe the soil and record the description in a boring log or logbook. The essential items in any written soil description are as follows:

- Classification group name (e.g., silty sand)
- Color, moisture, and odor
- Range of particle sizes and maximum particle size
- Approximate percentage of boulders, cobbles, gravel, sand, and fines
- Plasticity characteristics of the fines
- In-place conditions such as consistency, density, structure, etc.
- USCS classification symbol

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

GW[1] Well graded (poorly sorted) gravel (>50% gravel, <5% fines)

GP[1] Poorly graded (well sorted) gravel (>50% gravel, <5% fines)

GM1 Silty gravel (>50% gravel, >15% silt)

GC1 Clayey gravel (>50% gravel, >15% clay)

SW1 Well graded (poorly sorted) sand (>50% sand, <5% fines)

SP1 Poorly graded (well sorted) sand (>50% sand, <5% fines)

SM1 Silty sand (>50% sand, >15% silt)

SC1 Clayey sand (>50% sand, >15% clay)

ML2 Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness and plasticity)

L2 Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)

MH2 Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)

CH2 Inorganic, high plasticity (fat) clay (no dilatancy, high toughness and plasticity)

OL Organic low plasticity silt or organic silty clay

OH Organic high plasticity clay or silt

PT Peat and other highly organic soils

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

2 If the soil is estimated to have 15% to 25% sand or gravel, or both, the words "with sand" or "with gravel" (whichever predominates) shall be added to the group name (e.g., clay with sand, CL; or silt with gravel, ML). If the soil is estimated to have 30% or more sand or gravel, or both, the words "sandy" or "gravelly" (whichever predominates) shall be added to the group name (e.g., sandy clay, CL). If the percentage of sand is equal to the percent gravel, use "sandy."

Figure I-E-1 defines the terminology of the USCS. Flowcharts presented in Figures I-E-2 and I-E-3 indicate the process for describing soils. The particle size distribution and the plasticity of the fines are the two properties of soil used for classification. In some cases, it may be appropriate to use a borderline classification, e.g., SC/CL, if the soil has been identified as having properties that do not distinctly place the soil into one group.

2.1.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. To become proficient in estimating this factor requires extensive practice and frequent checking. The steps involved in determining particle size distribution are listed below.

1. Select a representative sample (approximately 1/2 of a 6-inch long by 2.5 inch diameter sample liner.)

2. Remove all particles larger than 3 inches from the sample. Estimate and record the percent by volume of these particles. Only the fraction of the sample smaller than 3 inches is classified.

3. Estimate and record the percentage of dry mass of gravel (less than 3 inches and greater than 1/4 inch.

4. Considering the rest of the sample, estimate and record the percentage of dry mass of sand particles (about the smallest particle visible to the unaided eye).

5. Estimate and record the percentage of dry mass of fines in the sample (do not attempt to separate silts from clays).

6. Estimate percentages to the nearest 5%. If one of the components is present in a quantity considered less than 5%, indicate its presence by the term "trace".

7. The percentages of gravel, sand, and fines must add up to 100%. "Trace" is not included in the 100% total.

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

DEFINITION OF TERMS

MAJOR DIVISIONS			SYMBOLS	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More Than Half of Material is Larger Than No. 200 Sieve Size	**GRAVELS** More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN GRAVELS** (Less than 6% Fines)	**GW**	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS With Fines	**GM**	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN SANDS** (Less than 6% Fines)	**SW**	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SANDS With Fines	**SM**	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More Than Half of Material is Smaller Than No. 200 Sieve Size	**SILTS AND CLAYS** Liquid Limit is Less Than 50%		**ML**	Inorganic silts, rock flour, fine sandy silts or clays, and clayey silts with non- or slightly-plastic fines
			CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limit is Greater Than 50%		**MH**	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, clayey silt
			CH	inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			**PT**	Peat and other highly organic soils

GRAIN SIZES

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		
200	40	10	4	3/4"	3"	12"	
U.S. STANDARD SERIES SIEVE				CLEAR SQUARE SIEVE OPENINGS			

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

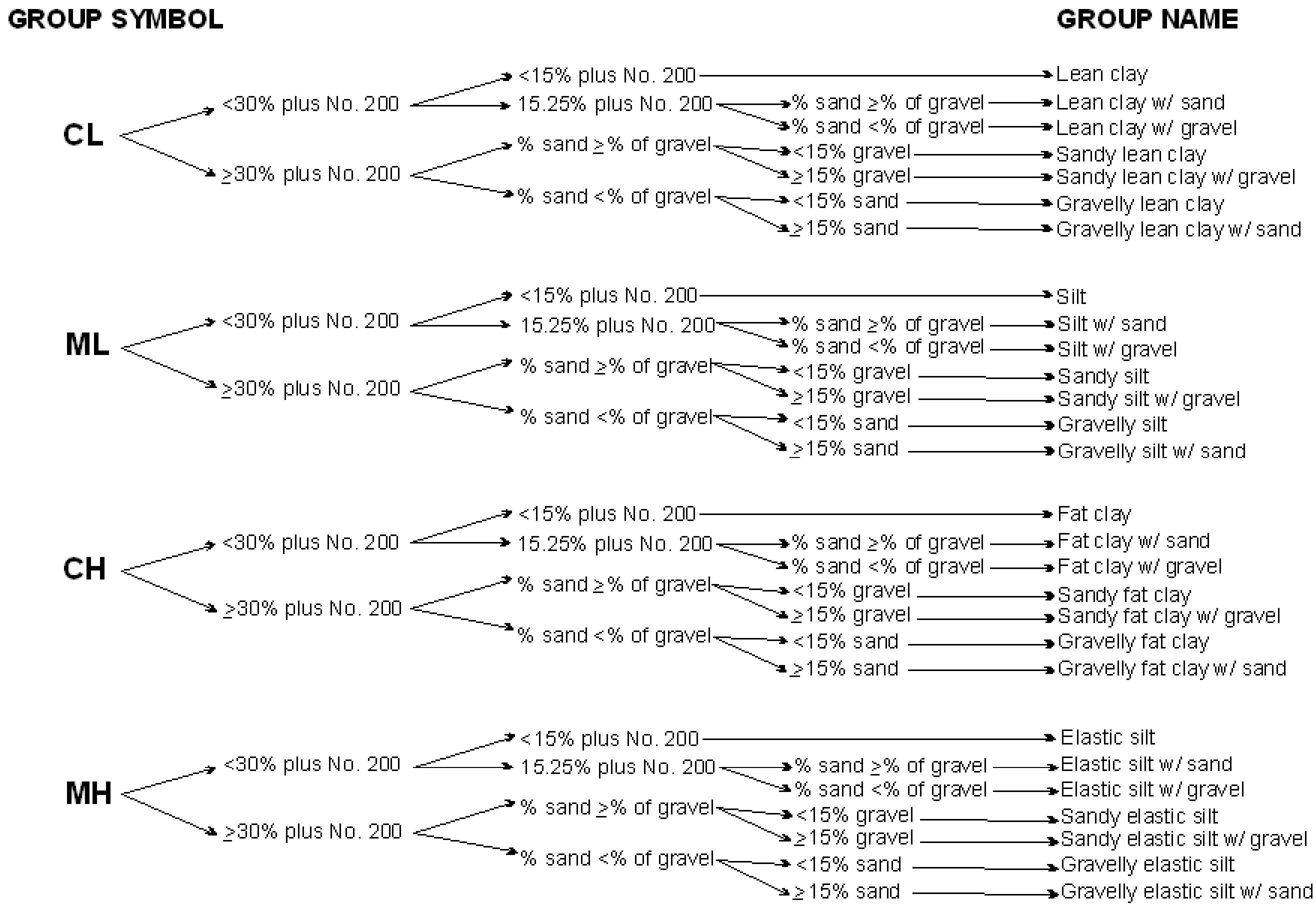
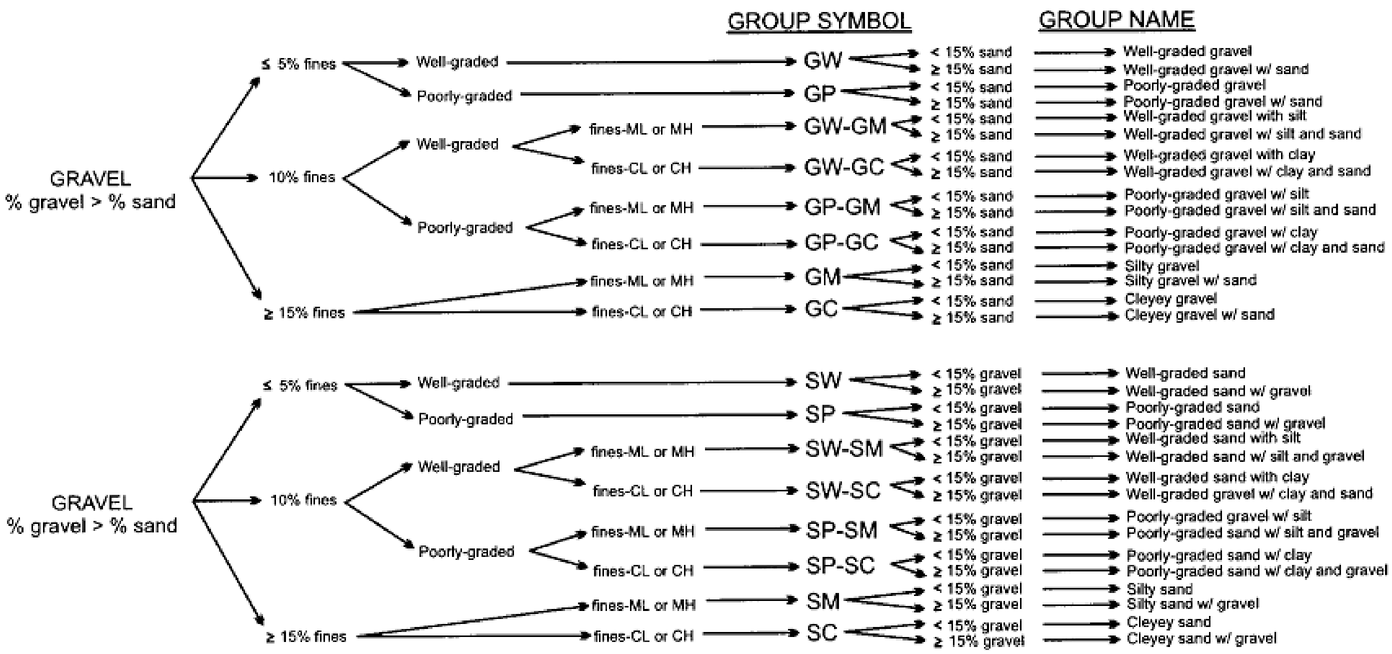


Figure I-E-3
Flow Chart for Soils with Gravel



2.1.2 Soil Dilatancy, Toughness, and Plasticity

2.1.2.1 Dilatancy

To evaluate dilatancy, the following procedures shall be followed:

1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
2. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table I-E-1. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Table I-E-1
Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

2.1.2.2 Toughness

Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble at a diameter of 1/8 inch when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table I-E-2.

Table I-E-2
Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

2.1.2.3 Plasticity

The plasticity of a soil is defined by the ability of the soil to deform without cracking, the range of moisture content over which the soil remains in a plastic state, and the degree of cohesiveness at the plastic limit. The plasticity characteristic of clays and other cohesive materials are defined by the liquid limit and plastic limit. The liquid limit is defined as the soil moisture content at which soil passes from the liquid to the plastic state as moisture is removed. The test for the liquid limit is a laboratory, not a field, analysis.

The plastic limit is the soil moisture content at which a soil passes from the plastic to the semi-solid state as moisture is removed. The plastic limit test can be performed in the field and is indicated by the ability to roll a 1/8-inch (0.125-inch) diameter thread of fines, the time required to roll the thread, and the number of times the thread can be re-rolled when approaching the plastic limit.

The plasticity tests are not based on natural soil moisture content but on soil that has been thoroughly mixed with water. If a soil sample is too dry in the field, water should be added prior to performing classification. If a soil sample is too sticky, the sample should be spread thin and allowed to lose some soil moisture.

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

Table I-E-3
Criteria for Describing Plasticity

Description	Criteria
Non-Plastic	A 1/8-inch thread cannot be rolled.
Low plasticity	The thread can barely be rolled.
Medium plasticity	The thread is easy to roll and not much time is required to reach the plastic limit.
High plasticity	It takes considerable time rolling the thread to reach the plastic limit

2.1.3 Angularity

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

- Rounded—particles have smoothly-curved sides and no edges;

- Subrounded-particles have nearly plane sides, but have well-rounded corners and edges;
- Subangular—particles are similar to angular, but have somewhat rounded or smooth edges; and
- Angular—particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

2.1.4 Color, Moisture, and Odor

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

Table I-E-4
Soil Moisture Content Qualifiers

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

Color is described by hue and chroma using the Munsell Soil Color Chart. For the sake of uniformity, all site geologists shall utilize this chart for soil classification. Doing so will facilitate correlation of geologic units between boreholes logged by different geologists The Munsell color chart is a small booklet of numbered color chips with names like "5YR 5/6, yellowish-red". Mottling or banding of colors should be noted. It is particularly important to note and describe staining because it may indicate contamination.

If odors are noted, they should be described if they are unusual or suspected to result from contamination. An organic odor may have the distinctive smell of decaying vegetation. Unusual odors may be related to hydrocarbons, solvents, or other chemicals in the subsurface. An organic vapor analyzer (OVA) may be used to detect the presence of volatile organic contaminants. In general, respirators should be worn if strong organic odors are present.

2.1.5 In-place Conditions

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

2.1.5.1 Density/Consistency

Density and consistency describe a physical property that reflects the relative resistance of a soil to penetration. The term "density" is commonly applied to coarse to medium-grained sediments (i.e., gravels, sands), whereas the term "consistency" is normally applied to fine-grained sediments (i.e., silts, clays). There are separate standards of measure for both density and consistency that are used to describe the properties of a soil.

The density or consistency of a soil is determined by observing the number of blows required to drive a 1 3/8-inch (35 mm) diameter split barrel sampler 18 inches using a drive hammer weighing 140 lbs. (63.5

kg) dropped over a distance of 30 inches (0.76 m). The number of blows required to penetrate each 6 inches of soil is recorded in the field boring log during sampling. The first 6 inches of penetration is considered to be a seating drive; therefore, the blow count associated with this seating drive is recorded but not used in determining the soil density/consistency. The sum of the number of blows required for the second and third 6 inches of penetration is termed the "standard penetration resistance," or the "N-value." The observed number of blow counts must be corrected by an appropriate factor if a different type of sampling device (e.g., Modified California Sampler with liners) is used. For a 2 3/8-inch I.D. Modified California Sampler equipped with brass or stainless steel liners and penetrating a cohesionless soil (sand/gravel), the N-value from the Modified California Sampler must be divided by 1.43 to provide data that can be compared to the 1 3/8-inch diameter sampler data.

For a cohesive soil (silt/clay), the N-value for the Modified California Sampler should be divided by a factor of 1.13 for comparison with 1 3/8-inch diameter sampler data.

The sampler should be driven and blow counts recorded for each 6-inch increment of penetration until one of the following occurs:

- A total of 50 blows have been applied during any one of the three 6-inch increments; a 50-blow count occurrence shall be termed "refusal" and noted as such on the boring log.
- A total of 150 blows have been applied.
- The sampler is advanced the complete 18 inches without the limiting blow counts occurring, as described above.

If the sampler is driven less than 18 inches, the number of blows per partial increment shall be recorded on the boring log. If refusal occurs during the first 6 inches of penetration, the number of blows will represent the N-value for this sampling interval. Representative descriptions of soil density/consistency vs. N-values are presented in Table I-E-5.

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

Description	Field Criteria (N-Value) 1 3/8" I.D. Sampler	2" I.D. Sampler using 1.43 factor
Very loose	0-4	0-6
Loose	4-10	6-14
Medium dense	10-30	14-43
Dense	30-50	43-71
Very Dense	>50	>71

Table I-E-5b
Measuring Soil Density with a California Sampler Consistency:
Fine-Grained Cohesive Soils

Description	Field Criteria (N-Value) 1 3/8" I.D. Sampler	2" I.D. Sampler using 1.13 factor
Very soft	0-2	0-2
Soft	2-4	2-4
Medium Stiff	4-8	4-9
Stiff	8-16	9-18
Very Stiff	16-32	18-36
Hard	>32	>36

For undisturbed fine-grained soil samples, it is also possible to measure consistency with a hand-held penetrometer. The measurement is made by placing the tip of the penetrometer against the surface of the soil contained within the sampling liner or shelby tube, pushing the penetrometer into the soil a distance specified by the penetrometer manufacturer, and recording the pressure resistance reading in pounds per square foot (PSF). The values are as follows:

Table I-E-6
Measuring Soil Consistency with a Hand-held Penetrometer

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

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

Table I-E-7
Measuring Soil Consistency Using Thumb Pressure

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will penetrate soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

2.1.5.2 Cementation

Cementation is used to describe the friability of a soil. Cements are chemical precipitates that provide important information as to conditions that prevailed at the time of deposition, or conversely, diagenetic effects that occurred following deposition. Seven types of chemical cements are recognized by Folk (1980). They are as follows:

Quartz	-	siliceous;
Chert	-	chert-cemented or chalcedonic;
Opal	-	opaline;
Carbonate	-	calcitic, dolomitic, sideritic (if in doubt, calcareous should be used);
Iron oxides	-	hematitic, limonitic (if in doubt, ferruginous should be used);
Clay minerals	-	if the clay minerals are detrital or have formed by recrystallization of a previous clay matrix, they are not considered to be a cement. Only if they are chemical precipitates, filling previous pore space (usually in the form of accordion-like stacks or fringing radial crusts) should they be included as "kaolin-cemented," "chlorite-cemented," etc.
Miscellaneous minerals	-	pyritic, collophane-cemented, glauconite-cemented, gypsiferous, anhydrite-cemented, baritic, feldspar-cemented, etc.

The degree of cementation of a soil is determined qualitatively by utilizing finger pressure on the soil in one of the sample liners to disrupt the gross soil fabric. The three cementation descriptors are as follows:

Weak	-	friable, crumbles or breaks with handling or slight finger pressure;
Moderate	-	friable, crumbles or breaks with considerable finger pressure;
Strong	-	not friable, will not crumble or break with finger pressure.

2.1.5.3 Structure

This variable is used to qualitatively describe physical characteristics of soils that are important to incorporate into hydrogeological or geotechnical descriptions of soils at a site. Appropriate soil structure descriptors are as follows:

Granular	-	spherically-shaped aggregates with faces that do not accommodate adjoining faces.
Stratified	-	alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness.
Laminated	-	alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness.
Blocky	-	cohesive soil that can be broken down into small angular or subangular lumps that resist further breakdown.
Lensed	-	inclusion of a small pocket of different soils, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soils are present, the soil being described can be termed homogeneous if the description of the lenses is included.
Prismatic or Columnar	-	particles arranged about a vertical line, ped is bounded by planar, vertical faces that accommodate adjoining faces; prismatic has a flat top; columnar has a rounded top.
Platy	-	particles are arranged about a horizontal plane.

2.1.5.4 Other Features

Mottled	-	soil that appears to consist of material of two or more colors in blotchy distribution.
Fissured	-	breaks along definite planes of fracture with little resistance to fracturing (determined by applying moderate pressure to sample using thumb and index finger)
Slickensided	-	fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)

2.1.6 Development of Soil Description

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

2.1.6.1 Coarse-grained Soils

Coarse-grained soils are divided into sands and gravels. A soil is classified as a sand if over 50% of the coarse fraction is "sand-sized." It is classified as a gravel if over 50% of the coarse fraction is composed of "gravel-sized" particles. The written description of a coarse-grained soil shall contain, in order of appearance:

Typical name including the second highest percentage constituent as an adjective, if applicable (underlined), grain size of coarse fraction, Munsell color and color number, moisture content, relative density, sorting, angularity, other features such as stratification (sedimentary structures) and cementation, possible formational name, primary USCS classification, secondary USCS classification (when necessary), and approximate percentages of minor constituents (i.e., sand, gravel, shell fragments, rip-up clasts, etc.) in parentheses.

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

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

2.1.6.2 Fine-grained Soils

Fine-grained soils are further subdivided into clays and silts according to their plasticity. Clays are rather plastic, while silts have little or no plasticity. The written description of a fine-grained soil should contain, in order of appearance:

Typical name including the second highest percentage constituent as an adjective, if applicable (underlined), Munsell color, moisture content, consistency, plasticity, other features such as stratification, possible formation name, primary USCS classification, secondary USCS classification (when necessary), and the percentage of minor constituents in parentheses.

Example: SANDY Lean CLAY, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70% fines, 30% sand, with minor amounts of disarticulated bivalves (about 5%)).

2.1.6.3 Organic Soils

For highly organic soils, the types of organic materials present will be described as well as the type of soil constituents present using the methods described above. Identify the soil as an organic soil, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, from black to brown, when exposed to air. Some organic soils will lighten in color significantly when air-dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

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

2.2 ROCK CLASSIFICATION

The purpose of rock classification is to thoroughly describe the physical and mineralogical characteristics of a specimen and to classify it according to an established system. The generalized rock classification system described below was developed for NAVFAC NW because, unlike the USCS for soils, there is no universally accepted rock classification system. In some instances, a more detailed and thorough rock classification system may be appropriate. Any modifications to this classification system, or the use of an alternate classification system should be considered during preparation of the site Work Plan and Field Sampling Plan. Both the Project Manager and the Technical Director/QA Program Manager must approve modifications to this classification system, or the use of another classification system.

Describing rock specimens on a common basis is essential so that rocks described by different site geologists are comparable. Site geologists describing rock specimens as a part of NAVFAC NW activities must use the classification system described herein, or if necessary, another more detailed classification system. Use of a common classification system provides the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC NW sites.

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

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

Figure I-E-4
Rock Classification System

DEFINITION OF TERMS

PRIMARY DIVISIONS			SYMBOLS	SECONDARY DIVISIONS
SEDIMENTARY ROCKS	Clastic Sediments	CONGLOMERATE	CG	Coarse-grained Clastic Sedimentary Rock types including: Conglomerates and Breccias
SEDIMENTARY ROCKS	Clastic Sediments	SANDSTONE	SS	Clastic Sedimentary Rock types including: Sandstone, Arkose and Greywacke
SEDIMENTARY ROCKS	Clastic Sediments	SHALE	SH	Fine-grained Clastic Sedimentary Rock types including: Shale, Siltstone, Mudstone and Claystone
SEDIMENTARY ROCKS	Chemical Precipitates	CARBONATES	LS	Chemical Precipitates including: Limestone, Crystalline Limestone, Fossiliferous Limestone Micrite and Dolomite
SEDIMENTARY ROCKS	Chemical Precipitates	EVAPORITES	EV	Evaporites including: Anhydrite, Gypsum, Halite, Travertine and Caliche
IGNEOUS ROCKS		EXTRUSIVE (Volcanic)	IE	Volcanic Rock types including: Basalt, Andesite, Rhyolite, Volcanic Tuff, and Volcanic Breccia
IGNEOUS ROCKS		INTRUSIVE (Plutonic)	II	Plutonic Rock types including: Granite, Diorite and Gabbro
METAMORPHIC ROCKS		FOLIATED	MF	Foliated Rock types including: Slate, Phyllite, Schist and Gneiss
METAMORPHIC ROCKS		NON-FOLIATED	MN	Non-foliated Rock types including: Metaconglomerate, Quartzite and Marble

- Classification Name (i.e., schist)
- Color
- Mineralogical composition and percent
- Texture/Grain size (i.e., fine-grained, pegmatitic, aphlitic, glassy, etc.)
- Structure (i.e., foliated, fractured, lenticular, etc.)
- Rock Quality Designation (sum of all core pieces greater than two times the diameter of the core divided by the total length of the core run, expressed as a percentage) and
- Classification symbol (i.e., MF).

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

3.0 DOCUMENTATION

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

4.0 REFERENCES

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

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

Munsell Soil Color Chart, 1990 Edition (Revised).

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

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

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5.0 ATTACHMENTS

None.

LAND SURVEYING

1.0 PURPOSE

This standard operating procedure (SOP) sets forth protocols for acquiring land surveying data to facilitate the location and mapping of geologic, hydrologic, geotechnical data, and analytical sampling points and to establish topographic control over project sites.

2.0 PROCEDURES

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

- All surveying work shall be performed under the direct supervision of a land surveyor registered in the state or territory in which the work is being performed (i.e. a Professional Land Surveyor, PLS).
- Survey instruments shall be calibrated in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall have been calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration (NOAA) standards and at the minimum accuracy standards set forth below. The horizontal accuracy for location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be one in ten thousand feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet.
- Surveys shall be referenced to the local established coordinate systems and all elevations and benchmarks established shall be based on North American Vertical Datum of 1988.
- Surveyed points shall be referenced to Mean Sea Level (Mean Lower Low Water Level).
- Appropriate horizontal and vertical control points shall be jointly determined prior to the start of survey activities. If discrepancies in the survey (e.g., anomalous water level elevations) are observed, the surveyor may be required to verify the survey by comparison to a known survey mark. If necessary, a verification survey may be conducted by a qualified third party.
- All field notes, sketches and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates and elevations. All surveyed locations shall be mapped using a base map or other site mapping specified by the Project Manager.
- All surveys shall begin and end at the designated horizontal and vertical control points to determine the degree of accuracy of the surveys.

- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Pins shall be driven to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. They shall be clearly marked with brightly colored weatherproof flagging and paint.
- The point on a monitoring well casing that is surveyed shall be clearly marked by filing grooves into the casing on either side of the surveyed point.

3.0 DOCUMENTATION

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

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

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

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

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

4.0 REFERENCES

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

5.0 ATTACHMENTS

None.

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

1.0 PURPOSE

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

2.0 PROCEDURES

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

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

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

2.1 TRIP BLANK

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

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

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

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

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

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

Notes:

[1]NA means not applicable.

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

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

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

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

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

2.2 EQUIPMENT RINSATE SAMPLES

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

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

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

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

2.3 FIELD BLANKS

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

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

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

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

2.4 FIELD DUPLICATE

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

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

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

2.5 REFERENCE SAMPLES

There are two types of background levels of chemicals:

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

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

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

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

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

2.6 TEMPERATURE BLANKS

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

2.7 LABORATORY QUALITY CONTROL SAMPLES

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

2.7.1 Matrix Spike/matrix Spike Duplicate

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

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

2.8 QUALITY CONTROL (QC) LEVELS

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

3.0 DOCUMENTATION

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

4.0 REFERENCES

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

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

EPA. 1992. RCRA Technical Enforcement Guidance Document.

SOP III-I, Equipment Decontamination

SOP, III-D, *Logbooks*

5.0 ATTACHMENTS

None.

LOGBOOKS

1.0 PURPOSE

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

2.0 PROCEDURE

2.1 EQUIPMENT

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

2.2 LOGBOOK MAINTENANCE

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

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

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

2.3 RECORDING FIELD ACTIVITIES

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

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

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

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

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

The field logbook serves as the primary record of field activities. When possible, the field book should be dedicated to a singular Navy Activity/Installation to facilitate long-term records archiving. Entries shall be made chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct the applicable events. Individual data forms may be generated to provide systematic data collection documentation. Entries on these forms shall meet the same requirements as entries in the logbook and shall be referenced in the applicable logbook entry. Individual data forms shall reference the applicable logbook and page number. At a minimum, names of all samples collected shall be included in the logbook even if recorded elsewhere.

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

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

- Date and time of all onsite activities

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

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

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

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

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

3.0 DOCUMENTATION

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

4.0 REFERENCES

SOP I-A-11, *Sample Naming*

5.0 ATTACHMENTS

Attachment III-D-1 Description of Logbook Entries

Attachment 1
Description of Logbook Entries

Logbook entries shall contain the following information, as applicable, for each activity recorded. Some of these details may be entered on data forms as described previously.

Name of Activity	For example, Asbestos Bulk Sampling, Charcoal Canister Sampling, Aquifer Testing.
Task Team Members and Equipment	Name all members on the field team involved in the specified activity. List equipment used by serial number or other unique identification, including calibration information.
Activity Location	Indicate location of sampling area as specified in the Field Sampling Plan. Record valid Navy Installation/Active and Site, at a minimum.
Weather	Indicate general weather and precipitation conditions.
Level of Personal Protective Equipment	The level of personal protective equipment (PPE), e.g., Level D, should be recorded.
Methods	Indicate method or procedure number employed for the activity.
Sample IDs	Indicate the unique identifier associated with the physical samples. Identify QC samples. Value can be numeric or alphanumeric and must not already exist in the database.
Sample Type and Volume	Indicate the medium, container type, preservative, and the volume for each sample.
Sample Collection Information	Indicate the location of sample, date and time of collection, sample matrix, sample depth interval, sample methods, sample handling, including filtration and preservation, analysis required and packaging and shipping information.
Time and Date	Record the time and date when the activity was performed (e.g., 0830/08/OCT/89). Use the 24-hour clock for recording the time and two digits for recording the day of the month and the year.
Analyses	Indicate the appropriate code for analyses to be performed on each sample, as specified in the Field Sampling Plan.
Field Measurements	Indicate measurements and field instrument readings taken during the activity.
Chain of Custody and Distribution	Indicate chain-of-custody for each sample collected and indicate to whom samples are transferred and the destination.
References	If appropriate, indicate references to other logs or forms, drawings or photographs employed in the activity.

Narrative (including time and location)	Create a factual, chronological record of the team's activities throughout the day, including the time and location of each activity. Include descriptions of any general problems encountered and their resolution. Provide the names and affiliations of non-field team personnel who visit the site, request changes in activity, impact to the work schedule, requested information, or observe team activities. Record any visual or other observations relevant to the activity, the contamination source, or the sample itself. It should be emphasized that logbook entries are for recording data and chronologies of events. The logbook author must include observations and descriptive notations, taking care to be objective and recording no opinions or subjective comments unless appropriate.
Recorded by	Include the signature of the individual responsible for the entries contained in the logbook and referenced forms.
Checked by	Include the signature of the individual who performs the review of the completed entries.

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

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish standard protocols for all U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) field personnel and their contractors for use in maintaining field and sampling activity records, writing sample logs, labeling samples, ensuring that proper sample custody procedures are utilized, and completing chain-of-custody/analytical request forms.

2.0 PROCEDURES

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

2.1 RECORD KEEPING

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

2.2 SAMPLE LABELING

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

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

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

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

2.3 Custody Procedures

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

2.3.1 Sample Collection Custody Procedures

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

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

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

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

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

Field personnel shall also log individual samples onto carbon copy chain-of-custody forms when a sample is collected. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 2.4 indicating sample number, matrix, date and time of collection, number of containers, analytical methods to be performed on the sample, and preservatives added (if any). The samplers will also sign the COC form signifying that they were the personnel who collected the samples. The COC form shall accompany the samples from the field to the laboratory. When a cooler is ready for shipment to the analytical laboratory, the person delivering the samples for transport will sign and indicate the date and time on the accompanying COC form. One copy of the COC form will be retained by the sampler and the remaining copies of the COC form shall be placed inside a self-sealing bag and taped to the inside of the cooler. Each cooler must be associated with a unique COC form. Whenever a transfer of custody takes place, both parties shall sign and date the accompanying carbon copy COC forms, and the individual relinquishing the samples shall retain a copy of each form. One exception is when the samples are shipped; the delivery service personnel will not sign or receive a copy because they do not open the coolers. The laboratory shall attach copies of the completed COC forms to the reports containing the results of the analytical tests. An example COC form is provided in Attachment III-E-2. An example of a completed COC form is provided in Attachment III-E-3 and described in Section 2.4.

2.3.2 Laboratory Custody Procedures

The following are custody procedures to be followed by an independent laboratory receiving samples for chemical analysis; the procedures in their Laboratory Quality Assurance Plan (LQAP) must follow these same procedures. A designated sample custodian shall take custody of all samples upon their arrival at the analytical laboratory. The custodian shall inspect all sample labels and COC forms to ensure that the information is consistent, and that each is properly completed. The custodian will also measure the temperature of the samples in the coolers upon arrival. The custodian shall also note the condition of the samples including:

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

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

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

The custodian shall then assign a unique laboratory number to each sample and distribute the samples to secured storage areas maintained at 4°C. The unique laboratory number for each sample, contractor sample ID, client name, date and time received, analysis due date, and storage details shall also be manually logged onto a sample receipt record and later entered into the laboratory's computerized data management system. The custodian shall also sign the shipping bill and maintain a copy.

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

2.4 COMPLETING CHAIN-OF-CUSTODY/ANALYTICAL REQUEST FORMS

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

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

Box 1 Project Manager: This name shall be the name that will appear on the report. Do not write the name of the Project Coordinator or point of contact for the project instead of the Project Manager.

Project Name: Write it, as it is to appear on the report.

Project Number: Write it as it is to appear on the report. It shall include the project number, task number, and general ledger section code. The laboratory subcontract number should also be included.

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

Box 3 Sample Disposal Instructions: These instructions will be stated in the Basic Ordering Agreement (BOA) or each Task Order statement of work with each laboratory.

Shipment Method: State the method of shipment, e.g., hand carry; air courier via FEDEX, AIRBORNE, DHL or equivalent.

Comment: This area shall be used by the field team to communicate observations, potential hazards, or limitations that may have occurred in the field or additional information regarding analysis. For example: a specific metals list, explanation of Mod 8015, Mod 8015 + Kerosene, samples expected to contain high analyte concentrations.

Box 4 Cooler Number: This will be written somewhere on the inside or outside of the cooler and shall be included on the COC. Some laboratories attach this number to the trip blank identification, which helps track VOC samples. If a number is not on the cooler, field personnel shall assign a number, write it on the cooler, and write it on the COC.

QC Level: Enter the reporting/QC requirements, e.g., NAVFAC NW QC Level C, D, or E.

Turnaround time (TAT): TAT for contract work will be determined by a sample delivery group (SDG), which may be formed over a 14-day period, not to exceed 20 samples. Standard turnaround time once the SDG has been completed is 35 calendar days from receipt of the last sample in the SDG. Entering NORMAL or STANDARD in this field will be acceptable. If quicker TAT is required, it shall be in the subcontract with the laboratory and reiterated on each COC to remind the laboratory.

Box 5 Type of containers: The type of container used, e.g., 1-liter glass amber, for a given parameter in that column.

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

Box 6 Sample number: Five-character alpha-numeric identifier to be used by the laboratory to identify samples. The use of this identifier is important since the labs are restricted to the number of characters they are able to use. See SOP I-A-11, Sample Naming.

Description (sample identification): This name will be determined by the location and description of the sample, as described in SOP I-A-11, Sample Naming. This sample identification should not be submitted to the laboratory, but should be left blank. If a computer COC version is used, the sample identification can be input but printed with this block black. A cross-referenced list of sample number and sample identification must be maintained separately.

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

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

Lab Identification: This is for laboratory use only.

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

Box 8 Analytical Parameters: Enter the parameter by descriptor and the method number desired. When requesting metals that are modifications of the standard lists, define the list in the comment section. This would not be necessary when requesting standard list metals such as priority pollutant metals (PPM), target compound list from ILM03.0, and Title 22 metals which are groups of metals commonly requested and should not cause any confusion as to what metals are being analyzed. Whenever possible, list the parameters as they appear in the laboratory subcontract to maintain consistency and avoid confusion.

In the boxes below the analytical parameter, indicate the number of containers collected for each parameter by marking an "X". If more than one container is used for a sample, write a number in the desired box to indicate a request for analysis and to indicate the number of containers sent for that analysis.

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

Relinquished By: This space shall contain the signature of the person who turned over the custody of the samples to a second party other than an express mail carrier such as FEDEX, DHL or Air Borne Express.

Received By: Typically, this is a written signature by a representative of the receiving laboratory, or a field crewmember who delivered the samples in person from the field to the laboratory. A courier such as FedEx or DHL does not sign because they do not open the coolers. It must also be used by the prime contracting laboratory when samples are sent to a subcontractor.

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

Received By (Laboratory): This space is for the final destination (e.g., at a subcontracted laboratory).

Box 10 Lab Number and Questions: This box is to be filled in by the laboratory only.

Box 11 Control Number: This number is the "COC" followed by the first sample number in a cooler, or contained on a COC. This control number must be unique and never used twice. Record the date the COC is completed. It should be the same date the samples are collected.

Box 12 Total No. of Containers/row: Sum the number of containers in that row.

Box 13 Total No. of Containers/column: Sum the number of containers in that column.

Because COC forms contain different formats based upon who produced the form, not all of the information listed in items 1 to 13 may be recorded. However, as much of this information as possible shall be included.

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

Complete one COC form per cooler. Whenever possible, reduce the number of trip blanks by placing all samples to be analyzed for VOA, gasoline, and BTEX compounds into one cooler. Complete all sections and be sure to sign and date the COC form. One copy of the COC form must remain with the field personnel.

3.0 DOCUMENTATION

The COC/analytical request form shall be faxed daily, if possible, to the Task Order Laboratory Coordinator for accuracy verification. Following the completion of sampling activities, the sample logbook and COC forms will be transmitted to the Project Manager for storage in project files. The Project Manager shall review COC forms on a monthly basis at a minimum. The data validators shall also receive a copy. Along with the data delivered, the original COC/analytical request form shall be submitted by the laboratory. Any changes to the analytical requests that are required shall be made in writing to the laboratory. A copy of this written change shall be sent to the data validators and placed in the project files. The reason for the change shall be included in the project files so that recurring problems can be easily identified.

4.0 REFERENCES

SOP I-A-11, *Sample Naming*

SOP III-D, *Logbooks*

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

USEPA. 1986. EPA NEIC Policies and Procedures, National Enforcement Investigations Center, Denver, Colorado.

USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA OSWER Directive 9355 3-01).

USEPA. 1992. RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD).

USEPA. 1995 and as updated. Test Methods for Evaluating Solid Waste (SW-846), Third edition.

5.0 ATTACHMENTS

Attachment III-E-1 Chain-of-Custody Seal

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

Attachment III-E-3 Sample Completed Chain-of-Custody/Analytical Request Form

Attachment III-E-4 Sample Out-of-Control Form

Attachment III-E-1
Chain-of-Custody Seal

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

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

Chain-of-Custody

Control Number: 94H0

Date Page ____ of ____

CTO/DO Manager:

CTO/DO Name:

CTO/DO Number:

Deliver results to the address above or as stated in contract

Cooler No:

QC Level: TAT:

Bill To:

Company:

Address:

Sample Disposal

Shipment

Comments:

# of containers:

Preservatives:

Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010				Extra Volume MS/MSD	HOLD	Total # of Containers
							TOTALS:																

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

For Lab Use

Lab No.:

Does COC match samples: Y or N

Broken container: Y or N

Received within holding time: Y or N

COC seal intact: Y or N

Any other problems: Y or N

If problems, Client contacted: Y or N

Date contacted: ___/___/___

Temperature (°C):

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

Attachment III-E-3
Sample Completed Chain-Of-Custody/
Analytical Request Form

Chain-of-Custody

Control Number: **96H0HC205**

Date 9 / 3 / 96 Page 1 of 1

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

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

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

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

Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010				Extra Volume MS/MSD	HOLD	Total # of Containers
container # (water):									1	2	2	1	2	1							2		
Preservatives:									HCL	HCL			HNO3										
HC205		9/6/96	9:35		X				X	X	X	X	X	X									1
HC206		9/6/96	9:50		X				X	X	X	X	X	X									1
HC207		9/6/96	10:15		X				X	X	X	X	X	X									1
HC208		9/6/96	10:25		X				X	X	X	X	X	X									1
HC209		9/6/96	10:45		X				X	X	X	X	X	X									1
HC210		9/6/96	10:55			X		X		X													2
HC211		9/6/96	12:50			X			X	X	X	X	X	X									8
								TOTALS:	6	8	7	6	7	6									16

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

For Lab Use

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

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

Attachment III-E-4
Sample Out-Of-Control Form

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

		Samples Affected (List by Accession AND Sample No.)
Date Recognized:	By:	
Dated Occurred:	Matrix	
Parameter (Test Code):	Method:	
Analyst:	Supervisor:	

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

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

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

SAMPLE HANDLING, STORAGE, AND SHIPPING

1.0 PURPOSE

This standard operating procedure (SOP) sets forth the methods for use by U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) field personnel and their contractors engaged in handling, storing, and transporting water, soil and/or sediment samples.

2.0 PROCEDURE

2.1 HANDLING AND STORAGE

Immediately following collection, all samples will be labeled according to the procedures in SOP III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures*. The lids of the containers shall not be sealed with duct tape, but may be covered with custody seals or placed directly into sealed plastic bags. The sample containers shall be placed in an insulated cooler with frozen gel packs (such as "blue ice") or ice in double, self-sealing bags. Samples should occupy the lower portion of the cooler, while the ice should occupy the upper portion. An absorbent material (e.g., proper absorbent cloth material) may be placed on the bottom of the cooler to contain liquids in case of spillage. All empty space between sample containers shall be filled with bubble wrap, Styrofoam "peanuts," or other appropriate material. Prior to shipping, glass sample containers should be wrapped on the sides, tops, and bottoms with bubble wrap or other appropriate padding and/or surrounded by packing material to prevent breakage during transport. Prior to shipment, the ice or cold packs in the coolers may require replacement to maintain samples as close to 4°C as possible during transport of the samples to the analytical laboratory. Samples shall be shipped as soon as possible to allow the laboratory to meet holding times for analyses. The procedures for maintaining sample temperatures at 4°C, pertains to all water, soil, and sediment field samples.

2.2 SHIPPING

All appropriate U.S. Department of Transportation (DOT) regulations (e.g., 49 Code of Federal Regulations (CFR), Parts 171-179) shall be followed in shipment of air, soil, water, and other samples.

2.2.1 Hazardous Materials Shipment

Field personnel must state whether any sample is suspected to be a hazardous material. A sample should be assumed to be hazardous unless enough evidence exists to indicate it is nonhazardous. If not suspected to be hazardous, shipments may be made as described in the Section 2.2.2 for non-hazardous materials. If hazardous, the procedures summarized below must be followed.

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

All persons offering for shipment any hazardous material must be properly trained in the appropriate regulations, as required by HM-126F, Training for Safe Transportation of Hazardous Materials. The training covers loading, unloading, handling, storing, and transporting of hazardous materials, as well as emergency preparedness in the case of accidents. Carriers such as commercial couriers must also be trained.

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

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

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

2.2.2 Nonhazardous Materials Shipment

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

When a cooler is ready for shipment to the laboratory, copies of the chain-of-custody form shall be placed inside a sealed plastic bag and placed inside of an insulated cooler. The coolers will then be sealed with waterproof tape and labeled "Fragile," "This-End-Up" (or directional arrows pointing up), or other appropriate notices. Custody seals will be placed on the coolers as discussed in SOP III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures*.

2.2.3 Shipments from Outside the Continental United States

Shipment of sample coolers to the U.S. from locations outside the continental U.S. is controlled by the USDA and is subject to their inspection and regulation. Documentation is required to prove that the analytical laboratory receiving samples is certified. The laboratory must have certification by USDA to receive and properly dispose of soil; this is called a "USDA Soil Import Permit." In addition, all sample coolers must be inspected by a USDA representative, affixed with a label indicating that the coolers contain environmental samples, and shipping forms stamped by the USDA inspector prior to shipment. In addition, samples shipped from U.S. territorial possessions or foreign countries, must be cleared by the

U.S. Customs Service upon entry into the United States. As long as the commercial invoice is properly completed (see below), shipments typically pass through U.S. Customs without the need to open coolers for inspection.

Completion and use of proper paperwork will, in most cases, minimize or eliminate the need of the USDA and U.S. Customs to inspect the contents. Attachment III-G-5 shows an example of how paperwork may be placed on the outside of coolers for nonhazardous materials. For hazardous materials, refer to Section 2.2.1.

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

1. **Courier Shipping Form & Commercial Invoice** - See Attachments III-G-6, III-G-7, and III-G-8 for examples of the information to be included on these forms. Both forms should be placed inside a clear plastic adhesive-backed pouch, which adheres to the package (typically supplied by the courier) and placed on the cooler lid as shown in Attachment 5.

2. **Soil Import Permit and USDA Letter** (soil only) - See Attachments III-G-9 and III-G-10 for examples. The laboratory shall supply these documents prior to mobilization. The USDA in Hawaii often does stop shipments of soil without these documents. The 2" x 2" USDA label (described below), the USDA letter, and soil impact permit should be stapled together and placed inside a clear plastic pouch. Clear plastic and adhesive-backed pouches are typically supplied by the mailing courier.

3. The analytical laboratory should supply the Soil Import Permit. Although original labels are preferred, copies of this label, which are cut out to the 2" x 2" dimensions, are acceptable. Placing one label (as shown in Attachment III-G-5) covered with clear packing tape and one stapled to the actual permit is suggested.

4. The USDA does not control water samples, thus the requirements for soils listed above do not apply.

5. **Custody Seals**. Task Order personnel must sign and date custody seals. At least two seals should be placed in such a manner that they stick to both the cooler lid and body. The seals shall be placed so the cooler/container cannot be opened without breaking the seal. The custody seals are then covered with clear packing tape. This prevents the seal from coming loose and enables detection of tampering.

6. **Address Label**. A label stating the destination (the sending and laboratory, company, or location address) should be affixed to each cooler. The label should also include both telephone numbers.

7. **Special Requirements for Hazardous Materials** - see Section 2.2.1.

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

3.0 DOCUMENTATION

Records shall be maintained as required by implementing these procedures.

4.0 REFERENCES

HM-126F, Training for Safe Transportation of Hazardous Materials

SOP III-E, Record Keeping, Sample Labeling, and Chain-of-Custody Procedures

5.0 ATTACHMENTS

Attachment III-G-1 Example Package Marking

Attachment III-G-2 Packing Groups

Attachment III-G-3 Label for Dangerous Goods in Excepted Quantities

Attachment III-G-4 SW-846 Preservative Exception

Attachment III-G-5 Sample Cooler Marking Figure

Attachment III-G-6 Example Courier Form

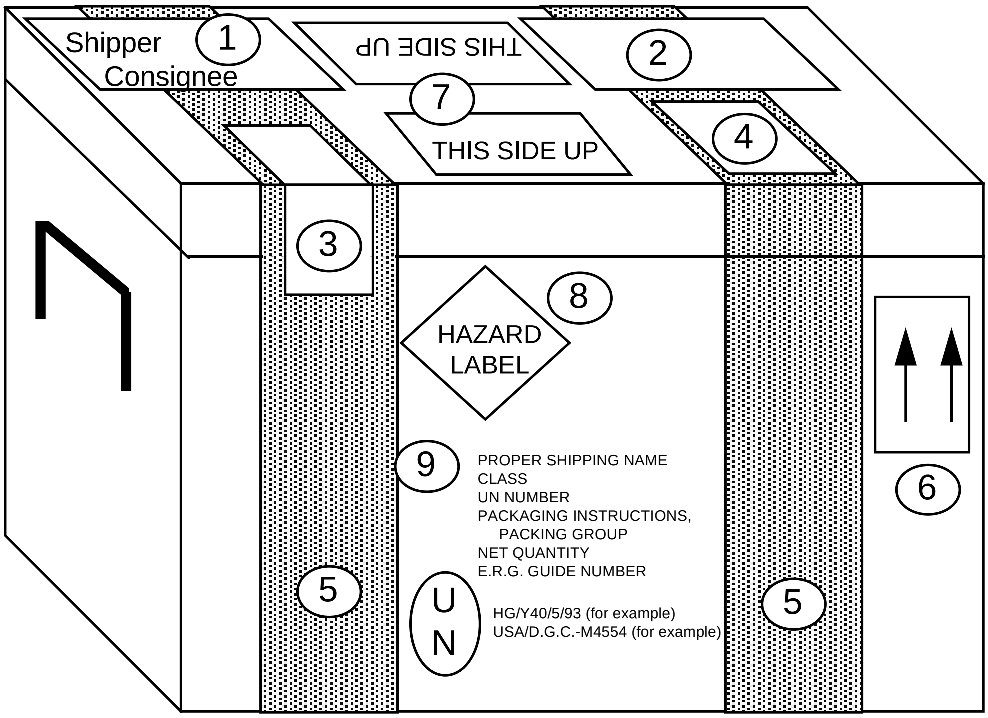
Attachment III-G-7 Commercial Invoice - Soil

Attachment III-G-8 Commercial Invoice - Water

Attachment III-G-9 Soil Import Permit

Attachment III-G-10 Soil Samples Restricted Entry Labels

Attachment III-G-1
Example Hazardous Material Package Marking



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

Attachment III-G-2
Packing Groups

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

Note A: Packing groups are not used for this class or division.

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

Note C: Applies only to Organic Peroxides when contained in a chemical kit, first aid kit or polyester resin kit.

Note D: See 6.1.4.1, 6.1.4.2 and 6.2.1.1 through 6.2.1.7, radioactive material in excepted packages.

Note E: For substances in Class 9 for which no packing group is indicated in the List of Dangerous Goods, Packing Group II quantities must be used.

Attachment III-G-3
Label For Dangerous Goods In Excepted Quantities

DANGEROUS GOODS IN EXCEPTED QUANTITIES

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

____
Signature of Shipper

______________________ ____________________
Title Date

____

____
Name and address of Shipper

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

Class:	2	3	4	5	6	8	9
	☐	☐	☐	☐	☐	☐	☐

and the applicable UN Numbers are:

ATTACHMENT III-G-4
Preservative Exception

Measurement	Vol. Req. (mL)	Container[2]	Preservative [3,4]	Holding Time[5]
MBAS	2 50	P,G	Cool, 4ºC	48 Hours
NTA	5 0	P,G	Cool, 4ºC	24 Hours

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

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

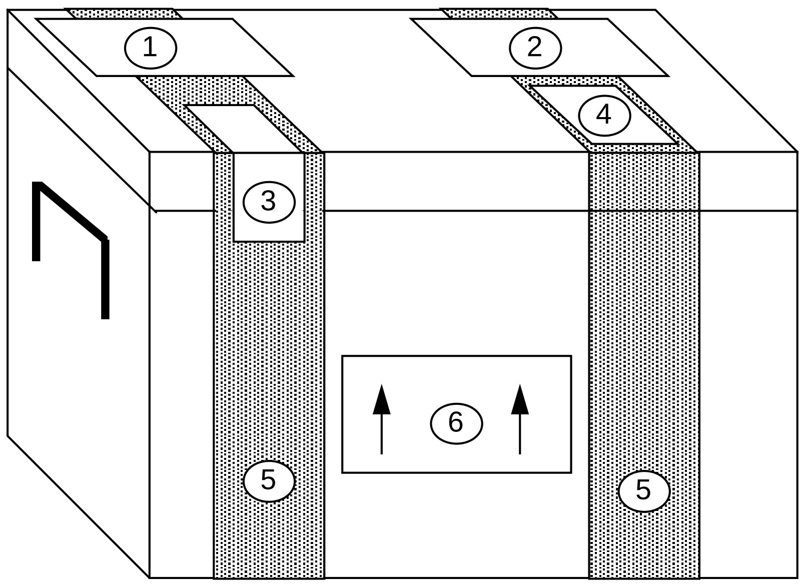
3. Sample preservation should be performed immediately upon sample collection. For composite samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4ºC until compositing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

4. When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. for the preservation requirements of Table 1, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentration of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or grater); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

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

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

Attachment III-G-5
Non-Hazardous Material Cooler Marking Figure For Shipment From Outside the Continental United States



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

Attachment III-G-6
Example Courier Form

FedEx. USA Airbill FedEx Tracking Number 801704855619 0200 Form I.D. No. SPL11 Sender's Copy

1 From (please print and press hard)

Date Sender's FedEx Account Number Account Number

Sender's Name Joe Smith Phone (808) 545-2462

Company OGDEN ENVIRONMENTAL/CRC ACCT

Address 680 IWILEI RD STE 660 Dept/Floor/Suite/Room

City HONOLULU State HI ZIP 96817

2 Your Internal Billing Reference Information (Optional) (First 24 characters will appear on invoice)

3 To (please print and press hard)

Recipient's Name Sample Receipt Phone ( ) Lab Phone #

Company Lab Name

Check here if residence (Extra charge applies for FedEx Express Saver)

Address Lab Address (To "HOLD" at FedEx location, print FedEx address here) (We Cannot Deliver to P.O. Boxes or P.O. ZIP Codes) Dept/Floor/Suite/Room

City State ZIP

For HOLD at FedEx Location check here: Hold Weekday (Not available with FedEx First Overnight) Hold Saturday (Not available at all locations) (Available for FedEx Priority Overnight and FedEx 2Day only)

For Saturday Delivery check here (Extra Charge. Not available to all locations) (Available for FedEx Priority Overnight and FedEx 2Day only)

Service Conditions, Declared Value, and Limit of Liability – By using this Airbill, you agree to the service conditions in our current Service Guide or U.S. Government Service Guide. Both are available on request. SEE BACK OF SENDER'S COPY OF THIS AIRBILL FOR INFORMATION AND ADDITIONAL TERMS. We will not be responsible for any claim in excess of $100 per package whether the result of loss, damage, or delay, non-delivery, misdelivery, or misinformation, unless you declare a higher value, pay an additional charge, and document your actual loss in a timely manner. Your right to recover from us for any loss includes intrinsic value of the package, loss of sales, interest, profit, attorney's fees, costs, and other forms of damage, whether direct, incidental, consequential, or special, and is limited to the greater of $100 or the declared value but cannot exceed actual documented loss. The maximum declared value for any FedEx Letter and FedEx Pak is $500. Federal Express may, upon your request, and with some limitations, refund all transportation charges paid. See the FedEx Service Guide for further details.

Questions? Call 1·800·Go·FedEx (800)463-3339

The World On Time

4a Express Package Service Packages under 150 lbs. Delivery commitment may be later in some areas.
FedEx Priority Overnight (Next business morning) | FedEx Standard Overnight (Next business afternoon) | FedEx 2Day* (Second business day) | FedEx Express Saver* (Third business day) | FedEx First Overnight (Earliest next business morning delivery to select locations) (Higher rates apply)
*FedEx Letter Rate not available. Minimum charge: One pound rate.

4b Express Freight Service Packages over 150 lbs. Delivery commitment may be later in some areas.
FedEx Overnight Freight (Next business day) | FedEx 2Day Freight (Second business day) | FedEx Express Saver Freight (Up to 3 business days)
(Call for delivery schedule. See back for detailed descriptions of freight services.)

5 Packaging: FedEx Letter | FedEx Pak | FedEx Box | FedEx Tube | Other Pkg. — Declared value limit $500

6 Special Handling
Does this shipment contain dangerous goods? Yes (As per attached Shipper's Declaration) | Yes (Shipper's Declaration not required)
Dry Ice (Dry Ice, 9, UN 1845 III ___ x ___ kg. 904) (Dangerous Goods Shipper's Declaration not required) | Cargo Aircraft Only

7 Payment
Bill to: Sender (Account no. in section 1 will be billed) | Recipient | Third Party | Credit Card | Cash/Check
(Enter FedEx account no. or Credit Card no. below)
FedEx Account No.
Credit Card No. Exp. Date

Total Packages | Total Weight | Total Declared Value* | Total Charges
$ .00 $

*When declaring a value higher than $100 per shipment, you pay an additional charge. See SERVICE CONDITIONS, DECLARED VALUE, AND LIMIT OF LIABILITY section for further information.

8 Release Signature Sign to authorize delivery without obtaining signature.

Your signature authorizes Federal Express to deliver this shipment without obtaining a signature and agrees to indemnify and hold harmless Federal Express from any resulting claims.

287

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003520091 4

RETAIN THIS COPY FOR YOUR RECORDS

Attachment III-G-7
Commercial Invoice - Soil

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

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

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

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

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

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

ATTACHMENT III-G-8
Commercial Invoice - Water

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

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

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

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

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

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

Attachment III-G-9
Soil Import Permit

UNITED STATES DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE PROGRAMS

COMPLIANCE AGREEMENT

1. NAME AND MAILING ADDRESS OF PERSON OR FIRM Ogden Environmental & Energy Service Co. 680 Iwilei Road, Suite 660 Honolulu, HI 96817	2. LOCATION 680 Iwilei Road, Suite 660 Honolulu, HI 96817 Telephone: 545-2462 Fax: 528-5379

3. REGULATED ARTICLE(S)
Foreign soil samples destined to approved laboratories in the Continental United States transiting through Honolulu International Airport and military facilities on Oahu, Hawaii.

4. APPLICABLE FEDERAL QUARANTINE(S) OR REGULATIONS

7 CFR 330.300

6. *I/We agree to the following:*

See the attached Addendum, Foreign Soil Samples Destined To Approved Laboratories In The Continental United States Transiting Through Honolulu International Airport And Military Facilities On Oahu, Hawaii

THIS COMPLIANCE AGREEMENT IS VALID FOR 2 YEARS FROM THE DATE OF ISSUANCE.
For renewal, call our office at 861-8446 or Fax 861-8450.

EXPIRATION DATE: SEPTEMBER 30, 2000

7. SIGNATURE Betsy D. [signature]	8. TITLE Air & Hazardous Waste Group Manager	9. DATE SIGNED 9/9/98
The affixing of the signatures below will validate this agreement which shall remain in effect until canceled, but may be revised as necessary or revoked for noncompliance.		10. AGREEMENT NO. OAHU-ST-002 11. DATE OF AGREEMENT September 2, 1998

12. PPQ OFFICIAL (*Name and Title*) Michael M. Jodoi, Supervisor, Satellite Operations	13. ADDRESS USDA, APHIS, PPQ 3375 Koapaka Street, Suite G330 Honolulu, HI 96819
14. SIGNATURE [signature]	
15. STATE AGENCY OFFICIAL (*Name and Title*) N/A	16. ADDRESS N/A
17. SIGNATURE N/A	

PPQ FORM 519 REPLACES PPQ 274, 519, 560, AND AQI 83, WHICH ARE OBSOLETE
AUG. 1977

Soil - Foreign\Foreign Soil - Transit Comp Agree Form 519.twp

Attachment III-G-10
Soil Samples Restricted Entry Labels

U.S. DEPARTMENT OF AGRICULTURE

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

PLANT PROTECTION AND QUARANTINE

HYATTSVILLE, MARYLAND 20782

soil samples

restricted entry

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

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

PPQ FORM 550 Edition of 12/77 may be used

(JAN 83)

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(JAN 83)

EQUIPMENT DECONTAMINATION

1.0 PURPOSE

The standard operating procedure (SOP) describes general methods of equipment decontamination (decon) for use by U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) field personnel and their contractors during field sampling activities. Some sites may require additional steps (e.g. nitric rinses for metals, hexane for chlorinated pesticides) to insure equipment is properly deconned. These should be identified and addressed in the Work Plans and/or the Quality Assurance Project Plans (QAPPs)

2.0 PROCEDURES

Decontamination of equipment is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program should include consideration of the following factors:

- The location where the decon procedures will be conducted
- The types of equipment requiring decon
- The frequency of equipment decontamination
- The cleaning technique and types of cleaning solutions appropriate to the contaminants of concern
- The method for containing the residual contaminants and wash water from the deconning process
- The use of a quality control measure to determine the effectiveness of the decontamination procedure (e.g. equipment rinsate samples)

This subsection describes standards for decontamination, including the techniques to be used, frequency of decontamination, cleaning solutions, and effectiveness.

2.1 DECONTAMINATION AREA

An appropriate location for the decontamination area at a site shall be selected on the basis of the ability to control access to the area, control residual material removed from equipment, the need to store dirty and clean equipment, and the ability to restrict access to the area being investigated. The decontamination area shall be located an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

2.2 TYPES OF EQUIPMENT

Examples of drilling equipment that must be deconned includes drill bits, auger sections, split spoon samplers, and hand tools. Decontamination of monitoring well development and ground-water sampling equipment includes submersible pumps, non-disposable bailers, interface probes, water level meters, bladder pumps, airlift pumps, and lysimeters. Other sampling equipment that may require decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless steel spoons and bowls, soil sample liners and caps, wipe sampling templates, COLIWASA samplers, and dippers. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and should be properly disposed of after one use.

2.3 FREQUENCY OF EQUIPMENT DECONTAMINATION

Down-hole drilling equipment and equipment used in monitoring well development and purging shall be decontaminated prior to initial use and between each borehole or well. However, down hole drilling equipment may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, the drilling tools shall be decontaminated prior to drilling deeper. Groundwater sampling should be initiated by sampling ground water from the monitoring well where the least contamination is suspected. This is more important when not using disposable equipment. All groundwater, surface water, and soil sampling devices shall be decontaminated prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

2.4 CLEANING SOLUTIONS AND TECHNIQUES

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

A rinse decontamination procedure is acceptable for equipment such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following: (1) wash with a non-phosphate detergent (Citrinox®, Liquinox®, or other suitable phosphate free detergent) and potable water solution, (2) rinse with potable water, and (3) rinses with deionized or distilled water. Equipment shall be disassembled as much as is practical, prior to cleaning. An initial gross wash scrub down and quick rinse should be completed at the beginning of the process if equipment is heavily soiled. After decontamination, care needs to be taken that the cleaned equipment does not become contaminated. This may require wrapping items in foil or plastic and storing the equipment in a specified “clean” area.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. The pumps shall be decontaminated by circulating fluids through the pump while it is operating. This circulation can be done using a clean 4-inch or greater diameter pipe equipped with an end cap. The pipe shall be filled with enough decon fluid to submerge the pump, the pump placed within the capped pipe, and the pump operated while circulating the fluids within the pipe. The decontamination sequence shall include (1) detergent and potable water, (2) potable water rinse, and (3) deionized or distilled water rinse. The decontamination fluids shall be changed after each cycle. Changing of the fluids may include dumping of the detergent water, mixing detergent in the potable water rinse, using the deionized water as the potable rinse and renewing the distilled/deionized water. All decon water shall be disposed of as outlined in the field work plans.

Decontamination solvent(s) to be used during field activities will be specified in Project Work Plans or QAPPs. If solvents are used, sufficient time must be allowed to insure the solvent has evaporated from the equipment prior to reuse.

Equipment used for measuring field parameters such as pH, temperature, specific conductivity, and turbidity shall be rinsed with deionized or distilled water. New, unused soil sample liners and caps will be cleaned using the three step process, outlined above, to remove any dirt or cutting oils that may be on them prior to use.

2.5 CONTAINMENT OF RESIDUAL CONTAMINANTS AND CLEANING SOLUTIONS

Decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water. This may require setting up a containment area with a system for pumping the water generated decontamination water into proper containers.

Clean equipment should be stored in a separate location to prevent recontamination. Decontamination fluids contained within the bermed area shall be collected and disposed of as outlined in the field sampling plan.

Containment of fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices shall be accomplished using wash buckets or tubs. The decontamination fluids shall be collected and disposed of as outlined in the field sampling plan.

2.6 EFFECTIVENESS OF DECONTAMINATION PROCEDURES

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment rinsate samples or wipe testing. Equipment rinsates consist of analyte-free water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a cloth over the surface of the equipment after cleaning. Further descriptions of these samples and their required frequency of collection are provided in SOP III-B, *Field QC Samples (Water, Soil)*. These quality control measures provide "after-the fact" information that may be useful in determining whether or not cleaning methods were effective in removing the contaminants of concern.

3.0 DOCUMENTATION

The decontamination process shall be recorded in the field logbook.

4.0 REFERENCES

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

5.0 ATTACHMENTS

None.

EQUIPMENT CALIBRATION, OPERATION, AND MAINTENANCE

1.0 PURPOSE

This standard operating procedure (SOP) describes the activities and responsibilities of the U.S. Naval Facilities Engineering Command Northwest (NAVFAC NW) personnel pertaining to the operating, calibration, and maintenance of equipment used to collect environmental data. Reliable measurements of data required by the field sampling plan are necessary because the information recorded may be the basis for development of remedial action and responses.

2.0 PROCEDURES

2.1 EQUIPMENT CALIBRATION

All water quality monitoring equipment will be calibrated and adjusted to operate within the manufacturers' specifications. Water quality instruments and equipment that require calibration are to be calibrated to specifications prior to field use. In addition, a one-point calibration check is made at midday and at intervals outlined in the field sampling plan. A final check is conducted at the end of each field day. This is not a recalibration of the meter but a check of the calibration to ensure the continued accuracy of the meter. All calibration information shall be recorded in the project logbook.

Special attention shall be paid to instruments that may be affected by the change in the ambient temperature or humidity. Calibration checks should also be performed when sampling conditions change significantly, a change of sample matrix, and/or readings are unstable or there is a change of parameter measurements that appear unusual.

2.2 EQUIPMENT MAINTENANCE

All field monitoring equipment, field sampling equipment, and accessories are to be maintained in accordance with the manufacturer's recommendations and specifications and/or established field practices. All maintenance will be performed by qualified personnel and documented in the field logbook.

Equipment requiring battery charging shall be charged as recommended by the manufacturer. Backup batteries for meters requiring them shall be included as part of the meters accessories. Care must be taken to protect meters from adverse elements. This may involve placing the meter in a large plastic bag to shield it from the weather.

3.0 DOCUMENTATION

All field equipment calibration, maintenance, and operation information shall be recorded within the field logbook. This is to document that appropriate procedures have been followed and to track the equipment operation. All entries in the field logbook must be written accurately and legibly as outlined in the SOP III-D, *Logbooks*.

Logbook entries shall contain, but are not necessarily limited to, the following:

- Equipment model and serial numbers
- Date and time of calibration or maintenance performed
- Calibration standard used
- Calibration lot number and expiration date if listed on bottle
- Calibration procedure used if there are multiple options
- Calibration and calibration check readings including units used
- Problems and solutions regarding use, calibration or maintenance of the equipment
- And other pertinent information

4.0 REFERENCES

SOP III-D, *Logbooks*

5.0 ATTACHMENTS

None.

Guidelines for Logging Soil Borings

Tunnels and Earth Engineering Practice

September 2015

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Appendixes

Guidelines for Logging Soil Borings

1. Introduction

The purpose of this document is to guide CH2M HILL staff in accurately and consistently recording the field data necessary to characterize soil borings and recovered soil samples. Adherence to a standard format for recording data will help streamline project efforts and lead to a consistent presentation of subsurface data.

2. Policy

The guidelines presented herein are recommended for CH2M HILL projects where soil borings are conducted as part of a subsurface exploration program. These guidelines establish the minimum information that should be recorded in the field to sufficiently describe information gathered during drilling, as well as characterize soil samples collected during the exploration program. Additional information may need to be collected based on project-specific requirements. This document does not address abandonment of boreholes, installations (e.g., piezometer, monitoring wells, thermistors or similar) or final presentation of the data (e.g., gINT logs). Guidelines for these activities will be presented in separate standalone documents.

For projects where environmental contamination is possible or expected, additional planning and procedures will be required that are not included in these guidelines. CH2M health and safety personnel, as well as other experience project staff should be consulted to establish procedures for drilling, sampling, storing, and testing of samples with environmental contamination. For projects where contamination was not expected, but is encountered during the field program, the work should be stopped and the geotechnical task lead contacted before any further work occurs.

The geotechnical task lead should review these guidelines and determine if additional data requirements are needed for the project. Certain project stakeholders (clients or regulators) may require the use of different forms and/or logging requirements. In such cases, the guidelines presented herein should still be referenced to supplement those requirements to meet the overall project goals, as determined by the geotechnical task lead.

The typical CH2M HILL Standard Soil Boring Log Form should be used on all projects for field logging of soil borings (Figure 1). The form provides a template to document information recommended by ASTM D5434, *Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock*, and ASTM D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. This document provides direction to meet the general requirements of these standards, as well as other relevant ASTM standards discussed subsequently. It should be stressed that the logger should be familiar with the ASTM standards; these guidelines are not a substitute for the ASTM (or other) standards.

CH2M HILL staff members are encouraged to provide suggestions for clarification or improvements to this document.

3. Borings with Soil and Rock

Most exploratory boreholes that involve rock coring are advanced using soil boring techniques until rock is encountered. Because the contact between soil/highly weathered rock and sound rock can be gradual, it is not always clear when to begin rock coring. A separate document, “CH2M HILL Guidelines for Logging of Rock Cores” provides direction on determining how and when to switch to rock coring.

In some cases, both soil drilling and rock coring may be used in a single borehole. For example, where the transition to rock is gradual, coring may be performed through harder rock zones, and Standard Penetration Test (SPT) samples may be taken intermittently where softer material or soil infilling is encountered. Switching back and forth between methodologies requires advance planning with the drilling firm to ensure that the correct equipment is available on-site. Field logs should clearly describe procedures and drilling techniques used to advance the full depth of exploration.

4. Soil Boring Log Form

A typical CH2M HILL Standard Soil Boring Log Form is shown in Figure 1; it is recommended that the form be printed on weatherproof paper (e.g., all-weather *Rite-in-the-Rain* brand paper), which is available from office reprographics departments and from all regional warehouses. See Appendix C for a full-page printable version of the log. Following are instructions for completing the log forms. Appendix A contains examples of completed field soil boring logs.

All heading information on the form should be filled out completely on each log page, and all technical items in each column addressed or otherwise marked “N/A” as appropriate. The logger should review completed logs for accuracy, clarity, consistency, and completeness. On large projects with multiple loggers, it is recommended that logs be frequently reviewed for consistency by a single person (i.e., the geotechnical task lead or designee).

4.1 Soil Boring Log Standard Information

4.1.1 Project Number

Fill in the CH2M HILL project number, including appropriate task and function numbers.

4.1.2 Boring and Sheet Number

Enter the complete boring number, including prefix or suffix. If the boring consists of both soil drilling and rock coring, the soil boring log and the rock core log must have the same boring number. Boring names and numbers should be as required by the client and to meet project requirements. Boring naming convention should be established before the field program commences, and may be as simple as the boring name and number (e.g., B-01) for small projects, or more complex where multiple programs have been conducted over time, or when it is advantageous to indicate installations in the name. An example for the latter case is CH-B-05vwp-15, where CH stands for CH2M HILL, B stands for boring, 05 stands for the boring number, vwp indicates a vibrating wire piezometer, and 15 indicates the last two digits of the year.

Enter the number of the log sheet (i.e., page number). The sheets for a single boring should be sequentially numbered; do not begin a new numbering sequence for any rock core logs that follow soil boring logs. Where rock coring follows soil drilling, appropriate notes should be added to the last soil boring log form used to indicate that the borehole log is continued on the rock core log that follows, beginning at the depth at which soil sampling was ended. These notes should be entered into the Comments column of the log.

4.1.3 Project

Fill in the name of the project or client.

4.1.4 Location and Elevation

For all borings, regardless of whether or not post-survey is planned, record the approximate location of the boring such that the boring can be relocated in the field with the recorded information.

If the boring location was staked or otherwise marked by survey before boring, indicate the distance and direction from the location, using modifiers such as “approximate” or “estimated,” as appropriate (e.g., estimate 5 feet NW of staked location). The reason for moving a staked boring may be helpful to note in the Comments section (e.g., gas line interference). When possible, also include stationing, coordinates, mileposts, or similar information (e.g., MP 242+15; 12 feet behind guardrail). If the boring is conducted at the staked location, a notation of “at staked location” should be made.

If a pre-exploration survey location was not provided or is not available, measure to recoverable reference points (e.g., stationary objects such as guardrails, buildings, fire hydrants), with enough measurements to either recover the location for a post-exploration survey or to document the location if a post-survey is not conducted. Where available and informative, identify the client facility, distance from nearest intersection, town and state, or similar descriptive location information. If available, a hand-held GPS unit may also be used to record the boring locations in the field, however, field measurements should still be made to provide a check on the GPS measurements.

Enter the elevation of the ground surface at the boring location. If the boring is offset from a surveyed or staked location with an elevation, provide an approximate elevation difference relative to the ground surface between the staked or surveyed location and the actual boring location. If it is estimated from a topographic map or is roughly determined using a hand level, use the modifier "approximate." As with the boring location, it is important to tie the boring elevation to a recoverable reference point (fire hydrant, floor slab) if no other elevation data are available. Such points can be picked up later in a site survey, from which boring elevations can be determined.

4.1.5 Drilling Contractor

Enter the name of the drilling company and the city and state where the company or the drill crew is based, along with the first initial and full last name of the lead driller.

4.1.6 Drilling Method and Equipment

Identify the drilling method and equipment, including the following:

- Make, model and serial number of the drill rig(s) used in the exploration;
- Method of drilling: e.g., mud rotary, hollow-stem auger, air rotary, sonic, overburden drilling with eccentric big ("ODEX"), etc.;
- Drill tool types and sizes: e.g., rod size for both drilling and sampling, bit type and size, casing size;
- Fluids type: e.g., air, mud, water;
- SPT hammer type (if used) and efficiency (if known): e.g., automatic hammer (eff=78%), safety hammer (no efficiency for safety hammer); and,
- Core barrel type, length, and diameter.

4.1.7 Water Levels

Water levels should be measured at the completion of each boring and recorded in the Comments column with a date and time. For multi-day borings, the water level should be measured each morning before resuming drilling. If possible, obtain a water level reading approximately 24 hours after completion of drilling. Water levels should also be noted during drilling activities, such as when first encountered.

Water levels observed in boreholes that use drilling methods with introduced fluids, such as mud rotary drilling or rock coring, may not be representative of the static water level. For such boreholes, the point at which fluids are added should be noted in the Comments column, e.g., switching from hollow-stem auger to mud rotary techniques.

Water level measurements observed in boreholes with casing still in place to maintain borehole stability may also not be representative of groundwater conditions. Regardless, water level measurements in these instances may be useful and should be recorded with the appropriate notations (e.g., may not be representative due to fluids, amount of casing left in place, etc.).

Water level measurements that are considered representative of static water levels should be entered in the header of the form.

If there are nearby bodies of water, it may be helpful to approximate the water levels in the vicinity of the boring. The information can be helpful in approximating long-term water levels in the exploration area.

If water levels will be taken after completion of drilling using a piezometer, whether an open standpipe, a monitoring well, or installed instrument, the log should include relevant information on the installation of the measurement system in the Comments column. For example, the top and bottom of the sand pack and screened interval, the depth of the instrument installation (e.g., vibrating wire piezometer), initial calibration readings, etc.

4.1.8 Start and Finish

Enter the times and dates the boring was started and completed. These times are intended to document drilling time, not including abandonment or installations. The Comments column can be used to clarify start and finish as required, such as for starting and ending dates and times for abandonment and installations if there are no other forms available to record this information.

4.1.9 Logger

Enter the logger's first initial and full last name.

4.2 Boring Log Technical Data

4.2.1 Depth Below Surface

Use a scale that is adequate for the needs of the project and does not crowd the field notations. Logging ten to twenty feet per page is often suitable for most projects, depending on the complexity of the subsurface materials. To the extent possible, use the same scale on all sheets for a log; if different scales are required, the scale change should be clearly identified on the log.

4.2.2 Sample Interval, Number, Type and Recovery

For discrete sampling, a solid horizontal line should be drawn across the log in the Sample columns (number, type, recovery) through the SPT column at the top and bottom of each sample attempted, whether SPT, thin-walled (e.g. Shelby tube), or other type. For continuous soil recovery methods such as sonic drilling, a system similar to rock coring may be used where a horizontal line is drawn through the same columns at the top and bottom of each sonic run. For drilling methods such as air rotary where only cuttings are collected, the geotechnical task lead should determine the appropriate means to record the required information. Additional notes and examples are provided below.

- For discrete sampling, the sample number and type should be recorded in the appropriate columns. For example, 1-SS = first sample, split spoon. Number samples consecutively, regardless of type. For example, if a thin-walled tube sample such as a Shelby tube (ST) or a Pitcher tube (PT) sample was taken following the 1-SS sample, their designation should read 2-ST or 2-PT. Enter a sample number for all discrete sample attempts even if no material was recovered in the sampler. Where more than one soil type is recovered in a single SPT and the soils are preserved separately for laboratory testing or other purposes, the sample may be designated with an “A” and “B”, e.g., 2A-SS and 2B-SS.
- For continuous recovery drilling, the run number and type (e.g., 1-SN for sonic) should be entered as the sample number/type. Further sample notions should be determined by the task lead, depending on how much of the soil is collected for preservation and/or laboratory testing. See subsection 7 of these guidelines for additional notes.
- For projects where soil and rock coring is conducted in the same boring, the numerical sequence for the core runs should start with new numbering; e.g., if the last soil sample was 10-SS, the first rock core would be designated 1-HQ. Certain projects may dictate that a continuous numbering system be used from soil sampling to rock core logging. If alternating soil samples and rock core are taken, the sample numbering should remain consecutive (e.g., 8-SS, 9-NQ, 10-SS, 11-NQ, etc.).
- For both discrete and continuous sampling, record the total length of the soil recovered to the nearest tenth of a foot. Slough at the top of the sample should be discarded and not included in recovery measurements.
- For grab or bag samples taken from cuttings (or other recovered materials) during drilling, such as from hollow-stem auger, ODEX or air rotary, recording of the sample information should be determined by the task lead. At a minimum, the sample should be numbered or otherwise appropriately labeled with

the estimated depth range (e.g., 6-B or 4-GB, bag sample of ODEX cuttings from 10-15 feet). The numbering may be a separate numbering scheme or continuous with other sampling as appropriate for the project.

4.2.3 Standard Penetration 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 last two 6-inch penetration intervals for 18-inch samples and the second and third 6-inch penetration intervals for 24-inch samples. A typical 18-inch SPT involving successive blow counts of 2, 3, and 4 is recorded as 2-3-4 (7); a typical 24-inch SPT involving successive blow counts of 4, 8, 9, and 20 is recorded as 4-8-9-20 (17).

Where an SPT sampler advances or sinks under the weight of rods (WOR) or weight of the hammer (WOH) for part or all of the sample length, the length of travel to the nearest 0.1 foot or inch along with the blow counts required to drive through the remainder of the sample interval should be recorded as the N-value, such as WOH/12”-2. If the sampler sinks the entire sample interval, terminate the sample at the required sampling depth, and record the N-value as WOH, WOR or both as appropriate. Where possible, WOH and WOR samples be drilled out and re-sampled beneath the original sample interval. For this type of re-sampling, and in other similar cases, a 6-inch gap between the bottom of the previous interval and the top of the next interval can help minimize disturbance in the top of the deeper sample.

When there is no soil recovery in an SPT, the soil description column should state “No Recovery” and any notes regarding the sample should be included in the Comments column. As with the case of WOH and WOR samples, no recovery samples should be drilled out and resampled at an appropriate interval beneath the original sample interval where possible and practicable.

A SPT can be terminated prematurely in hard materials if the sampler encounters refusal, where refusal is defined as one of the following:

- A penetration of more than 6 inches but less than 12 inches with a blow count of 100
- A penetration of less than 6 inches with a blow count of 50
- No movement of the sampler after 10 successive hammer blows

Partial penetrations (less than 18”) should be recorded as shown in the following examples:

- An example blow count of 50 blows for 4 inches is recorded as 50/4"
- An example blow count of 27 blows for 6 inches and 50 blows for 3 inches is recorded as 27-50/3”
- An example blow count of 14, 32 and 50 blows in 2 inches is recorded as 14-32-50/2”

See the Standard Penetration Test Procedures subsection of these guidelines for additional discussion.

4.2.4 Soil Description

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to the latest revision of ASTM D2488, *Visual-Manual Procedure for Description and Identification of Soils*. The Unified Soil Classification System (USCS) Group Symbol is based on numerical values of certain soil properties that are measured by laboratory tests (per ASTM D2487). Also, 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. Corrections and additions to the field classification can be made through laboratory testing.

Soil descriptions should be precise and comprehensive without being verbose. The overall character of the soil should not be distorted by excessive emphasis on relatively insignificant details. In general, similarities between consecutive samples should be stressed rather than differences. When samples appear to be of the same material, the description may be recorded as “same as SS-17.” Report the specific sample that is referred to rather than just “same as above.” For minor differences, the description may record the similar sample and the difference such as: "same as SS-19 except very dense" or "same as SS-5 except wet and trace organics."

The logger should be as consistent as possible in describing samples throughout the field program. By being consistent, final reduction of the field data is more efficient. For example, if a laboratory test shows that a material field-classified consistently as a silt is actually a lean clay, the logs can be updated appropriately. The final boring logs should show the USCS group name in parenthesis, e.g., (ML), when the ASTM D2488 procedures are used, and should show the group name without a parenthesis, e.g., ML, when ASTM D2477 procedures are used (as is done with laboratory testing).

Soil descriptions should be applied as follows:

- For discrete sampling, the soil descriptions should be applied to the samples recovered. For changes in lithology within the soil sample, indicate the length of the materials as measured from either the top of the sample or from the top of the borehole as directed by the geotechnical task lead. For example, SS-5A: 0-5" *describe soil*; SS-5B: 5-13" *describe soil* or SS-3A: 15.0-15.4' *describe soil*; SS-3B: 15.4-16.2' *describe soil*
- For thin-wall tube samples, the materials visible at the top and bottom of the tube should be described on the log in the soil description column.
- For continuous soil recovery (e.g., sonic) the soil should be described in a manner similar to rock cores, where the depths are indicated with the appropriate soil descriptors. For example:

  10.0-10.2': *describe soil*

  10.2-13.4': *describe soil*

  13.4-15.0': *describe soil*

  Zones of no recovery should be logged similar to that done for rock core logging (e.g., 17-17.3' no recovery). See the CH2M HILL Guidelines for Logging of Rock Cores for other guidance that may be helpful.
- For drilling methods where only cuttings are returned (e.g., air rotary), the geotechnical task lead should determine the level of description required to meet the project requirements. As an example, the cuttings can be described for each interval drilled in the Comments column, as the cuttings are not likely to represent the true soil conditions due to alterations in size of the grains and mixing of soils. Any grab samples collected can also be described in the Comments column.

The format and order for soil descriptions should usually be as follows, unless otherwise specified for the project by the task lead:

1. Soil name (synonymous with ASTM D2488 Group Name) with appropriate modifiers
2. USCS Group Symbol
3. Color, preferably using a Munsell soil color chart
4. Moisture content
5. Relative density (sands and gravels) or consistency (silts and clays)
6. Estimate of soil particle percentages and sizes
7. Estimate of plasticity and dilatancy for fine grained soils; estimate of plasticity for fines in coarse grained soils
8. Soil structure, mineralogy, cementation, presence of organics, reaction to HCl, presence of cobbles, or other descriptors such as appropriate to the project

9. Inference of fill versus native material (e.g., "FILL" is stated at the end of the soil description; additional information can be presented in the Comments column)

This order follows, in general, the format described in ASTM D2488. Details on these items are provided in the following sections, and examples of soil descriptions are provided in Table 1.

Soil Name

The basic name of a soil should be consistent with the ASTM D2488 Group Name based on visual estimates of gradation and plasticity. The ASTM D2488 flow charts are presented in Appendix C. Group Symbol application is discussed in the next subsection.

The following are example descriptions; note that percentages are based on weight, not volume:

- 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 SILT WITH SAND. 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 (i.e., more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D2488. The maximum size and angularity or roundedness of gravel and sand-sized particles should also be recorded. For fine-grained soil (i.e., 50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D2488.

The presence of large sized materials, such as cobbles and boulders, is often critical information for design and construction considerations. Where there is evidence of cobbles or boulders in the formation such as glacial tills, the soil name should include the modifier "with cobbles" or "with cobbles or boulders," e.g., Silty Sand with Gravel and Cobbles (SM). Cobbles and large materials may only appear in samples as fragments (e.g., fractured segments where on portion is rounded and the rest is fresh and angular), and the logger should note the presence of the larger materials based on visual observation, as well as drilling action, poor sample recovery due to large materials plugging the sample, or other indirect means which should be noted in the Comments column as appropriate. Because the small sampling size of standard split-spoon samples do not allow for collection of intact large granular materials like cobbles, estimates of percentages of cobbles and boulders are difficult to make with soil borings alone. For projects where obtaining percentages of these materials is desired with a high degree of accuracy, test pits are recommended.

Interlayered or interbedded soil should each be described starting with the predominant type. An introductory name, such as Interlayered (or Interbedded) Silty Sand (SM) and Silt (ML), should be used. Also, the relative proportion of each soil type should be indicated (see Table 1 for example).

Group Symbol

The appropriate group symbol from ASTM D2488 should be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated. When laboratory testing is conducted, the final log description should reflect group symbol names with no parenthesis to indicate that ASTM D2487 applies.

In accordance with ASTM D2488, 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.

Color

The predominant color of the soil should be recorded, ideally using the Munsell® soil color chart (Munsell Color, 2009b). The name of the color chip along with the Munsell notation should be recorded on the boring log. In addition to the predominant color, gradual or abrupt color changes, such as mottling or staining, should be recorded. These additional colors can be described using Munsell notations or alternative descriptions at the discretion of the task lead. Review the instructions in the Munsell publications for proper use of the Munsell chart and preservation of the color chips.

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 in Table 2.

Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on field N-values (ASTM D1586). If the presence of large gravel or disturbance of the sample (e.g., heave) 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 should be estimated from N-values for disturbed samples such as SPTs, and on the results of pocket penetrometer or torvane results for saturated, undisturbed samples (e.g., the bottom of thin tube samples). Pocket penetrometer results may also be useful for disturbed samples, however, however they may not be representative (see Section 8).

Relationships for determining relative density or consistency of soil samples are shown in Tables 3 and 4.

Soil Particle Descriptions, Soil Structure, Mineralogy, Plasticity and Other Descriptors

Other important information to record includes descriptions of the soil mass and discontinuities such as inclusions, joints or fissures, slickensides, bedding or laminations, root holes, organic materials, and wood debris, or other debris materials. Significant mineralogical information should be noted. Cementation, abundant mica, or unusual mineralogy should be described, as well as other information such as organic debris or odor. Estimated percentages may be useful for some items, such as estimate 15% organic particles.

Estimates of particle sizes should be included when possible for each main group of particles (gravel, sand and fines). “Fines” refers to all particles passing the No. 200 sieve; silt-size and clay-size particles should not be estimated separately. The descriptors of plasticity and dilatancy will give an indication of the relative percentage of each. Note that percentages are estimated based on weight, not volume. Percentages should be provided numerically (e.g., estimated 20-25% fines); percentages that are less than five percent may be labeled as “trace” (e.g., trace fine sand).

The particle shapes should be included for at least coarse sands and gravels, and for other sand-size particles as the project requires. This information may be helpful in determining the origin of the materials (e.g., alluvium) and friction angle values. The descriptors should be as shown in Table 6; ASTM D2488 provides photographs of applicable particles for additional reference.

An estimate of plasticity should be provided for the fine-grained fraction of soils classified as silts and clays and for the fines contained within coarse grained soils. The procedures given in ASTM D2488 provide a means to estimate plasticity, which should be reported as shown in Table 7.

Dilatancy should be reported for the fine-grained fraction of soils classified as silts and clays. Dilatancy does not need to be reported for the fines present in coarse grained materials. Dilatancy should be reported as shown in Table 8.

Reaction to hydrochloric acid (HCl) should be recorded for all materials suspected of carbonate derivation or where required for other purposes such as for acid forming potential. HCl reactions should be reported as shown in Table 9. HCl dilution for carbonate material determination is outlined in ASTM D2488, and is generally 1 part concentrated HCl (10 N) and 3 parts distilled water. The HCl (both undiluted and diluted) could cause burns, and care should be taken when handling.

Other relevant descriptors include cementation, dry strength, toughness, structure (e.g., criteria given in Table 7 of ASTM D2488) and other items as determined relevant for the project. Appropriate reporting of these items should be determined by the geotechnical task lead.

Examples of reporting of the items described in this subsection are shown in Table 1.

4.2.5 Relative Drilling Resistance

The relative drilling resistance (RDR) between sample intervals should be assessed and documented. The criteria and typical ground conditions for RDR values ranging from 1 to 5 are summarized in Table 10. The logger should determine a RDR value for each drilling interval between samples, based on the observations and input the driller.

4.2.6 Comments

This column should contain pertinent information not addressed elsewhere on the log form. Types of information to record include pertinent observations (e.g., changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). Also note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed.

The driller's observations and perceptions of the materials encountered can provide valuable information to the logger. A good relationship with the driller should be established at the beginning of the field program, as well as a clear understanding for the driller to alert the field staff to any significant changes in drilling throughout the program. Changes in material, occurrence of boulders, pockets of harder or softer materials, color changes, and loss of drilling fluid can all be invaluable data to record for future interpretation of subsurface conditions. Such information should be attributed to the driller and recorded in this column with the appropriate depth. The abbreviation "DR" for "driller reports" or "driller remark" may be used, e.g., 10' - DR 50% circulation loss; 25' – DR material change.

Some projects may require that times be recorded for various items such as sample attempts, start and end of continuous drilling runs, equipment downtime, or similar items.

Specific information to record in the Comment column includes the following:

- The date and time drilling began and ended each day for multi-day borings
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter or other related drilling information; this information may help to determine the presence of larger diameter material than can be sampled.
- RDR values, with brief description of drilling condition (e.g., constant chattering, no chattering, fast advancing, etc.) and depth
- Depth and percentage of drilling fluid loss
- Use of drilling fluids, changes in drilling fluids

- Notes on cuttings materials (e.g., changes in color, consistency)
- Depth of hole caving or heaving
- Start/end time for continuous drilling runs
- Sample times
- Depth of change in material; this is especially important where discrete samples are collected as it may provide information for interpreting the soil strata between samples
- Presence of large materials such as cobbles, boulders, wood, logs, debris or similar
- Presence and thickness of suspected fill materials
- Sampling information for thin-walled samples (e.g., pressure used, issues, etc.)
- If appropriate for the material sampled, the results of pocket penetrometer or torvane test, eg., PP = ______ TSF or TV = _____TSF.
- Information and/or results of *in situ* testing, as appropriate (e.g., Packer test performed at 17 feet, see separate log)
- Piezometer or other installation information such as unique well number (required by some states), screen and sand pack depths, casing diameter and depth, installation depth of instruments, initial calibration values, etc.
- Abandonment information such as bentonite chips or grout, number of bags used, difficulties in abandonment, surface finish
- Samples pulled for laboratory testing
- Additional samples collected from cuttings
- Description of early boring termination such as drilling refusal, obstacles, or similar; for refusal conditions, record the time to advance the bit (e.g., 5 minutes to advance 2 inches)
- Description of unusual odors or the presence of suspicious materials indicating contamination
- Abbreviations used in the log (e.g., f = fine grained, c = coarse grained, np = non-plastic, etc.)

Depending on project requirements, information on abandonment of the hole (e.g., bentonite chips, grout) and on installations such as monitoring wells, piezometers, and thermistors may also be recorded in this column as directed by the task lead. Examples include the type and number of bags of chips, the time to complete abandonment, well installation details, etc. Abandonment procedures for borings will vary based on state requirements, environmental considerations (e.g., aquifer penetration, contamination, etc.) and future planned facilities (e.g., borings drilled in dam foundations, etc.). Proper abandonment techniques should be established before drilling commences.

5. Standard Penetration Test Procedures

SPTs are conducted to obtain a measure of the resistance of the soil to penetration of the sampler and to recover a disturbed soil sample. Unless project requirements specify otherwise, SPTs should be conducted in accordance with ASTM D1586, *Standard Test Procedure for Penetration Test and Split-Barrel Sampling of Soils*. The information contained in this section provides additional guidance.

McGregor and Duncan (1998) provides a detailed survey and summary of research findings regarding the effects of various practices and equipment on SPT results (e.g., overstating or understating field N-values). While beyond the scope of these guidelines, McGregor and Duncan (1998) also provide a summary of corrections and correlations available for interpreting SPT results, as well as interpreting Becker Penetration Tests.

5.1 Equipment

Before starting the testing, the necessary equipment should be inspected for compliance with the requirements of ASTM D1586. The split-barrel sampler should measure 2-inch outside diameter (O.D.), with 1-3/8-inch inner diameter (I.D.), and should have a split tube at least 18 inches long. The minimum size drilling rod for sampling allowed is "A" rod (1-5/8-inch O.D.). If available, a stiffer rod, such as "N" rod (2-5/8-inch O.D.), should be used for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

Items that should be recorded related to SPT include the information noted below. This information is used to interpret and correct the field SPT results to appropriate engineering values for use in design.

- Sampler size(s)
- Rod size(s)
- Hammer type (e.g., donut, safety, automatic); if the hammer is powered by a cathead, the operator's first initial and last name should be recorded along with the number of rope wraps.
- Type and use of liners in the sampler
- Significant deviations from the ASTM procedures

For projects where it is critical, the efficiency (energy transfer) of an automatic hammer should be requested from the driller. Energy transfer measurements are performed by a specialized testing firm and are done in accordance with ASTM D4633. Such testing is typically independent of the specific exploration and the readings are considered acceptable if they were obtained within a year of the project, unless significant maintenance or other changes to the hammer have occurred. Some projects may required project-site-specific energy testing.

For project with seismic design elements, see Subsection 5.3 notes.

5.2 Procedures

SPTs should generally be conducted at intervals not exceeding 5 to 10 feet, and at least in every change of strata. Smaller spacing (e.g., 2.5-foot spacing) is often used at the top of the borehole (e.g., first 10 feet) or in specific areas of interest. Larger spacing is permissible when the sampling depth exceeds 100 feet or when the purpose of the hole is to collect information only at specific elevations. Sample spacing should be determined as part of the project planning. SPTs are often also be taken immediately following collection of thin-walled tube samples.

Before driving the split-barrel sampler, loose and foreign material should be removed from the bottom of the borehole. The driller may elect to tag the bottom of the hole with a weighted tape before the tools are lowered into the hole. Alternatively, the rod stickup should be observed and measured when necessary to ensure that the sampler is being driven from the bottom of the borehole. The SPT should be performed by driving a standard split-barrel sampler 18 inches into undisturbed soil at the bottom of the borehole by a 140-pound guided hammer or ram, falling freely from a height of 30 inches. If appropriate or desired for the project, 24-inch samples may also be taken in the same manner.

As noted in subsection 4.2.3, the SPT N-value is the number of blows required to drive the sampler for three 6-inch intervals, for a total of 18 inches (or four 6-inch intervals for a total of 24 inches) and should be recorded on the soil boring log.

5.3 General Considerations

The following comments and suggestions should be considered when performing SPTs:

- Before the start of drilling, it is important to establish a clear protocol for collecting SPT blowcount data. It is important to understand whether the driller, helper or the engineer will measure the blowcounts. Although generally preferable for the engineer to do this, the engineer may be distracted by logging of the previous sample, and the drilling operation may be more efficient and more accurate if it benefits from the undistracted attention of the driller or helper during sampling. If the driller or helper measures the blowcounts, the engineer should spot check blowcounts as a consistency measure.
- The borehole should be cleaned out before every sample attempt. Because a minor amount of caving can be expected, the borehole can be considered to be adequately cleaned if no more than 4 inches of loose or foreign material has collected at the bottom of the borehole. A greater amount of caving is sufficient cause to require the hole to be cleaned again.
- At times “continuous” sampling using SPTs may be employed for additional samples or to adequately characterize the subsurface conditions. This generally consists of using a 24-inch drive for the SPTs and taking samples at 2-foot intervals. Note that the depth accuracy in drilling is generally within 0.5 to 1 foot depending on driller skill and equipment, and no matter how well a borehole is cleaned before a sample, there is always some material left in the borehole. As a result, samples taken in this manner often contain a portion of drilling disturbed soils and/or slough. It may be more advantageous to obtain, 18-inch or 24-inch samples on a 2.5-foot interval to allow for some margin to obtain quality samples. This method of sampling is labor intensive, especially for deeper depths, and should be considered when budgeting projects.
- Where heaving conditions are expected (e.g., loose sands beneath the water table or artesian conditions), drilling methods should be selected to minimize heave, as it generally results in erroneous SPT values. Borings with potential for heave should be carefully monitored and any heave should be recorded on the boring log in the Comments column. Drilling methods such as mud rotary or casing with casing advancer are preferred for expected heaving conditions, however, careful work with hollow-stem augers (HSA), such as an experienced driller using drilling fluids with the HSA and slow withdrawal of the auger plug can also minimize heave. Hollow-stem auger drilling is generally not appropriate for drilling loose sands below the water table unless rigorous heave control measures are implemented.
- The ball check valve in the split-barrel sampler should be cleaned and working properly for each sample. Bent, chipped, or damaged shoes should be replaced. The split-barrel halves should not be warped. In case of zero sample recovery (i.e., if the sample is lost during first attempt), a catcher can be used during subsequent attempts to facilitate recovery.
- During SPT sampling, it is important that rod connections be tight and that the hammer guide be connected securely to the drill rods. If the hammer guide connection becomes loose, much of the hammer energy may be lost because of deflection of the hammer coupling. If a lifting rope is used, it should not rub against the mast.
- During SPT sampling, it is important that the drill rods be positioned at the center of the drill hole. This is necessary to preclude the development of friction between drill rods and the walls of the borehole or casing, and provide consistent and reproducible energy transfer to the sampler.
- If the hammer weight is raised by means of a rope and cathead, generally 2-1/2 wraps on the cathead should be used. The operator should exercise care to prevent friction of the rope on the cathead during the fall of the hammer. The logger should carefully observe sampling procedure for consistency, noting any changes or deviations to the testing in the Comments section of the borehole log.
- Occasionally, non-standard procedures or equipment are used for obtaining samples (such as 3-inch O.D. split-barrel samplers, or 300-pound hammers). Any nonstandard practice should be described in

the Comments section of the borehole log and the blow counts should be clearly marked as not conforming to SPT procedures.

- For projects where the potential for earthquake-induced liquefaction will be determined using the empirical SPT procedure or projects with rigorous quality requirements, additional SPT requirements will be necessary. These include use of a SPT hammer that has a recent efficiency measurement, sometimes referred to as a "calibrated" hammer, and careful recording of all SPT sampling equipment. For consistency of SPT measurements, it is usually necessary to use an automatic hammer. Regardless of the type of hammer, it is critical that the energy delivered by the hammer be established. Hammer efficiency measurements should be conducted for the specific equipment being used, and if the rope-cathead procedure is being used, for the specific operators who will conduct the SPTs in the field. The geotechnical task lead should determine the appropriate calibration period, e.g., if an efficiency measurement within the past year is acceptable or if a project specific efficiency measurement should be conducted for the project.

6. Thin-walled Samples

Thin-walled tube samples are often taken on projects with fine-grained materials where specialty testing such as strength and consolidation are desired. Thin-walled samples are often referred to as "undisturbed" samples, but it is more accurate to describe them as "relatively undisturbed, "especially as compared SPT samples. Thin-walled samples should be obtained in accordance with ASTM D1587 *Thin-Walled Tube Sampling of Soils for Geotechnical Purposes*. Specific field sampling procedures followed should be noted on the logs.

As with SPT samples, the ASTM D1587 provides information on the appropriate dimensions for samplers. This information and any deviations should be recorded on the boring log in the Comments section. Tubes used for samples should be inspected and observed for wall thickness, end taper or cutting edge, coatings, presence of rust, etc.

During testing, pertinent information that should be recorded is outlined below:

- Information on the sampler type: e.g., direct push Shelby Tube, Osterberg type sampler, Pitcher barrel type sampler;
- Pressure applied during the test for soft materials, e.g., down pressure or hydraulic pressure from the rig (per rig gauges) or if the material is soft enough, weight of the rods, etc.;
- Drilling times or related information for hard materials recovered through a pitcher tube type sampler;
- Issues with recovery of the sampler such as excessive handling or disturbance;
- Notation of any damage to the tube;
- Recovery of the sample collected in the tube;
- Results of field strength testing such as pocket penetrometer results and/or torvane results;
- SPT samples may be desirable immediately below thin-walled samples (e.g., taken in the same hole as the thin-walled sample was extracted)
- Specific field procedures, such as allowing the sample to sit for a period of time before retrieving the sample.

Samples obtained from thin-walled techniques are generally used for higher-order, more expensive laboratory testing and care should be taken to achieve as high a quality of sample as possible.

7. Sonic Drilling

Recording information from sonic drilling or a similar continuous sampling process has been noted in other sections of this report. The information collected from sonic drilling will depend on the project goals. If the goal of the project is for the entirety of the recovered soil materials (referred to as a soil core) is to be logged and preserved, procedures similar to those used for rock coring are applicable (e.g., logging of the entire recovered soil core by depth, notation of strata changes, zones of no recovery). Discrete samples pulled for laboratory testing should be recorded on the log in the Comments column (e.g., 7-B, bag sample from 10.4 to 10.8 feet).

8. Field Strength Testing

Routine field strength testing includes pocket penetrometer and torvane testing. The instructions included with these tools should be followed for proper use. Additional guidance is included below. Other field strength testing such as field vane shear are not covered in these guidelines (see ASTM and other agencies).

- Pocket penetrometer and torvane testing are intended to measure undrained strength, and therefore are only applicable to saturated, fine-grained materials, e.g., silts and clays. Fine grained materials with sizeable coarse grained fractions, e.g. Silt with Gravel, should not be tested with these tools. If unsaturated materials are tested, appropriate notes should be recorded in the Comments column and the collected data should be carefully considered for applicability and accuracy.
- Pocket penetrometer testing should be implemented on recovered SPT samples and at the bottom of thin-walled tube samples, where possible. Pocket penetrometer testing may also be useful on sonic cores. The depth and results should be recorded in the Comments column.
- Torvane testing should be implemented at the bottom of thin-walled tube samples, where possible. The depth and results should be recorded in the Comments column.

9. Labeling, Handling and Photographing of Soil Samples

9.1 Sample Labeling and Handling

The samples recovered from the borehole are an important part of the boring record and should be properly packaged and labeled. Samples that are improperly or inadequately labeled are not useful. The following description outlines the typical requirements for packaging and labeling of samples; additional or more specific labeling may be required for certain projects.

- Disturbed (SPT) samples should be placed in glass jars or in sturdy plastic bags that are appropriately labeled. At a minimum, the project name, project number, boring number, sample number, sample depth, and date should be recorded. The choice of storage container should be based on planned laboratory tests and time frames. For example, if moisture contents are critical, sturdy plastic bags are appropriate if laboratory testing will take place shortly after collection. Otherwise, glass jars may be a better choice. Minimum sample sizes should be considered based on planned laboratory testing; in general, it is advisable to collect as much of each sample as possible to provide options for the laboratory. As noted previously, samples which encounter 2 separate material types should be split into multiple samples (e.g., A and B). SPT samples collected while mud-rotary drilling should take care to remove excess drilling fluid prior to placing in bags or jars.
- Thin-walled tubes should be cleaned of mud and moisture. When dry, use an indelible marker to label the sides with the following information: an arrow indicating the top of the sample, project name, project number, boring number, sample number, sample depth, amount of recovery, and date. The top and bottom of the sample should be circumscribed on the outside of the tube with a marker. The top lid of the tube should be labeled with the boring number, sample number, and depth, e.g.: A-12, 4-ST, 5-7’. Plastic lids should be placed on the ends and taped with airtight tape, such as electrical tape. Make

certain that the holes in the top of the tube are sealed. The open portion of the tube above the sample should be packed to prevent shifting of the soil with a non-absorbent material. Dampened newspaper is a convenient packing material, but can be problematic for a long-term storage and should be separated from the soil sample by a wax seal or an inverted cap. Waxing of Shelby tubes is essential if sample testing will not occur within a few days. Shelby tubes should be transported and stored vertically (top end up) with as little disturbance as possible.

- For sonic samples, if the entirety of the sonic core is planned to be kept for a period of time, appropriately sized boxes should be used to store the core. The boxes should be labeled similar to rock cores with the project name, project number, boring number, depths contained in the box, date, and where required, the recovery for each run. If only individual samples are pulled for preservation, the containers should be labeled with the project name, project number, boring number, depth range, and date.

Handling and storage of samples is dependent on the planned laboratory testing program and other project requirements. On large or remote projects where laboratory testing might be staged and samples may need to be stored for a long period of time, special storage conditions may be required, such as maintaining certain temperature and humidity levels. Samples of any type should not be allowed to freeze. Thin-walled samples have special considerations to keep them as "undisturbed" as possible. Samples that are contaminated or are expected to be contaminated should be handled in accordance with the health and safety plan for the project. ASTM D4220 *Standard Practices for Preserving and Transporting of Soil Samples* provides guidance on preserving and transporting samples.

9.2 Photographing of Soil Samples

As directed by the task lead, photographs of split-spoon and sonic samples should be collected in the field. Guidance is provided below and examples are provided in Appendix B.

- For SPTs, the sample should be photographed while still in the split-spoon with a whiteboard or other method indicating the sample information listed in subsection 9.1. The split-spoon should be photographed with the top of the sample on the left hand side of the photograph. A legible scale and a Munsell color chart (where used on the project) should be included in the photograph.
- For sonic cores, the samples should be photographed similar to rock cores. One sonic run or core box should be photographed at a time, and depending on the size of the box, several photographs may be required to adequately show the soil core. For example, an overall picture to show the entire core box should be included, along with close-ups of the box (e.g., right, middle, left hand sides of the box) so that the details of the core are visible. Special features or samples selected for laboratory testing can also be photographed separately. The inner box lid or a white board with the same information should be framed in the picture to include pertinent information. Photos should not be oblique and should include a legible scale, such as a folding ruler; if used on the project, the Munsell color chart should be included in a photograph. Photographs can be most easily and efficiently taken in the field while the soil core is fresh, and with natural light.

10. Field Equipment and Field Reference Guides

A suggested field equipment list of tools and supplies that are useful or necessary in various phases of soil logging is provided in Appendix C, along with a field reference guide that provides quick access to the many of the key logging items discussed in this procedure. Appendix C also contains a full page version of the soil log suitable for copying, as well as the ASTM flow charts for determining Group Symbol and Group Name.

11. References

11.1 Cited References

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Tables

TABLE 1
Example Soil Descriptions

Group Name and Symbol	Description
Poorly Graded Sand (SP)	light brown (7.5YR 6/3), moist, loose, fine silica sand, trace non-plastic fines
Fat Clay (CH)	dark gray (7.5YR 4/1), moist, stiff, high plasticity, no dilatancy
Silt (ML)	light greenish gray (GLEY 1 7/1), wet, very loose, non-plastic, very rapid dilatancy, some mica, moderate HCL reaction, carbonate derived.
Well-Graded Sand With Gravel and Cobbles (SM)	reddish brown (2.5 YR 5/4), moist, dense, fine to coarse sand, est. 20% subangular gravel to 0.6 inch maximum, cobbles to est. 8”, est. 10% non-plastic fines, trace organic particles
Poorly Graded Sand With Silt (SP-SM)	white (5YR 8/1), wet, medium dense, fine to medium sand, est. 10-15% non-plastic fines, no HCL reaction
Organic Soil With Sand (OH)	dark brown to black (7.5YR 3/2 t0 2.5/1), wet, firm to stiff, est. 20% fine sand, trace of mica, fine roots, no HCL reaction
Silty Gravel With Sand (GM)	light red (2.5 YR 6/8), moist, very dense, fine to medium sand, est. 25% subrounded gravel to 1.2 inches maximum, est. 30% non-plastic fines, strongly cemented
Interlayered Silt (ML) and Silty Sand (SM)	60% ML and 40% SM; layers 1.5 to 3 inches thick; olive gray (5Y 5/4), ML is nonplastic, very rapid dilatancy; SM is fine sand with est. 35% non-plastic fines
Lean Clay (CL)	dark greenish gray (GLEY 1 4/1), moist, firm, low to medium plasticity, slow dilatancy, trace very fine sand, interbedded CL layers 0.2 to 1.2 inches thick, no HCL reaction
Silty Sand With Gravel (SM)	light yellowish brown (10YR 6/4), moist, medium dense, well-graded sand, est. 25% gravel to 1.0 inch maximum, est. 15-20% fines, trace small particles of coal, fill
Sandy Elastic Silt (MH)	light gray to white (5YR 7/1 to 8/1), wet, stiff, non-plastic, very rapid dilatancy, est. 35% fine carbonate sand, moderately cemented, mild HCl reaction
Lean Clay With Sand (CL)	very dark grayish brown (10YR 3/2), moist, stiff, low plasticity, slow dilatancy, est. 30% fine sand
Well-Graded Gravel With Silt and Sand (GW-GM)	Brown (7.5YR 4/3), moist, very dense, rounded gravel to 3.0 inch maximum, est. 10% fine to coarse sand, est. 20% non-plastic fines.

TABLE 2

Criteria for Describing Moisture Content

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

Source: ASTM D2488

TABLE 3

Relative Density of Coarse-Grained Soil

Blows/Ft	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium
31-50	Dense
50	Very Dense

Source: Sowers, 1979

TABLE 4

Consistency of Fine-Grained Soil

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

Source: Sowers, 1979

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TABLE 5
Particle Size Guidance

Description	Sieve Size	Examples
Boulder	Greater than 12 inches	> Basketball
Cobble	3 to 12 inches	Fist to basketball
Coarse Gravel	3/4 to 3 inches	Thumb to fist
Fine Gravel	No. 4 to 3/4 inches (4.75mm to 3/4 inches)	Pea to thumb
Coarse Sand	No. 10 to No. 4 (2.0 to 4.75 mm)	Rock salt to pea
Medium Sand	No. 40 to No. 10 (0.425 to 2.0 mm)	Sugar to rock salt
Fine Sand	No. 200 to No. 40 (0.075 to 0.425 mm)	Flour to sugar
Silt and Clay	Passing No. 200 (< 0.075mm)	Grains not visible

TABLE 6
Criteria for Describing Angularity of Coarse-Grained Particles

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular, but have rounded edges
Subrounded	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

Source: ASTM D2488

TABLE 7
Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-inch (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when dried than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reach the plastic limit. The lump can be formed without crumbing when drier than the plastic limit.

Source: ASTM D2488

TABLE 8
Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

Source: ASTM D2488

TABLE 9
Criteria for Describing Reaction with Hydrochloric Acid (HCl)

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Source: ASTM D2488

TABLE 10
Relative Drilling Resistance Criteria

RDR	Term	Criteria	Typical Ground Conditions
1	Very easy	No chatter, very little resistance, very fast and steady drill advance rate	Very soft to soft silts and clays; very loose to loose silts and sands; no gravel, cobbles, boulders or rubble
2	Easy	No chatter, some resistance, fast and steady drill advance rate	Firm to stiff silts and clays; loose to medium dense silts and sands; little or no gravel, no to very few cobbles, boulders or pieces of rubble
3	Moderate	Some chatter, firm drill resistance with moderate advance rate	Stiff to very stiff silts and clays; dense silts and sands; medium dense sands and gravel; occasional cobbles or rubble pieces (2 to 3 occurrences per 10 feet)
4	Hard	Frequent chatter and variable drill resistance, slow advance rate	Very stiff to hard silts and clays with some gravel and cobbles; very dense to extremely dense silts and sands with some gravel; dense to very dense sands and gravel; very weathered, soft bedrock; frequent cobbles and boulders or rubble pieces (3 to 4 occurrences per 10 feet)
5	Very hard	Constant chatter, variable and very slow drill advance, nearly refusal	Hard to very hard silts and clays with some gravel; very dense to extremely dense gravelly sand or sandy gravel; very frequent cobbles and boulders (at least 5 occurrences per 10 feet); weathered, very jointed bedrock

Source: Hunt, 2014

Figures

FIGURE 1
Blank Soil Boring Log (Typical) [See Appendix C for a full page copy]

ch2m

PROJECT NUMBER: BORING NUMBER:
Sheet:

SOIL BORING LOG

PROJECT: LOCATION:
ELEVATION: DRILLING CONTRACTOR:
DRILLING METHOD AND EQUIPMENT:
WATER LEVELS: START: FINISH: LOGGER:

DEPTH BELOW (ft)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	NUMBER	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 INTRUMENTATION

Appendix A
Examples of Completed Soil Boring Logs

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
462759	B-3A SHEET 1 OF 1

SOIL BORING LOG

PROJECT : Rocky Hill Interceptor, Rocky Hill/ Wethersfield, CT LOCATION : Wethersfield, CT

ELEVATION : 28.0 ft DRILLING CONTRACTOR : O. Cone/ New England Boring

DRILLING EQUIPMENT AND METHOD : Mobile Drill B-53, 2-1/4" SSA, 3-1/4" HSA ORIENTATION : Vertical

WATER LEVELS : dry during and after drilling START : 5/29/2013 END : 5/29/2013 LOGGER : Y. L. Chou

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
28.0					**3" Top Soil** 0-0.25' **Gravelly Silt With Sand (stratum 1) (ML)** 0.25' - brown to red brown, dry, stiff, nonplastic, coarse to fine gravel, coarse to fine sand, contains brick fragments		140 lbs Safety Hammer, 30" drop, NWJ rod, 2" OD & 24 " long Split Spoon Sampler, Off set 3' south east from B-3; Solid Stem Auger drilling to 5'. GW is dry during drilling and at completion. RDR = 2-3 (occcasional chattering and grinding)
5 / 23.0	5.0–7.0	20.0	SS-1	10-12-17-30 (29)	**Silty Sand With Gravel (stratum 1) (SM)** 5' - brown to red brown, moist, medium dense, coarse to fine sand and gravel		Switched to Hollow Stem Auger drilling RDR = 3 (chattering near 6')
	7.0–9.0	13.0	SS-2	40-28-22-17 (50)	7' - Same as above except dense, contains 1" cobble fragment		RDR = 2-3
10 / 18.0	9.0–11.0	17.0	SS-3	13-22-37-28 (59)	9' - Same as above except very dense		Wc=9.5% 41% fines RDR = 3-4 (grinding at 10')
	11.0–11.8	6.0	SS-4	22-50/4 (50/4")	**Poorly Graded Gravel With Sand And Silt (stratum 3) (GP-GM)** 11' - brown to red brown, dry, very dense, coarse to fine gravel and sand, cobble at 11'		RDR = 2-3 DRD = 4-5 (grinding at 11.5')
	13.0–13.1	0.0	SS-5	50/1 (50/1")			RDR = 4 (resistance; slow advancement)
15 / 13.0	15.0–15.1	1.0	SS-6	50/1 (50/1")	15' - 1" light gray rock fragment Bottom of Boring at 15.1 ft bgs on 5/29/2013		RDR = 4-5 (constant, slow advancement and grinding) Auger refusal at 15'
20							

PROJECT NUMBER: 338884	BORING NUMBER: BCA-7	SHEET 1 OF 2

SOIL BORING LOG

PROJECT : PEC COLA, New Hill, NC LOCATION : (NAD 27) (687127.9 N, 2013818.7 E)

ELEVATION : 263.2 ft MSL (NGVD 29) DRILLING CONTRACTOR : K. Canuel, S&ME

DRILLING EQUIPMENT AND METHOD : CME-750, Tricone Bit, 24 Split Spoon, 140 lb. Automatic Hammer ORIENTATION :

WATER LEVELS : --- START : 8/9/06 11:17 END : 8/9/06 16:07 LOGGER : LH

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
263.2	0.0 - 2.0	14.0	SS1SS	5-8-9-11 (17)	**Clay (CL)** 0.0-1.2' - reddish brown, light greenish gray mottling, dry, very stiff, trace roots		
	2.5 - 4.5	15.0	SS2SS	6-5-11-14 (16)	**Clay (CL)** 2.5-3.8' - reddish brown, trace brown mottling, dry, very stiff, gray sand pockets very fine to medium grained 3.5-3.8' - trace gravel laminated beds		
5 / 258.2	5.0 - 7.0	12.0	SS3SS	8-9-11-13 (20)	**Clay (CL)** 5.0-6.0' - reddish brown, trace brown mottling, dry, very stiff, gray and yellowish brown sand pockets very fine to medium grained		
	7.5 - 9.5	15.0	SS4SS	7-8-10-16 (18)	**Clay (CL)** 7.5-8.8' - reddish brown, trace brown mottling, dry, very stiff, brown clay pockets mottled light gray		
10 / 253.2	10.0 - 12.0	7.0	SS5SS	34-50/6 (50/6")	**Clay (CL)** 10.0-10.6' - reddish brown, moist, hard, low plasticity, laminated		Install NW surface casing to 10' bgs.
	12.5 - 14.5	5.0	SS6SS	50/5 (50/5")	**Clay (CL)** 12.5-13.0' - reddish brown, moist, hard, low plasticity, reddish black linear mottles		
15 / 248.2	15.0 - 17.0	11.0	SS7SS	39-50/6 (50/6")	**Clay (CL)** 15.0-16.0' - reddish brown, mottled reddish black and light greenish gray, moist, hard, low plasticity		
	17.5 - 19.5	10.0	SS8SS	15-17-50/5 (67/11")	**Clay (CL)** 17.5-18.4' - reddish brown, mottled reddish black and light greenish gray, moist, hard, low plasticity		
20							

PROJECT NUMBER: 338884	BORING NUMBER: BCA-7	SHEET 2 OF 2

SOIL BORING LOG

PROJECT : PEC COLA, New Hill, NC — LOCATION : (NAD 27) (687127.9 N, 2013818.7 E)

ELEVATION : 263.2 ft MSL (NGVD 29) — DRILLING CONTRACTOR : K. Canuel, S&ME

DRILLING EQUIPMENT AND METHOD : CME-750, Tricone Bit, 24 Split Spoon, 140 lb. Automatic Hammer — ORIENTATION :

WATER LEVELS : --- — START : 8/9/06 11:17 — END : 8/9/06 16:07 — LOGGER : LH

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
243.2	20.0–22.0	5.0	SS9SS	50/5 (50/5")	**Clay (CL)** 20.0-20.5' - reddish brown, mottled reddish black and light greenish gray, moist, hard, low plasticity		
25 / 238.2	25.0–27.0	6.0	SS10SS	50/6 (50/6")	**Silt (ML)** 25.0-25.3' - light gray and pale red, moist, very dense **Clay (CL)** 25.3-25.5' - reddish brown, mottled reddish black and light greenish gray, moist, hard, low plasticity		
							First water level = 7.4' bgs taken 8/10/06 at 20:02
30 / 233.2	30.0–30.2	2.0	SS11SS	50/2 (50/2")	**Sand With Silt (SP-SM)** 30.0-30.2' - light gray and pale red, moist, very dense, very fine to fine grained, subangular to subrounded, poorly sorted, 20% silt Bottom of Boring at 30.2 ft bgs on 8/9/06 16:07		
35 / 228.2							
40							

PROJECT NUMBER:	BORING NUMBER:
338884.FL	A-01 SHEET 1 OF 9

SOIL BORING LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

DRILLING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, cathead, NWJ rods, 6 tri-cone bit ORIENTATION : Vertical

WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	SAMPLE INTERVAL (ft)	RECOVERY (ft)	#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	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
41.6							"Water level is based on Ground Water Monitoring at LNP site (FSAR Table 2.4.12.08)" Water at 6' below ground surface
	3.5						
5 36.6	5.0	1.0	SS-1	5-4-3 (7)	**Poorly Graded Sand With Silt (SP-SM)** 3.5-4.5' - very pale orange to moderate yellowish brown, (10YR 8/2 to 10YR 5/4), wet, loose, very fine to fine grained, 10-15% fines, nonplastic, <10% root matter and organic material, trace concretions up to 1/4", very fine silica sand and silt in an iron matrix		Few dense lenses from 5.0-8.5', thin, relatively consistent drilling rate (moderately rapid)
	8.5						
10 31.6	9.4	0.5	SS-2	9-50/5 (59/11")	**Limestone Fragments** 8.5-8.75' - very pale orange, (10YR 8/2), strong HCl reaction, gravel-sized, subrounded to angular, up to 1"x1-1/2" **Silt (ML)** 8.75-9.0' - grayish orange, (10YR 7/4), moist to wet, hard, nonplastic, rapid dilatancy, mild to moderate HCl reaction, 10-15% very fine to medium grained sand, all carbonate derived		Very hard from 9.0-12.5', possible limestone lenses, light chatter, extremely slow advancement rate Relatively consistent from 12.5-28.5', moderately rapid drilling rate
	13.5						
15 26.6	15.0	0.8	SS-3	27-17-4 (21)	**Silt With Limestone Fragments (ML)** 13.5-14.3' - very pale orange, (10YR 8/2), wet, very stiff, nonplastic, mild to moderate HCl reaction, 10-15% very fine to fine grained sand, 3 limestone lenses (<1/2") at 13.5', 13.7' and 14.0', all carbonate derived		
	18.5						SS-4 actual sample depth is 18.5-20.0'
20	20.0	1.3	SS-4	40-54-50 (104)			

PROJECT NUMBER: 338884.FL	BORING NUMBER: A-01 SHEET 2 OF 9

SOIL BORING LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

DRILLING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, cathead, NWJ rods, 6 tri-cone bit ORIENTATION : Vertical

WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	SAMPLE INTERVAL (ft)	RECOVERY (ft)	#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	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
21.6					**Sandy Silt (ML)** 18.5-19.75' - very pale orange, (10YR 8/2), moist, hard, nonplastic, rapid dilatancy, mild to moderate HCl reaction, 35-40% very fine to fine grained sand, all carbonate derived		
	23.5 - 25.0	1.5	SS-5	17-24-31 (55)	**Sandy Silt With Limestone Fragments (ML)** 23.5-25.0' - grayish orange, (10YR 7/4), wet, hard, nonplastic, rapid dilatancy, moderate to strong HCl reaction, 20% fine to coarse gravel, limestone fragments are extremely weak rock (R0); similar to 18.5-19.75'		
25 / 16.6							
	28.5 - 29.3	0.8	SS-6	34-50/3.5 (84/9.5")	**Silty Sand With Limestone Fragments (SM)** 28.5-29.25' - Same as 23.5-25.0' except 72% fine to medium grained sand, interbedded with limestone lenses (<1/2") at 28.5-28.8' and intermittent throughout		Slow advancement rate from 28.5-33.5' with several dense lenses <0.5' thick, associated with light chatter
30 / 11.6							
	33.5 - 33.7	0.2	SS-7	50/2.5 (50/2.5")	**Limestone Fragments** 33.5-33.7' - grayish orange to dusky yellowish brown, (10YR 7/4 to 10YR 2/2), mild to moderate HCl reaction, gravel-sized limestone fragments up 1-1/2" diameter, sample includes 1/2" thick iron cemented lenses that have no HCl reaction		
35 / 6.6							
	38.5 - 39.6	1.1	SS-8	28-35-50/1 (85/7")			Extremely dense from 39.0-46.0', slow drilling with light to heavy rig chatter
40							

PROJECT NUMBER:	BORING NUMBER:
338884.FL	A-01 SHEET 2 OF 9

SOIL BORING LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

DRILLING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, cathead, NWJ rods, 6 tri-cone bit ORIENTATION : Vertical

WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	SAMPLE INTERVAL (ft)	RECOVERY (ft)	#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	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
21.6					**Sandy Silt (ML)** 18.5-19.75' - very pale orange, (10YR 8/2), moist, hard, nonplastic, rapid dilatancy, mild to moderate HCl reaction, 35-40% very fine to fine grained sand, all carbonate derived		
	23.5-25.0	1.5	SS-5	17-24-31 (55)	**Sandy Silt With Limestone Fragments (ML)** 23.5-25.0' - grayish orange, (10YR 7/4), wet, hard, nonplastic, rapid dilatancy, moderate to strong HCl reaction, 20% fine to coarse gravel, limestone fragments are extremely weak rock (R0); similar to 18.5-19.75'		
25 / 16.6							
	28.5-29.3	0.8	SS-6	34-50/3.5 (84/9.5")	**Sandy Silt With Limestone Fragments (ML)** 28.5-29.25' - Same as 23.5-25.0' except 40% fine to medium grained sand, interbedded with limestone lenses (<1/2") at 28.5-28.8' and intermittent throughout		Slow advancement rate from 28.5-33.5' with several dense lenses <0.5' thick, associated with light chatter
30 / 11.6							
	33.5-33.7	0.2	SS-7	50/2.5 (50/2.5")	**Limestone Fragments** 33.5-33.7' - grayish orange to dusky yellowish brown, (10YR 7/4 to 10YR 2/2), mild to moderate HCl reaction, gravel-sized limestone fragments up 1-1/2" diameter, sample includes 1/2" thick iron cemented lenses that have no HCl reaction		
35 / 6.6							
	38.5-39.6	1.1	SS-8	28-35-50/1 (85/7")			Extremely dense from 39.0-46.0', slow drilling with light to heavy rig chatter
40							

PROJECT NUMBER:	BORING NUMBER:
338884.FL	A-01 SHEET 3 OF 9

SOIL BORING LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

DRILLING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, cathead, NWJ rods, 6 tri-cone bit ORIENTATION : Vertical

WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	SAMPLE INTERVAL (ft)	RECOVERY (ft)	#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	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
1.6					**Sandy Silt With Limestone Fragments (ML)** 38.5-39.58' - olive gray to light olive gray, (5Y 3/2 to 5Y 5/2), wet, hard, low to medium plasticity, slow to rapid dilatancy, moderate to strong HCl reaction, 35% fine to coarse grain sand, trace organic content, limestone interbeds at 38.5-38.7' and intermittently throughout		
	43.5 / 43.8	0.3	SS-9	50/3 (50/3")	**Limestone Fragments** 43.5-43.75' - light olive gray, (5Y 6/1), mild HCl reaction, very fine to fine gravel, up to 3/4"x1/2"		
45 / -3.4							
	48.5	0.3	SS-10	28-50/2 (78/8")	**Silty Sand (SM)** 48.5-48.8' - yellowish gray, (5Y 8/1), wet, very dense, 30% fines, nonplastic, mild to moderate HCl reaction, fine to medium grained sand, 10% gravel-sized limestone fragments		Split spoon sample SS-10 actually advanced 48.5-49.2
50 / -8.4					Begin Rock Coring at 49.0 ft bgs See the next sheet for the rock core log		
55 / -13.4							
60							

PROJECT NUMBER:	BORING NUMBER:	
338884.FL	A-01	SHEET 4 OF 9

ROCK CORE LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

CORING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, NQ tools, NW/HW casing ORIENTATION : Vertical

WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
49.0 50 / -8.4 51.5	R1-NQ 2.5 ft 88%	42	0 >10 2 NR	49.55-49.65, 50.2-50.3' - Fracture zone (2), rough, undulating, with 1" openings 50.45' - Mechanical break or fracture, 40 deg, rough, undulating, open <3/4" 50.75, 50.9' - Bedding plane or mechanical break (2), <10 deg, rough, undulating, open <1/2"		**Limestone** 49.0-51.2' - dark yellowish brown, (10YR 4/2), fine grained, extremely weak to very weak (R0 to R1), voids (<3/16") over 70% of surface except from 49.65-50.2' where voids (<1/16") cover <20% of surface, fossiliferous, cavities <1/2"x1/4" over <15% of surface, trace organics **No Recovery 51.2-51.5'**	Switch to NQ rock coring tooling at 49.0', drive HW casing to 49', seat casing in <6" rock, flush casing with 3-7/8" tricone bit R1: 5 minutes
55 / -13.4 56.5	R2-NQ 5 ft 98%	82	0 2 0 2 3 NR	53.0' - Mechanical break or fracture, <10 deg, rough, stepped to undulating, tight 53.8' - Mechanical break or fracture, <10 deg, rough, undulating, tight at fracture with associated cavity 54.4' - Mechanical break 55.0, 55.1' - Fractures, 35 deg, rough, undulating, tight 56.0, 56.2' - Mechanical break or fractures, <10 deg, rough, undulating, open <1/2"		**Limestone** 51.5-56.4' - moderate yellowish brown, (10YR 5/4), fine grained, moderate to strong HCl reaction, very weak to weak (R1 to R2), voids (<3/16") over 60-80% of surface, few cavities <1-1/2"x1" concentrated at 53.8', fossiliferous **No Recovery 56.4-56.5'**	R2: 10 minutes Water level at 1' below ground surface at 17:30, end drilling on 03/14/07
60 / -18.4 61.5	R3-NQ 5 ft 78%	48	>10 2 3 >10 NR	56.5-56.8' - Fracture zone, rough, undulating, gravel-sized (<1-1/2"x1"), open 57.0, 57.3, 57.5' - Fractures (3), 50-90 deg, smooth, undulating, intersecting fractures, tight 58.7, 58.85, 59.5' - Bedding plane or mechanical break (3), smooth, undulating, tight 58.95' - Mechanical break 59.75-60.0' - Fracture zone, rough, undulating, gravel-sized fragments <1"diameter, open		**Limestone** 56.5-60.4' - pale yellowish brown, (10YR 6/2), fine grained, very weak to medium strong (R1 to R3), voids (<3/16") over 85% of surface, fossiliferous, trace organics, extremely weak rock (R0) zones at 56.5-56.8', 58.7', 58.85', 59.5', 59.75-60.0' **No Recovery 60.4-61.5'**	Water level at 2' below ground surface on 03/15/07 07:30 R3: 16 minutes
65 / -23.4 66.5	R4-NQ 5 ft 99%	98	0 1 0 0 1 NR	61.3' - Bedding plane or mechanical break, rough, undulating, broken along weak bedding planes, tight 63.15' - Bedding plane, horizontal, rough, undulating, tight 63.5, 63.7, 63.95, 64.0, 64.05, 64.4, 64.45, 65.2' - Mechanical break (8)		**Limestone** 61.5-66.45' - pale yellowish brown, (10YR 6/2), very fine to fine grained, weak to medium strong (R2 to R3), voids (<3/16") over 60-80% of surface at 61.5-61.9', 62.5-62.8', 63.5-65.1' and 65.4-66.3', organic material as <1/4" thick laminations at 63.0-65.2' over 20% of surface; very weak rock (R1) at 62.7-63.1', 65.0-65.5' and 66.3', bioturbated with some secondary infilling at 65.5-66.3' **No Recovery 66.45-66.5'**	R4: 8 minutes
	R5-NQ		3 2	66.7, 67.5, 68.2, 68.5, 70.2, 70.3, 70.55' - Mechanical break or bedding plane (7), <10 deg, rough, undulating, <1/4" openings 67.3' - Fracture, 70 deg and vertical, rough, stepped to undulating, tight			Driller's Remark: Slight fluid loss in zone

PROJECT NUMBER:	BORING NUMBER:
338884.FL	A-01 SHEET 5 OF 9

ROCK CORE LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

CORING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, NQ tools, NW/HW casing ORIENTATION : Vertical

WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
70 -28.4	5 ft 92% 71.5	62	0 3 1 NR	69.45' - Fracture, 60 deg, smooth, undulating, tight		**Limestone** 66.5-71.1' - pale yellowish brown, (10YR 6/2), very fine to fine grained, very weak to weak (R1 to R2), voids up to 3/16" over 80% of surface, fossiliferous, trace laminated organics, very weak rock to weak rock at 66.5-67.0' and 70.0-71.1', medium strong rock (R3) at 69.0-70.0' **No Recovery 71.1-71.5'**	R5: 7 minutes
75 -33.4	R6-NQ 5 ft 96% 76.5	50	1 5 2 3 5 NR	72.35' - Bedding plane, <10 deg, rough, undulating, 1/4" soil seam infill, open 1/2" 72.6, 72.85, 72.95' - Bedding plane or mechanical break (3), <10 deg, rough, undulating, tight 73.7' - Mechanical break or bedding plane, 15 deg, rough, undulating, open 1/4" 74.1' - Mechanical break or bedding plane, horizontal, smooth, undulating, 1/4" infill, open 1/4" 74.8-75.2 and 75.5-76.0' - Clay seams (2), smooth, undulating, extremely weak rock (R0) zones		**Limestone** 71.5-76.3' - pale yellowish brown, (10YR 6/2), very fine to fine grained, weak (R2) to medium strong (R3) at 71.5-72.3', 72.7-73.7', and 74.2-74.7' with voids (<3/16") over 80% of surface; extremely weak (R0) to very weak (R1) at 72.3-72.7' and 73.7-74.2' with voids (<3/16") over 30% of surface; extremely weak (R0) to very weak (R1) interbeds from 74.7-76.0'; all fossiliferous **No Recovery 76.3-76.5'**	R6: 7 minutes
80 -38.4	R7-NQ 5 ft 77% 81.5	28	2 3 >10 10 NR	77.0, 77.3' - Fractures (2), 60 deg and 50-90 deg, rough, stepped to undulating, tight 77.95, 78.15, 78.3' - Fractures (3), <10 deg, rough, stepped to undulating, tight 78.65-79.0' - Fracture zone, rough, stepped to undulating, dissolution zone, angular to subangular gravel-sized fragments <1" diameter 79.2' - Fracture, vertical, smooth, undulating, tight 79.35, 79.5' - Fractures (2), rough, undulating, silt and/or clay sized infilling, tight 79.5-79.65' - Clay seam, 4-1/2" silt and/or clay sized infilling, Elastic Silt (MH) to Lean Clay (CL), moderate plasticity, low dilatancy, strong HCl reaction 79.85' - Bedding plane, smooth, undulating, tight		**Limestone** 76.5-79.5' - moderate yellowish brown to very light gray, (10YR 5/4 to N8), very fine to fine grained, weak to medium strong (R2 to R3), except extremely weak (R0) to very weak (R1) rock at 78.1-78.3' and 79.5-79.85'; 76.5-78.3' and 79.85-80.35' - 80% voids <3/16", fossiliferous (molds, casts); 78.3-79.0' - >90% voids <3/16", 30-40% cavities up to 1/2"x1/4", highly fractured zone; 79.0-79.5' - <20% voids <3/16", medium strong rock (R3) **Lean Clay - Elastic Silt (CL-ML)** 79.5-79.85' - medium plasticity, slow dilatancy, strong HCl reaction **No Recovery 80.35-81.5'**	03/20/2007 set NW casing to 80' to free NQ tooling 03/21/2007 continue rock coring from 81.5' below ground surface, 100% circulation with NW casing at 80' below ground surface R7: 10 minutes
85 -43.4	R8-NQ 5 ft 90% 86.5	76	>10 0 1 >10 0 NR	81.5-81.7' - Fracture zone, rough, undulating, gravel sized fragments <1/2" diameter, angular to subangular 82.25' - Fracture, 0-40 deg, rough, undulating, open <1" 83.6' - Bedding plane, <10 deg, rough, undulating, tight 84.0' - Mechanical break 84.65-84.8' - Fracture zone, horizontal and 20 deg, rough, undulating, fragmented rock, angular gravel sized fragments <1"diameter, open <2" 84.95' - Mechanical break, rough, undulating, open <1/2"		**Limestone** 81.5-86.0' - pale yellowish brown to moderate yellowish brown, (10YR 6/2 to 10YR 5/4), very fine to fine grained, mild to moderate HCl reaction, weak to medium strong (R2 to R3), voids (<3/16") over 60-80% of surface at 81.5-83.0' and 84.5-86.0', fossiliferous (molds <1/2"x1/4"), dissolution cavities up to 2"x1/2" at 82.3', 84.65-84.8', 84.9-85.15' and 85.6-86.65'	SC-1 collected at 84.95-86.0' R8: 9 minutes
	R9-NQ		>10 0	86.75-86.95' - Fracture zone, rough, undulating, angular gravel sized fragments <1-1/2" diameter, 2-1/2" open			

PROJECT NUMBER: 338884.FL	BORING NUMBER: A-01	SHEET 6 OF 9

ROCK CORE LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

CORING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, NQ tools, NW/HW casing ORIENTATION : Vertical

WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	5 ft 98%	80	1	89.0' - Bedding plane, <10 deg, rough, undulating, open 1/4"	
90 -48.4			0		
			2	90.95' - Bedding plane, horizontal, smooth, undulating, open <1/4"	R9: 11 minutes
	91.5		NR		
			1	91.25' - Mechanical break or bedding plane, 15 deg, rough, undulating, tight; 91.6' - Bedding plane, horizontal, smooth, undulating, tight	
			0	92.9' - Mechanical break	
	R10-NQ 5 ft 98%	82	3	93.85-93.95' - Fracture zone, rough, undulating, 3 fractures, open <1-1/2"	
95 -53.4			1		
			4	95.3' - Fracture, 75 deg, smooth, undulating, tight; 95.85-95.9' - Clay seam, horizontal, smooth, undulating, 3/4" clay infilling, Fat Clay (CH), medium gray (N5), moist, soft, high plasticity	R10: 16 minutes
	96.5		NR		
			1	96.05, 96.35' - Mechanical break or bedding plane (2), <10 deg, rough, undulating, tight	
			2	96.85, 97.55' - Bedding plane, <10 deg, rough, undulating, tight; 97.05, 99.0, 99.75, 101.05, 101.4' - Mechanical break (5)	SC-2 collected at 98.05-99.0'
	R11-NQ 5 ft 100%	98	0	98.0' - smooth, undulating, <1/2" silt and/or clay sized infilling	
100 -58.4			0		
			0		R11: 8 minutes
	101.5				
			1	101.55, 102.65, 103.75' - Bedding plane or fractures (3), horizontal, smooth, undulating, tight	
			1		
	R12-NQ 5 ft 96%	86	1	104.0, 104.85' - Mechanical break	
105 -63.4			0		
			>10	105.5-105.6' - Fracture zone, rough, undulating, gravel sized fragments, <1" diameter	R12: 3 minutes
	106.5		NR		
			0		
			1		
	R13-NQ				

LITHOLOGY (ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS)

Limestone
83.0-84.5' - mild to moderate HCl reaction, mottled with zones of bioturbation having a secondary infill of a very fine, medium strong rock (R3) matrix, voids (<3/16") over 30% of surface, secondary infilling of bioturbated zone consisting of 20-30% of surface, trace fossil molds

No Recovery 86.0-86.5'

Limestone
86.5-87.05' - moderate yellowish brown to very light gray, (10YR 4/2 to N8), very fine to fine grained, extremely weak to very weak (R0 to R1), grayish blue mottling (5PB 5/2), voids (3/16") over 60-80% of surface from 84.5-86.0' and fossiliferous with trace organics
87.05-89.15' - Same as 86.5-87.05' except very light gray (N8) and grayish blue (5PB 5/2) mottling, voids (3/16") over 50-60% of surface, fossiliferous (microfossils)
89.15-90.7' - fine grained, very weak (R1), voids (<3/16") over 30-50% of surface, moderately fossiliferous
90.7-91.4' - Same as 86.5-87.05' except no mottling

No Recovery 91.4-91.5'

Limestone
91.5-96.4' - moderate yellowish brown to yellowish gray, (10YR 5/4 to 5Y 7/2), very fine to fine grained, extremely weak to weak (R0 to R2)
91.55-91.85' - fine grained, very weak (R1), voids (<3/16") over 30-50% of surface, fossiliferous
91.85-94.6' - moderate HCl reaction, voids (<3/16") over 60-80% of surface, moderately fossiliferous (molds up to 1/2" x 1/4"), few cavities <1/2" diameter, trace organics
94.6-96.4' - strong HCl reaction, gradual transition to >30% voids up to 1/16", 1/4" diameter cavity with medium light gray (N6) clay infill

No Recovery 96.4-96.5'

Limestone
96.5-101.5' - yellowish gray, (5Y 7/2), very fine to fine grained, strong HCl reaction, extremely weak to very weak (R0 to R1), voids (<3/16") over 70-80% of surface, moderately fossiliferous (molds <1/2"x1/4"), trace organics; 1/2" silt seam at 98.0', slow to fast dilatancy, low plasticity, carbonate material

ROCK CORE LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

CORING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, NQ tools, NW/HW casing ORIENTATION : Vertical

WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	5 ft 100%	70	4	108.65' - Fracture, 75 deg, smooth, undulating, tight	
110 -68.4			4	109.1, 109.15, 109.25' - Fractures (3), 90, 30, 50 deg, smooth to rough, undulating, intersecting fractures from 108.7-109.5'; 109.65' - Fractures, 65 deg and 70 deg, rough, undulating, tight	R13: 10 minutes
	111.5		3	110' - Fracture, 75-85 deg, rough, undulating, tight, intersecting; 110.5-110.65' - Fracture zone, 50 deg and 70 deg, rough, undulating, open <1-1/2"	
			0		
			0		
	R14-NQ 5 ft 100%	100	0	113.35, 114.0, 114.2, 115.2, 116.25, 116.5' - Mechanical break (6)	SC-3 collected at 114.2-115.2'
115 -73.4			0		
	116.5		0		R14: 7 minutes
			1	116.6' - Bedding plane, horizontal, smooth, undulating, tight	
			0		
	R15-NQ 5 ft 97%	92	0	118.85, 119.85' - Mechanical break (2)	
120 -78.4			0		
	121.5		2	120.5-120.6' - Fracture zone, 25 deg and horizontal, rough, undulating, intersecting, open <1"	R15: 9 minutes
			NR		
			1	121.9' - Bedding plane, horizontal, smooth, undulating, tight	
			0		
	R16-NQ 5 ft 100%	84	0		
125 -83.4			0		
	126.5		>10	125.75-126.5' - Fracture zone, rough, undulating, gravel sized fragments <3"x1-1/2"	R16: 6 minutes
			2		
			1	127.25, 127.45, 127.7, 131.3' - Bedding plane, horizontal, smooth, undulating, tight	
	R17-NQ			128.7, 129.0' - Mechanical break (2)	

SYMBOLIC LOG

LITHOLOGY – ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS

Limestone
101.5-106.3' - yellowish gray, (5Y 7/2), very fine to fine grained, strong HCl reaction, extremely weak to very weak (R0 to R1), voids (<1/16") over 50% of surface, few cavities up to 1/2"x1/4", poorly to moderately fossiliferous; 105.6-106.05' weak rock (R2) zone, voids (<3/16") over 70% of surface, moderately fossiliferous, moderate HCl reaction at 105.6-106.05'
No Recovery 106.3-106.5'
Limestone
106.5-111.5' - moderate yellowish brown to yellowish gray, (10YR 5/4 to 5Y 7/2), very fine to fine grained, strong HCl reaction, very weak (R1), voids (<3/16") over 60-80% of surface, moderately to highly fossiliferous (molds <1/4" diameter) concentrated at 106.5-107.7' and 110.0-110.3', surface iron staining at 106.8', 107.8' and 109.5'
111.5-116.5' - yellowish gray, (5Y 7/2), very fine to fine grained, strong HCl reaction, very weak (R1), 40% voids to <1/16", poorly to moderately fossiliferous (molds <1/16"), iron staining at 113.8', 114.6' and 115.7'
116.5-119.0' - yellowish gray, (5Y 7/2), very fine to fine grained, strong HCl reaction, very weak to weak (R1 to R2), voids (<3/16") over 60% of surface, poorly to moderately fossiliferous (molds <1/2"x1/4")
119.0-121.35' - Same as 116.5-119.0' except 80% voids up to 3/16", few cavities up to 1/2" diameter, highly fossiliferous (molds <1/2")
No Recovery 121.35-121.5'
Limestone
121.5-122.65' - Same as 119.0-121.35'
122.65-124.0' - pale yellowish brown, (10YR 6/2), very fine to fine grained, very weak (R1), voids (<1/16") over >50% of surface, poorly fossiliferous (molds up to 1/4" diameter), few cavities up to 1/2"x1/4"
124.0-126.5' - Same as 122.65-124.0' except voids up to 3/16" over 60-80% of surface, extremely weak rock (R0), highly fossiliferous below 125.75', friable

PROJECT NUMBER: 338884.FL	BORING NUMBER: A-01	SHEET 8 OF 9

ROCK CORE LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

CORING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, NQ tools, NW/HW casing ORIENTATION : Vertical

WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
130 / -88.4	5 ft 100% (to 131.5)	87	0, 0, 1			**Limestone** 126.5-131.5' - yellowish gray, (5Y 7/2), very fine to fine grained, strong HCl reaction, very weak to weak (R1 to R2), voids (<3/16") over 60% of surface, poorly to moderately fossiliferous, few cavities <1/2" diameter, trace secondary infill of cavities, laminated bedding at 127.2', 127.85' and 128.95'	R17: 5 minutes
135 / -93.4	R18-NQ 5 ft 100% (131.5-136.5)	100	0, 0, 0, 0, 0	133.05, 134.0, 135.2' - Mechanical break (3)		131.5-136.5' - yellowish gray, (5Y 7/2), very fine to fine grained, very weak to medium strong (R1 to R3), 131.5-132.95' - voids <3/16" over 40% of surface, poorly fossiliferous (molds <1/2" diameter); 132.95-136.5' - voids up to 3/16" over 70% of surface, highly fossiliferous (molds <1/2"), molds over 30-50% surface	SC-4 collected at 133.05-134.0'; R18: 10 minutes
140 / -98.4	R19-NQ 5 ft 94% (136.5-141.5)	86	1, 2, 1, 0, >10, NR	137.5' - Bedding plane, horizontal, smooth, undulating, tight; 138.05, 138.45, 138.6' - Bedding plane, <10 deg, rough, undulating, tight; 140.9-141.2' - Fracture zone, rough, undulating, gravel sized fragments <2" diameter		136.5-141.2' - yellowish gray to light olive gray, (5Y 7/2 to 5Y 5/2), very fine to fine grained, strong HCl reaction, very weak to medium strong (R1 to R3), laminated bedding, 30-60% voids up to 3/16", poorly to moderately fossiliferous (molds <1/2"x1/4"), surface iron staining at 136.7', 137.7', 138.2', 139.1' and 140.5', laminated throughout; **No Recovery 141.2-141.5'**	R19: 8 minutes
145 / -103.4	R20-NQ 5 ft 70% (141.5-146.5)	23	>10, >10, 4, >10, NR	141.6-142.0' - Bedding plane (>10), <10 deg, smooth to rough, undulating, open <1/4"; 142.0-142.65' - Fracture zone, rough, undulating, angular gravel-sized fragments <1-1/2" diameter; 142.9, 143.3, 143.65, 144.15, 144.25, 144.5, 144.7' - Fractures (8), <10 deg, rough, undulating, <1/2" openings; 144.7-145.0' - Fracture zone, rough, undulating		**Limestone** 141.5-145.0' - moderate yellowish brown to yellowish gray, (10YR 5/4 to 5Y 7/2), very fine to fine grained, 141.5-142.0' - moderate yellowish brown, very weak to weak rock (R1-R2), voids (<3/16") over 70% of surface, moderately fossiliferous, trace organics, trace laminated bedding; 142.0-145.0' - voids up to 3/16" over 50% of surface, medium strong rock (R3), highly fossiliferous (molds <1"x1/2"), cavities <1.5"x1", several cavities with secondary mineral infill, heavily bioturbated; **No Recovery 145.0-146.5'**	Core barrel malfunction from 144.7-145.0' due to rock fragments wedged in bit; R20: 10 minutes
	R21-NQ (from 146.5)		2, 1	146.6' - Bedding plane, <10 deg, rough, undulating, open <1/4"; 146.8, 147.8' - Bedding plane (2), horizontal, smooth, undulating, tight			

ROCK CORE LOG

PROJECT : Progress Energy Florida - COLA Investigation, Levy County Site LOCATION : 1723879.2 N, 457603.8 E (NAD83)

ELEVATION : 41.6 ft (NAVD88) DRILLING CONTRACTOR : Universal Engineering Sciences, Jacksonville, FL; Driller: B. Truitt; Cathead Operator: B. Crews

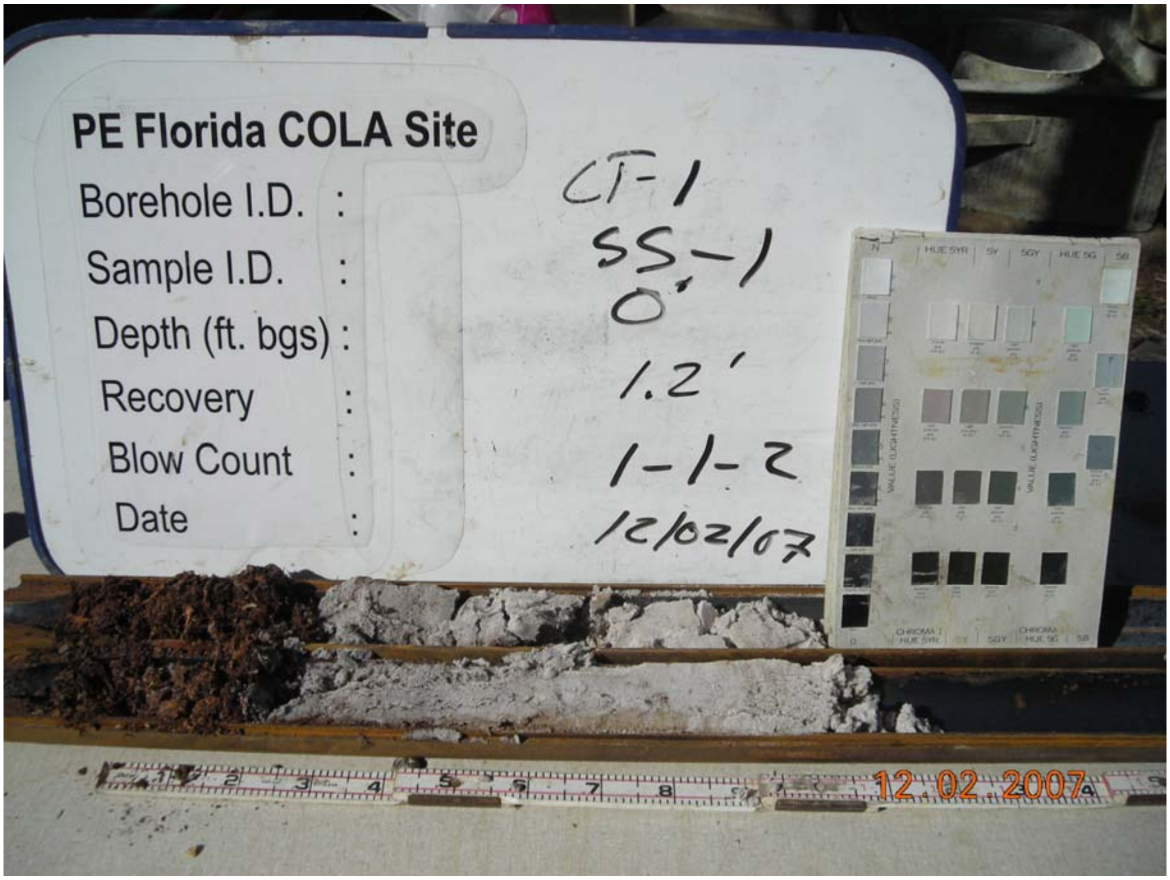
CORING METHOD AND EQUIPMENT : Dietrich D-50 S/N 232, mud rotary, NQ tools, NW/HW casing ORIENTATION : Vertical

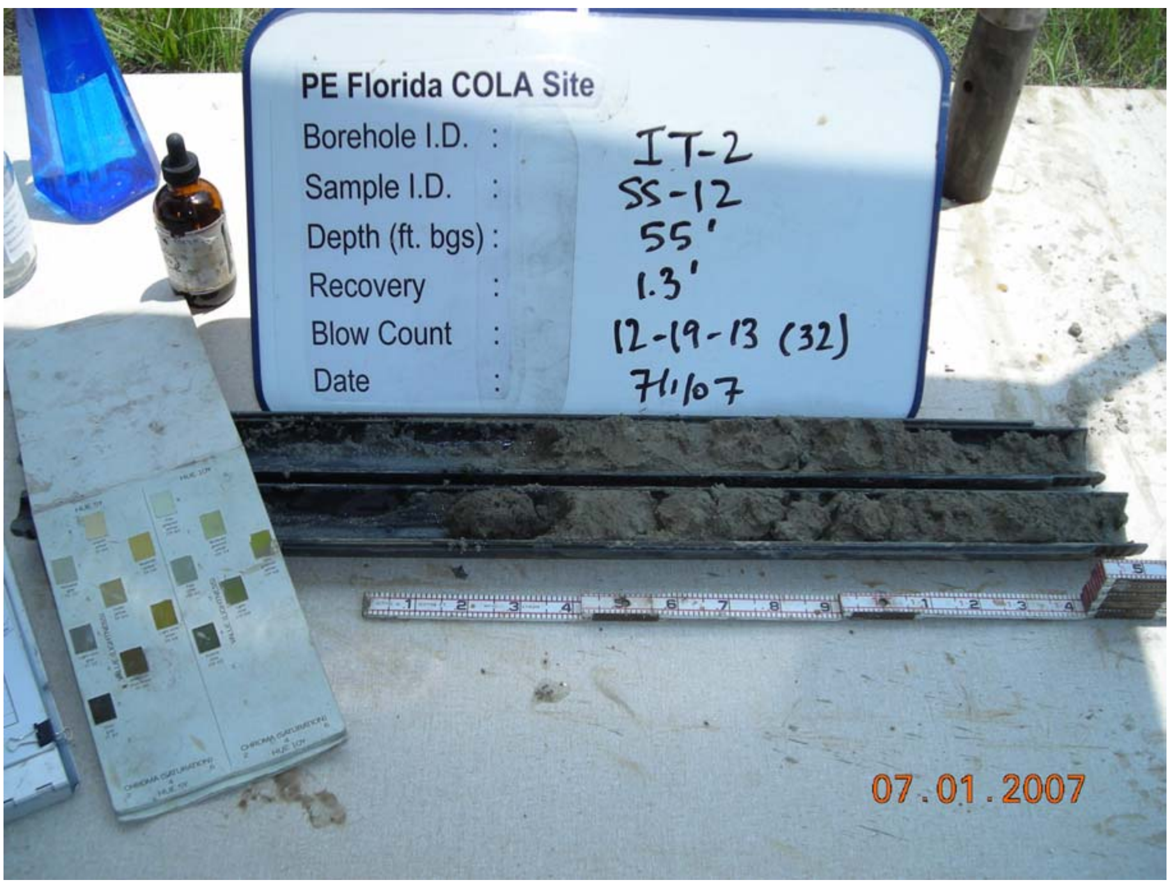
WATER LEVELS : 2 ft bgs on 03/15/07 START : 3/14/2007 END : 3/21/2007 LOGGER : R. Bitely

DEPTH BELOW SURFACE AND ELEVATION (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY – ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS – SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	5 ft 86%	80	1	148.95' - Bedding plane, horizontal, rough, undulating, open <1/4"		**Limestone** 146.5-150.8' - moderate yellowish brown to yellowish gray, (10YR 5/4 to 5Y 7/2), very fine to fine grained, mild to moderate HCl reaction, laminated bedding, 146.5-148.9' - weak to medium strong rock (R2-R3), voids (<3/16") over 30% of surface, voids increase to 80% from 148.3-148.9' 148.9-150.8' - very weak rock (R1), voids (up to 3/16") over 60% of surface, moderately fossiliferous (casts) concentrated at 148.9-150.0	
150 -108.4			0				
			0				R21: 13 minutes
	151.5		NR			**No Recovery 150.8-151.5'**	
			1	151.85' - Bedding plane, horizontal, rough, undulating, tight			SC-5 collected 151.85-152.8'
			1				
	R22-NQ 5 ft 100%	92	0	153.45-153.55' - Clay seam or bedding plane, horizontal, smooth, undulating, 5/8" silt and/or clay sized infilling, tight		**Limestone** 151.5-153.45' - Same as 148.9-150.8' except very weak (R1)	
155 -113.4			0			**Silty Sand (SM)** 153.45-153.55' - wet, loose, silt has rapid dilatancy, 50% fine to medium grained sand, calcareous, 1/4" thick lense	
	156.5		2	155.65, 156.35' - Bedding plane (2), <10 deg, smooth, undulating, tight			R22: 14 minutes
			3	156.7, 156.8, 156.9' - Bedding plane (3), <10 deg, smooth, undulating, tight		**Limestone** 153.55-156.5' - pale yellowish brown to yellowish gray, (10YR 6/2 to 5Y 7/2), very fine to fine grained, moderate to strong HCl reaction, medium strong (R3), 50-70% voids up to 3/16", poorly to moderately fossiliferous, laminated bedding concentrated at 155.0-156.5', few cavities <1/2"x1/4", 1 large (3/4"x1/2") cavity at 156.4'	
			0				
	R23-NQ 5 ft 100%	92	0	158.35, 158.6, 159.7' - Mechanical break (3)			
160 -118.4			0			156.5-161.5' - pale yellowish brown, (10YR 6/2), very fine to fine grained, moderate to strong HCl reaction, weak to very weak (R2 to R1), 60% voids up to 3/16", moderately fossiliferous (molds 3/4"x1/2" diameter), trace organics, trace secondary infill and silt-sized carbonate material at 158.35-158.5' and 160.5', medium strong rock (R3) lense at 158.7-159.7', laminated bedding at 156.5-156.9' and 160.5-160.9'	R23: 7 minutes
	161.5		1	160.65' - Bedding plane, <10 deg, smooth, undulating, tight			Water level at 5' below ground surface on 3/21/2007 at 18:30
						Bottom of Boring at 161.5 ft bgs on 3/21/2007	

Appendix B
Example Photographs of Soil Samples

Examples of SPT sample photographs and white boards.





Example of sonic soil cores - overall box photograph with box close ups (left and right sides).


Depth
In Box
Recovery
RQD
36-46'
All
7.5/100
20"/120"=16%
02.20.2007 16:17


PEF COLA
Boring # I-1
Depth 36' to 46'
Box # 5 of
Date 2/20/07
PE Florida COLA Site
Borehole I.D. : I-1
Run I.D. : R5-S
Depth (ft. bgs) : 36' - 46'
Recovery : 75%
RQD : 20"/120" = 16%
Date : 2/20/07
NR
02.20.2007 16:17

Appendix C
Field Equipment Checklist and Field Reference Guide

Suggested Field Equipment Checklist for Soil Sampling and Logging

- ☐ Project workplan, site investigation plans, and other planning information such as boring location map, boring summary tables, utility plans, etc.
- ☐ Permits: encroachment, environmental, etc.
- ☐ Copy of utility clearance
- ☐ Copy of the drilling contract or subcontract
- ☐ Previous site exploration data, geology maps, etc.
- ☐ Underground service alert ticket
- ☐ Site contact information
- ☐ Field Safety Instructions (FSI)/Health and Safety Plan (signed and dated by all field personnel); Pre-drilling safety checklist and other H&S Plan forms to be field out.
- ☐ Personal Protective Equipment and safety equipment per the FSI/HSP. Typical items include:
    - Hard hat
    - Safety glasses
    - Safety vest
    - Steel-toed boots
    - Ear protection (earplugs and/or ear muffs)
    - Work (outer) gloves and inner (latex or nitrile) gloves
    - Rain gear if appropriate
    - Cold weather gear if appropriate
    - Rubber boots if appropriate
    - Safety equipment (per FSI, e.g., fire extinguisher, first aid kit, environmental monitoring equipment such as a PID, snake chaps, bear spray, rubber boots, etc.)
    - Additional equipment as required for environmental contamination
- ☐ Logging and sampling supplies
    - Pens, pencils, erasers, and Sharpie-style permanent markers (thick and thin)
    - Chalk, soapstone, and/or lumber crayons for marking rock core samples
    - Field clipboard
    - Straight ruler including millimeters
    - Measuring tape / 6-foot folding rule in tenths and inches
    - Blank log sheets (and for rock if needed) on weatherproof paper
    - Munsell soil color charts (and rock if needed)
    - Notebook for daily documentation (field "yellow book")
    - White board with dry erase markers (or disposable note cards)

- ○ HD digital camera with extra batteries and memory
- ○ Wire straining for evaluating cuttings
- ○ Protractor
- ○ Core boxes (verify drillers to supply for proposed methods – sonic, rock coring, etc.)
- ○ Electric and duct tape
- ○ Bulk sample bags
- ○ Ziploc-style heavy duty/freeze bags (quart and gallon size) and/or glass jars
- ○ Plastic wrap
- ○ Materials for sealing thin-tube samples (parafin wax, stove, fuel, lighter, pot, etc. or confirm if drilling is providing)
- ○ Putty knife or spatula with rounded end for scraping samples out of spoons
- ○ Labels (carry extra for backup)
- ○ Buckets for large samples or carrying samples

- ☐ 3-ft step ladder (to photograph whole sonic core runs)
- ☐ 100-foot cloth or fiberglass tape
- ☐ Flagging and spray paint
- ☐ Sturdy folding tables and chairs
- ☐ Screwdriver – flat-head and phillips head
- ☐ Rock hammer
- ☐ Small sledge hammer
- ☐ Hand level and/or handheld inclinometer
- ☐ Approved utility knife
- ☐ Water depth meter
- ☐ Sunscreen, insect repellant, hand sanitizer, hand wash
- ☐ Paper towels/cloth rags
- ☐ Drinking water, food
- ☐ Spray bottles or hand sprayers and appropriate water (e.g., de-ionized may be required for environmental reasons)
- ☐ Hand-held GPS
- ☐ Laptop
- ☐ Cell phone or other site specific communication device
- ☐ Awning for high rainfall or sun protection
- ☐ Wooden stakes for marking borehole locations
- ☐ Trash bags

- ☐ Means of transporting Shelby tube samples
- ☐ Wrist watch
- ☐ Other project specific items
    - Understand access requirements and limitations.
    - Understand support vehicle requirements (e.g., car, truck, SUV, etc.).
    - Understand how drillers will get water if needed for drilling method (pump from stream with appropriate fish screens and permits, get from hydrant, client supplied, bring from offsite, how to dispose, fill with air-gap on water tank, etc.).
    - Potential limitations from fire danger (restricted work hours, post-work standby, spark arrestors on all equipment, etc.).
    - Be prepared to repair landscaping, or advise client that landscaping will be damaged by drill rig.
    - Understand if sidewalks patched, asphalt patched, concrete cored, air-knifing to expose utilities in upper portion of borehole.
    - Understand cuttings disposal (drum, scatter onsite, relocate to onsite disposal, etc.).
    - Traffic control subcontractor if needed, coordinate traffic control with drilling schedule.
    - Traffic cones or signage if needed.

PROJECT NUMBER	BORING NUMBER	Sheet: of

SOIL BORING LOG

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVEL : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-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:

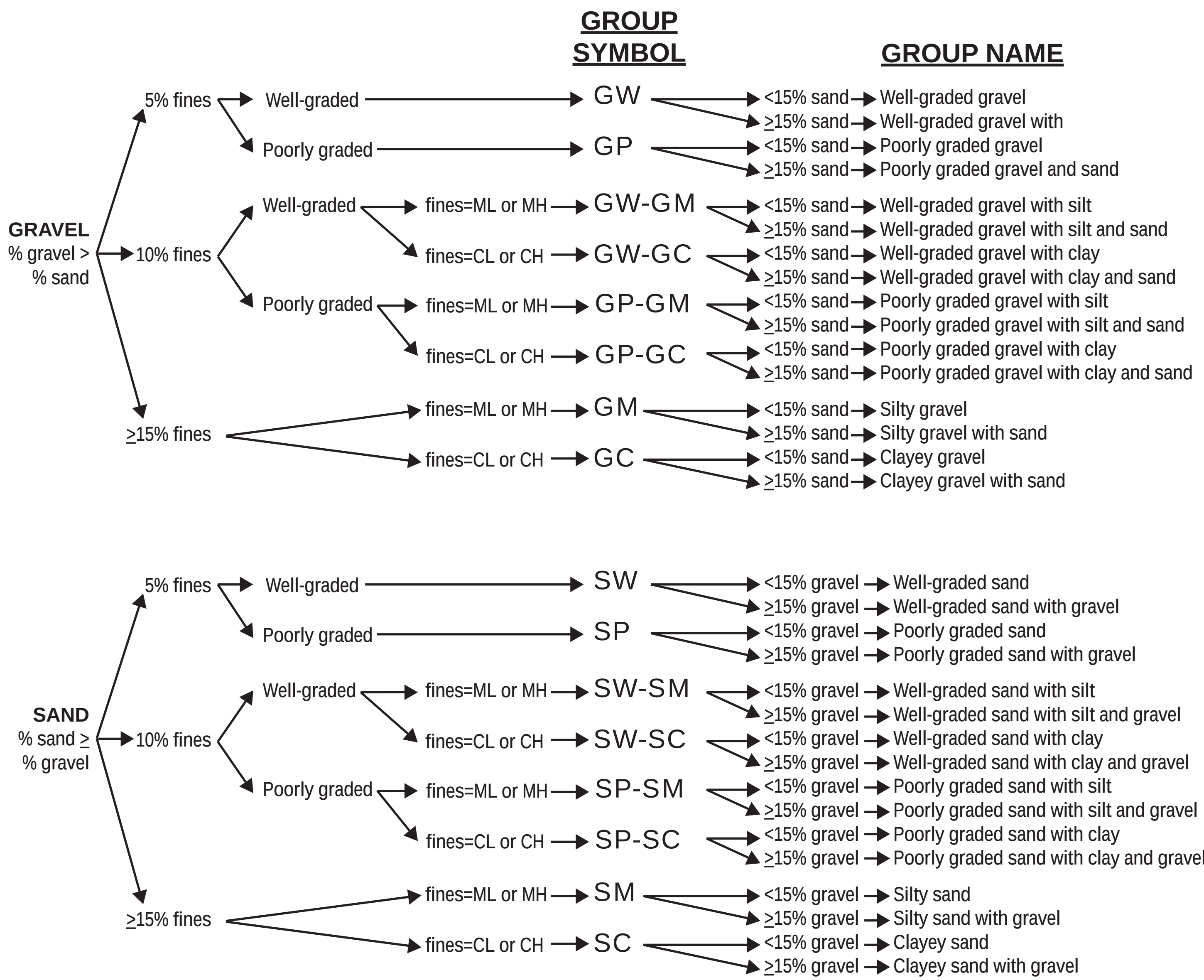
Fine-Grained and Organic Soil Flow Chart

GROUP SYMBOL				GROUP NAME
CL	<30% plus No. 200	<15% plus No. 200		Lean clay
		15-25% plus No. 200	% sand ≥% of gravel	Lean clay with sand
			% sand <% of gravel	Lean clay with gravel
	≥30% plus No. 200	% sand ≥% of gravel	<15% gravel	Sandy lean clay
			≥15% gravel	Sandy lean clay with gravel
		% sand <%gravel	<15% sand	Gravelly lean clay
			≥15% sand	Gravelly lean clay with sand
ML	<30% plus No. 200	<15% plus No. 200		Silt
		15-25% plus No. 200	% sand ≥% of gravel	Silt with sand
			% sand <% of gravel	Silt with gravel
	≥30% plus No. 200	% sand ≥% of gravel	<15% gravel	Sandy silt
			≥15% gravel	Sandy silt with gravel
		% sand <%gravel	<15% sand	Gravelly silt
			≥15% sand	Gravelly silt with sand
CH	<30% plus No. 200	<15% plus No. 200		Fat clay
		15-25% plus No. 200	% sand ≥% of gravel	Fat clay with sand
			% sand <% of gravel	Fat clay with gravel
	≥30% plus No. 200	% sand ≥% of gravel	<15% gravel	Sandy fat clay
			≥15% gravel	Sandy fat clay with gravel
		% sand <%gravel	<15% sand	Gravelly fat clay
			≥15% sand	Gravelly fat clay with sand
MH	<30% plus No. 200	<15% plus No. 200		Elastic silt
		15-25% plus No. 200	% sand ≥% of gravel	Elastic silt with sand
			% sand <% of gravel	Elastic silt with gravel
	≥30% plus No. 200	% sand ≥% of gravel	<15% gravel	Sandy elastic silt
			≥15% gravel	Sandy elastic silt with gravel
		% sand <%gravel	<15% sand	Gravelly elastic silt
			≥15% sand	Gravelly elastic silt with sand
OL/OH	<30% plus No. 200	<15% plus No. 200		Organic soil
		15-25% plus No. 200	% sand ≥% of gravel	Organic soil with sand
			% sand <% of gravel	Organic soil with gravel
	≥30% plus No. 200	% sand ≥% of gravel	<15% gravel	Sandy organic soil
			≥15% gravel	Sandy organic soil with gravel
		% sand <%gravel	<15% sand	Gravelly organic soil
			≥15% sand	Gravelly organic soil with sand

Where cobbles and boulders are present, add to Group Name

Source: ASTM D2488

Coarse-Grained Flow Chart



Where cobbles and boulders are present, add to Group Name

Source: ASTM D2488

FIELD REFERENCE GUIDE

Criteria for Describing Moisture Content	
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

Source: ASTM D2488

Relative Density of Coarse-Grained Soil	
Blows/Ft	**Relative Density**
0 - 4	Very loose
5 - 10	Loose
11 - 30	Medium
31 - 50	Dense
50	Very Dense

Source: Sowers, 1979

Consistency of Fine-Grained Soil			
Blows/Ft	**Consistency**	**Pocket Penetrometer (TSF)**	**Torvane (TSF)**
<2	Very soft	<0.25	<0.12
2 - 4	Soft	0.25- 0.50	<0.12 - 0.25
5 - 8	Firm	0.50 - 1.0	0.25 - 0.5
9 - 15	Stiff	1.0 - 2.0	0.5 - 1.0
16 - 30	Very stiff	2.0 - 4.0	1.0 - 2.0
30	Hard	>4.0	>2.0

Source: Sowers, 1979

Particle Size Guidance		
Description	**Sieve Size**	**Examples**
Boulder	Greater than 12 inches	> Basketball
Cobble	3 to 12 inches	Fist to basketball
Coarse Gravel	3/4 to 3 inches	Thumb to fist
Fine Gravel	No. 4 to 3/4 inches (4.75 mm to 3/4 inches)	Pea to thumb
Coarse Sand	No. 10 to No. 4 (2.0 to 4.75 mm)	Rock salt to pea
Medium Sand	No. 40 to No. 10 (0.425 to 2.0 mm)	Sugar to rock salt
Fine Sand	No. 200 to No. 40 (0.075 to 0.425 mm)	Flour to sugar
Silt and Clay	Passing No. 200 (<0.075 mm)	Grains not visible

Source: ASTM D2488

Criteria for Describing Angularity of Coarse-Grained Particles

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular, but have rounded edges
Subrounded	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

Source: ASTM D2488

Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-inch (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when dried than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reach the plastic limit. The lump can be formed without crumbing when drier than the plastic limit.

Source: ASTM D2488

Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

Source: ASTM D2488

Criteria for Describing Reaction with HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Source: ASTM D2488

STANDARD OPERATING PROCEDURE

Continuous 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 using continuously recording data loggers and pressure transducers.

II. Equipment and Materials

- Pressure transducers and data loggers (pressure transducers with built-in data loggers are also acceptable). The pressure rating should be appropriate for the anticipated range of submergence depths of each transducer.
- Portable computers and / or external data storage devices.

III. Procedures and Guidelines

- Synchronize time recording devices to the computer that will be used to program the data-logging pressure transducers before each aquifer test.
- Deploy transducers below the static water level in a given well. Depth of deployment will be determined by the FTL.
- Data-logging pressure transducers will be equipped with direct read cable so that the transducer functionality and data quality can be verified during the aquifer testing program.
- Secure transducers to the wells (e.g. using a slip mesh wire loop) such that the deployment depths do not shift during the aquifer test.
- Record automatic water level readings via data-logging pressure transducers using a linear or logarithmic time scale. A logarithmic time-scale is preferred for locations in which rapid initial changes in water levels are expected, such as pumping wells. A linear scale is generally sufficient for observation wells, unless pre-test activities indicate that rapid water level changes are expected at the observation wells. Follow the instruction manual for transducer setup.
- During the first hour of any test, monitor data loggers frequently. After the first hour, monitoring shall continue at least hourly.
- Reset pumping well transducer to begin logging logarithmically after pumping ceases.
- Download data from the transducers at the groundwater level monitoring period such as at the end of the aquifer test. Do not stop and restart tests during data

downloads. Collect manual water level measurements during transducer download.

- Remove pressure transducers and data loggers from the wells and decontaminate equipment after aquifer test is complete.

IV. Data Analysis

Depending on the type of aquifer and local setting, a variety of analysis techniques are available for data interpretation.

V. Attachments

None.

VI. Key Checks

- Equipment must be decontaminated and inspected before and after each use to ensure it is in good condition.
- Transducers and data loggers must be calibrated and tested before aquifer testing begins.
- Prior to deployment, verify that transducers have sufficient memory and battery capacity to store the anticipated number of measurements.

STANDARD OPERATING PROCEDURE

Multi RAE Photoionization Detector (PID)

I. Purpose

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

II. Scope

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

III. Definitions

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

Volatile Organic Compound (VOC) – VOC concentration in ppm

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

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

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

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

IV. Procedures

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

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

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

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

A. Calibration

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

Start up Instrument

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

On!……..

Multi RAE Version X.XX

Model Number SN XXXX

Date Time Temp

Checking Sensor Ids….

VOC Installed

CO Installed

H_2S Installed

OXY Installed

LEL Installed

H_2S VOC CO LEL OXY

Alarm Limits=

XX XX.X XX XX High XX.X

XX XX.X XX XX Low XX.X

XX XX.X XX STEL

XX XX.X XX TWA

Battery = X.XV Shut off at 4.2V

User Mode=

Alarm Mode=

Datalog Time Left

Datalog Mode

Datalog Period

Unit ready in….. 10 Seconds

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

Calibration Check and Adjustment

Allow instrument to warm up for 15 minutes.

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

Calibrate Monitor?

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

Fresh Air Calibration?

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

Zero…. In progress…

CO Zeroed! Reading = X

VOC Zeroed! Reading = X

LEL Zeroed! Reading = X

OXY Zeroed! Reading = X

Zero Cal done!
H_2S Zeroed! Reading = X

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

- Display will then read:

Multiple Sensor Calibration?

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

CO H_2S LEL OK? OXY

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

Apply Mixed gas

Calibration In progress …

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

CO cal’ed Reading=50

H_2S cal’ed Reading=25

LEL cal’ed Reading=50

OXY cal’ed Reading=20.9

Calibration done Turn off gas!

- Display will read:

Single Sensor Calibration?

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

CO VOC H_2S LEL pick? OXY

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

Apply VOC Gas

Calibration In progress…

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

VOC cal’d Reading=100

Calibration done Turn off gas!

Single Sensor Calibration?

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

- **CALIBRATION IS COMPLETE!**

B. Operation

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

C. Site Maintenance

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

D. Scheduled Maintenance

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

V. Quality Assurance Records

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

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

VI. References

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

DRAFT FINAL STANDARD OPERATING PROCEDURE – Navy CLEAN PROGRAM

Groundwater Sampling for Per- and Polyfluoroalkyl Substances (PFAS)

I. Purpose and Scope

This SOP provides guidelines for groundwater sample collection for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15. This SOP should be used in conjunction with approved region-specific groundwater sampling SOPs which provide methods for general and low-flow groundwater sampling. In cases in which information in this SOP conflicts with region-specific groundwater sampling SOPs, this SOP will supersede the information in the general SOPs.

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- If installing wells, ensure driller does not use polytetrafluoroethylene (PFTE)-containing drill lube or other drilling lubes containing PFAS. Biolube has been determined to be an acceptable drilling lube for installing wells where PFAS may be of concern. Additionally, Waterra surge blocks have been confirmed to not contain PFAS and may be used for development.
- Groundwater sampling equipment
  - PFAS-free tubing (avoid Teflon, Viton, PTFE and other fluorinated compounds)
    - High density polyethylene tubing (unlined)
    - If Masterflex tubing is needed for peristaltic pumps, Cole Parmer C-Flex (06424 series) and Tygon E-3603 (06509 series) are suitable options
  - PFAS-free Bailer (if using a bailer[1])
  - PFAS-free Pump such as:
    - Geotech PFAS-free Portable Bladder Pump (note, most bladder pumps include a Teflon-lined bladder, but Geotech currently has one model which is Teflon-free).
    - Panacea P120 or P125. The P200 Stainless Steel Pump may also be used, but the standard model contains Teflon at the tube connection. If you are using this Panacea model, you must request one with the "PTFE-free thread sealant option."
    - Waterra stainless foot-valve
    - QED Sample Pro

[1] Geotech and Waterra offer PFAS free bailer options

- Monsoon or Mega Monsoon submersible pump
- Grundfos Rediflo2 (this pump contains small Teflon components, but has not been shown to leach, it is less preferable than the other options)
- Peristaltic pump (may be suitable for shallow locations)

- Groundwater sample containers (high density polyethylene [HDPE] bottle with HDPE screwcap), sample bottles should not be glass as glass may sorb PFAS. Sample bottle caps should not contain Teflon. Notify your project manager (PM) if bottles provided by the lab are glass or contain Teflon parts.
- Laboratory prepared deionized, certified PFAS-free water for field blank collection
- PFAS-free shipping supplies (labels [if available][2], coolers, and ice)
- Loose leaf paper without waterproof coating or a spiralbound notebook (not waterproof)
- Metal clip board (if using loose-leaf paper)
- Pen (not Sharpie)
- Nitrile or latex gloves

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect groundwater samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

[2] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine

Follow Navy CLEAN SOPs for low-flow or conventional groundwater sample collection, depending on site requirements.

Sample Collection

Once water quality parameters have stabilized for low-flow purging, samples can be collected. For conventional purging, if water quality parameters do not stabilize, a minimum of 3 well volumes must be purged prior to sample collection.

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

1. Ensure that the end of the tubing does not touch the ground or equipment. Remove the cap from the sample bottle. Position the sample bottle under the end of the tubing.
2. Fill the bottle. Samples do not need to be collected headspace free.
3. Affix labels after bottles have been closed; collect only one sample at a time to avoid mislabeling. Pack the sample on ice immediately for shipment to the offsite laboratory. Avoid packing materials that may contain fluorine. Unpublished research has allowed us to generate a list of packing materials which do not contain fluorine. Please contact Bill Diguiseppi or Laura Cook for recommendations (because the research is not ours, it cannot be released externally at this time).

Equipment Decontamination

Whenever possible, use disposable equipment when collecting groundwater samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

Use of Water Quality Equipment and Water Level Indicators

Water quality meters typically do not contain PFAS. However, consistent with general sampling SOPs, disconnect the water quality meter prior to sampling. Some water level indicators do contain small polyvinylidene fluoride (a PFAS constituent for which we do not currently monitor) or less frequently, Teflon, components, but we have not noted cross contamination from water level indicators at any sites. The Durham Geoslope Water Level Indicators have been shown to be fluorine free.

V. References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/ Tandem Mass Spectrometry (LC/MS/MS).* September.

United States Navy, 2017. *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs).* September

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

Rotosonic Groundwater Sample Collection for Per- and Polyfluoroalkyl Substances

I. Purpose and Scope

This SOP provides guidelines for groundwater sample collection using rotosonic drilling technology for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15.

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- Sonic drill sampling rods and retractable stainless-steel screen without PFAS-containing components (Avoid Teflon, Viton, PTFE and all other fluorinated compounds)
- PFAS-free tubing (avoid Teflon, Viton, PTFE and other fluorinated compounds)
  - High density polyethylene tubing (unlined)
  - Masterflex tubing, Cole Parmer C-Flex (06424 series) and Tygon E-3603 (06509 series) are suitable options
- Water quality meter (Horiba® or YSI®)
- PFAS-free bladder pump
- Pre-cleaned sample containers
- Air monitoring and water quality instruments (as needed)
- Personal protective equipment
- Groundwater sample containers (high density polyethylene [HDPE] with HDPE screw cap [no Teflon caps])
- PFAS-free shipping labels (if available[1]) materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard
- Pen (not Sharpie)
- Nitrile or Latex gloves
- Laboratory prepared deionized, certified PFAS-free water for field blank collection
- PVC casing and screen for temporary well

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.

[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect groundwater samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine.

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

1. Decontaminate slotted lead rod and other downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment* and this SOP.
2. Drive lead probe rod to the desired sampling depth, and withdraw rods 2 to 3 feet to expose the retractable screen to the aquifer formation. Ensure that the screened lead rod has been inserted to the desired sampling depth. If using temporary well casing, deploy PVC screen and casing to desired sampling depth.
3. Insert the stainless-steel foot valve into the end of the polyethylene sampling tubing and insert tubing through the rods or insert peristaltic pump tubing through rods, depending on which method is used.
4. Collect and record one set of water quality parameters prior to sampling.

5. Fill all sample containers. Samples should be collected in accordance with SOP *Groundwater Sampling when Analyzing for Per- and Polyfluoroalkyl Substances (PFAS)*. Affix labels after bottles have been closed; collect only one sample at a time to avoid mislabeling.

6. Remove and discard polyethylene sampling tubing from the rods. Withdraw PVC temporary PVC screen and casing.

Equipment Decontamination

Ensure that the sonic rig operator thoroughly completes the decontamination process between sampling locations. Do not use water from the facility (e.g. fire hydrants) if there is a possibility that the water available is contaminated with PFAS.

Whenever possible, use disposable equipment when collecting groundwater samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

Use of Water Quality Equipment

Water quality meters typically do not contain PFAS. However, consistent with general sampling SOPs, disconnect the water quality meter prior to sampling.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS).* September.

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

STANDARD OPERATING PROCEDURE

Soil Sampling for Per- and Poly-fluoroalkyl Substances

I. Purpose

To provide general guidelines for the collection and handling of soil samples collected in support of per- and poly-fluorinated alkyl substance (PFAS) investigations.

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000.

II. Scope

The method described applies to soil sampling for PFAS constituents using a variety of collection tools (hand auger, split spoon, direct push technology [DPT] sampling, and trowel collection).

III. Equipment and Materials

- Sample jars (sample jars should be made of polyethylene as glass jars may sorb PFAS, please notify the project manager [PM] if glass jars are provided by the lab). Sample containers should not contain Teflon lids.
- A hand auger or other device that can be used to remove the soil from the ground. Stainless steel tools, carbon steel tools, or steel DPT tooling with acetate sleeves are preferred for PFAS sampling. Avoid any sampling materials containing Teflon. Any plastic sampling materials should be evaluated thoroughly before selection to ensure they are fluorine-free
- A stainless steel spatula or fluorine-free disposable plastic scoop should be used to remove material from the sampling device.
- Unpainted wooden stakes or pin flags
- Fiberglass measuring tape (at least 200 feet in length)
- GPS Unit
- PFAS-free shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Clipboard (if using loose-leaf paper)
- Pen (not Sharpie)
- Nitrile or Latex gloves

Equipment and materials used to collect soil samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton).

Specifically, the following material should be avoided during sampling:

- Gore-tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistent clothing with fluorochemical treatment or anything advertised as a water repellent.
- Weatherproof logbooks with fluorochemical coatings
- New clothing that has been washed fewer than six times

If a driller is supporting collection of soil samples in split spoons or acetate DPT sleeves, ensure the driller has not used and will not use drilling lube containing polytetrafluoroethylene (PFTE) or any other fluorine-containing substance. Biolube has been determined to be an acceptable substitute.

IV. Procedures and Guidelines

Prior to initiating soil sampling activities, steps should be taken to ensure the sampling area is free of pre-packaged food wrappers, microwave popcorn bags, blue ice containers, aluminum foil, Kim-wipes, sunscreen, insect repellent, and other personal hygiene products unless these products have been confirmed to be fluorine-free.

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

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

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

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

   1. For samples on a grid:

      a. Use measuring tape to locate each sampling point on the first grid line as prescribed in the sampling plan. As each point is located, drive a numbered stake in the ground and record its location on the site map and in the field notebook/clipboard.
      b. Proceed to sample the points on the grid line.
      c. Measure to location where next grid line is to start and stake first sample. For subsequent samples on the line take two orthogonal measurements: one to the previous grid line, and one to the previous sample on the same grid line.
      d. Proceed to sample the points on the grid line as described in Section C below.
      e. Repeat 1c and 1d above until all samples are collected from the area.

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

2. For non-grid samples:

   a. Use measuring tape to position sampling point at location described in the sampling plan by taking two measurements from fixed landmarks (e.g., corner of house and fence post).
   b. Note measurements, landmarks, and sampling point on a sketch in the field notebook, and on a site location map.
   c. Proceed to sample as described in Section C below.
   d. Repeat 2a through 2c above until all samples are collected from the area.
   e. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

C. To the extent possible, differentiate between fill and natural soil. If both are encountered at a boring location, sample both as prescribed in the field sampling plan. Do not locate samples in debris, tree roots, or standing water. In residential areas, do not sample in areas where residents' activities may impact the sample (e.g., barbecue areas, beneath eaves of roofs, driveways, garbage areas). If an obstacle prevents sampling at a measured grid point, move as close as possible, but up to a distance of one half the grid spacing in any direction to locate an appropriate sample. If an appropriate location cannot be found, consult with the Field Team Leader (FTL). If the FTL concurs, the sampling point may be deleted from the program. The FTL will contact the CH2M HILL PM immediately. The PM and Navy Technical Representative (NTR) will discuss whether the point should be deleted from the program. If it is deleted, the PM will follow-up with the NTR in writing.

D. To collect samples using standard methods:

1. Use a decontaminated stainless steel scoop/trowel or disposable plastic scoop to scrape away surficial organic material (grass, leaves, etc.) adjacent to the stake. New disposable scoops or trowels may also be used to reduce the need for equipment blanks if the disposable scoops have been confirmed by your project PFAS subject matter expert (SME) to be PFAS free.

2. If sampling:

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

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

3. Record lithologic description and any pertinent observations (such as discoloration) in the field notebook/clipboard.

4. Empty the contents of the scoop/trowel into a decontaminated stainless steel pan or dedicated sealable bag.

5. Repeat this procedure until sufficient soil is collected to meet volume requirements.

6. Homogenize cuttings in the pan using a decontaminated stainless steel utensil.

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

8. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.

9. Backfill the hole with soil removed from the borehole. To the extent possible, replace topsoil and grass and attempt to return appearance of sampling area to its pre-sampled condition. For samples in non-residential, unmowed areas, mark the sample number on the stake and leave stake in place. In mowed areas, remove stake.

E. To collect Samples Using DPT Methods

1. Decontaminate sampling tubes and other non-dedicated downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment*. Ensure that decontamination water used is PFAS free (do not use water from fire hydrants on-base for steam cleaning unless the water has been demonstrated to be free of PFAS).

2. Drive sampling tube to the desired sampling depth using the truck-mounted hydraulic percussion hammer. If soil above the desired depth is not to be sampled, first drive the lead rod, without a sampling tube, to the top of the desired depth.

3. Remove the rods and sampling tube from the borehole and remove the sampling tube from the lead rod.

4. Cut open the acetate liner using a specific knife designed to slice the acetate liners (see below).

5. Fill all sample containers, using a decontaminated or dedicated sampling implement. Label the containers and immediately place samples on ice for shipment to the laboratory.

6. Decontaminate all non-dedicated downhole equipment (rods, sampling tubes, etc.) in accordance with SOP Decontamination of Personnel and Equipment and ensure decontamination water is from a PFAS-free water source.

7. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

V. Attachments

None.

VI. Key Checks and Items

- Decontaminate utensils before reuse with the last rinse using laboratory-provided certified PFAS-free water or use dedicated, disposable utensils which are PFAS-free.
- Field blank and field reagent blank procedures for PFAS sampling vary based on the lab's Method 537 Modified SOP. When using a Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) accredited laboratory, follow any procedures specified in the approved method.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

United States Navy, 2015. *Field Sampling Protocols to Avoid Cross-Contamination during Water Sampling for Perfluorinated Compounds (PFCs).*

STANDARD OPERATING PROCEDURE – Navy CLEAN PROGRAM

Management of Liquid Waste Containing Per- and Polyfluoroalkyl Substances (PFAS)

I. Purpose and Scope

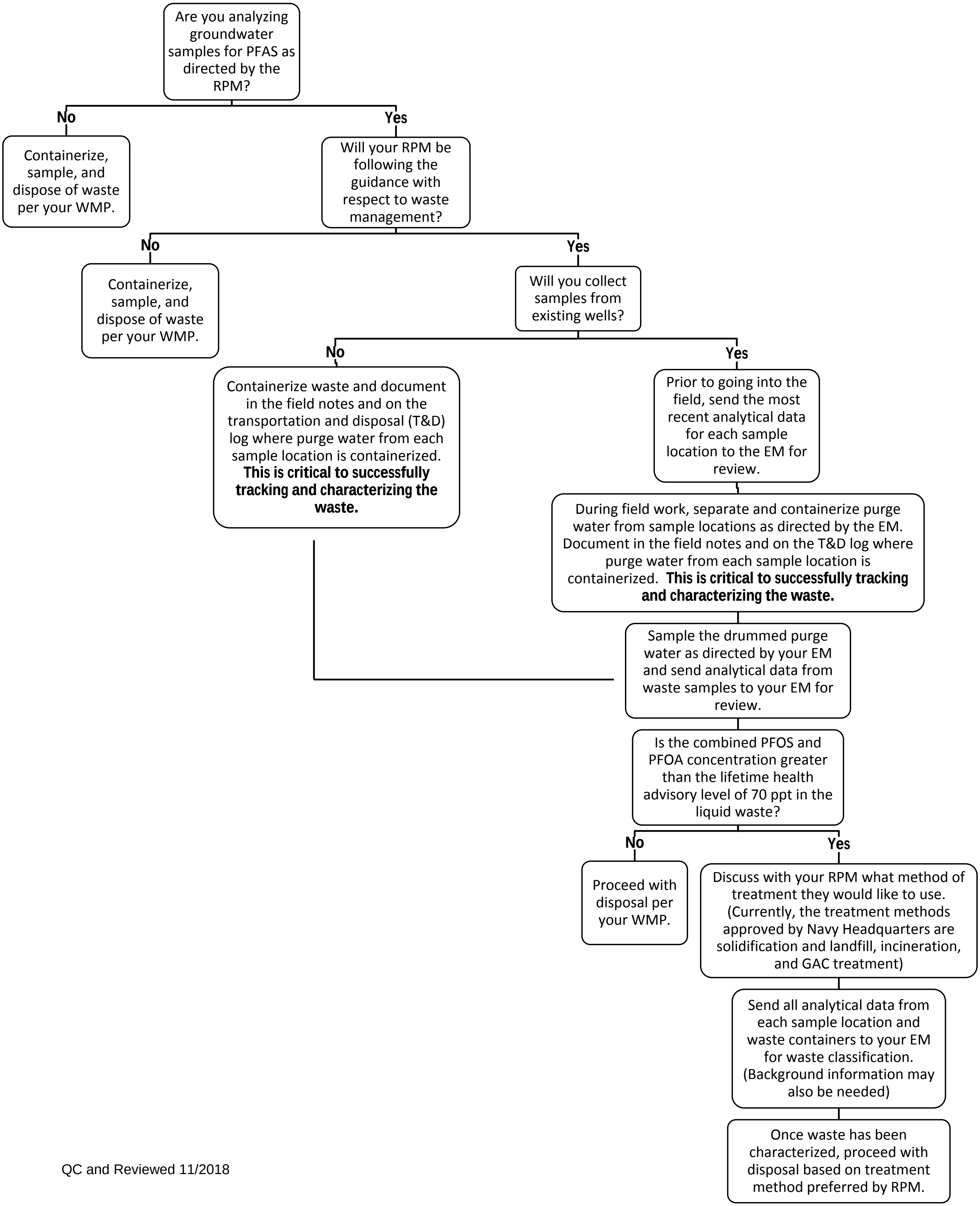
This SOP provides guidelines for managing waste containing per- and polyfluoalklyl substances (PFAS) in accordance with the *Interim Per- and Polyfluoralkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update* (guidance). This SOP should be used in conjunction with an Environmental and/or Waste Management Plan (EMP and/or WMP) approved by your Environmental Manager (EM). If you do not have a site-specific EMP, please contact your EM.

Standard procedures for managing liquid waste during PFAS investigation are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000.

Currently, PFAS are not regulated as a hazardous waste in US EPA regulations (state and territory rules may vary). Treatment of liquid waste containing PFAS, as recommended by the guidance, is a client directed action. When and how it is implemented will be left to the discretion of the individual RPMs. These project specific actions will be communicated with the Project Manager (PM) and/or Activity Manager (AM).

II. Procedures and Guidelines

The following flowchart outlines the procedures required to manage liquid waste during PFAS investigations. Any deviations from this procedure must be approved by the EM.


Are you analyzing groundwater samples for PFAS as directed by the RPM?
No
Containerize, sample, and dispose of waste per your WMP.
Yes
Will your RPM be following the guidance with respect to waste management?
No
Containerize, sample, and dispose of waste per your WMP.
Yes
Will you collect samples from existing wells?
No
Containerize waste and document in the field notes and on the transportation and disposal (T&D) log where purge water from each sample location is containerized. This is critical to successfully tracking and characterizing the waste.
Yes
Prior to going into the field, send the most recent analytical data for each sample location to the EM for review.
During field work, separate and containerize purge water from sample locations as directed by the EM. Document in the field notes and on the T&D log where purge water from each sample location is containerized. This is critical to successfully tracking and characterizing the waste.
Sample the drummed purge water as directed by your EM and send analytical data from waste samples to your EM for review.
Is the combined PFOS and PFOA concentration greater than the lifetime health advisory level of 70 ppt in the liquid waste?
No
Proceed with disposal per your WMP.
Yes
Discuss with your RPM what method of treatment they would like to use. (Currently, the treatment methods approved by Navy Headquarters are solidification and landfill, incineration, and GAC treatment)
Send all analytical data from each sample location and waste containers to your EM for waste classification. (Background information may also be needed)
Once waste has been characterized, proceed with disposal based on treatment method preferred by RPM.

Non-drinking Water Effluent Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose and Scope

This SOP provides guidelines for non-drinking water effluent sample collection for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Materials and Equipment

Equipment and Materials Required

- Sample containers (high density polyethylene [HDPE] with HDPE screw cap (no Teflon caps)
- PFAS-free labels (if available[1]) and shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard
- Pen (not Sharpie)
- Nitrile or Latex gloves (Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine)
- Meters for specific conductance, temperature, pH, and dissolved oxygen

Equipment and materials used to collect non-drinking water effluent samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton). Check with your PFAS subject matter expert (SME) during field preparation to ensure all equipment is free of fluorine-containing components.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect effluent samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

[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.

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guardpowder free nitrile gloves which were shown in research to contain fluorine.

Before effluent 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). Once the area has been determined to be free of materials potentially containing PFAS, follow the methods for effluent sample collection described below.

Effluent samples are collected manually by opening the effluent sampling port and allowing effluent to fill sample containers. An intermediary PFAS-free container may be used to allow for product and/or sediment settling prior to sample collection. Affix labels after bottles have been closed.

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.

Direct-Push Groundwater Sample Collection for Per- and Polyfluoroalkyl Substances

I. Purpose and Scope

This SOP provides guidelines for groundwater sample collection using direct-push (e.g., Geoprobe®) for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15.

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- Direct-push (e.g., Geoprobe®) sampling rods and retractable stainless-steel screen without PFAS-containing components (Avoid Teflon, Viton, PTFE and all other fluorinated compounds)
- PFAS-free tubing (avoid Teflon, Viton, PTFE and other fluorinated compounds) and stainless-steel foot valve
  - High density polyethylene tubing (unlined)
  - Masterflex tubing for peristaltic pumps, Cole Parmer C-Flex (06424 series) and Tygon E-3603 (06509 series) are suitable options
- Peristaltic pump
- Pre-cleaned sample containers
- Air monitoring and water quality instruments (as needed)
- Personal protective equipment
- Groundwater sample containers (high density polyethylene [HDPE] with HDPE screw cap [no Teflon caps])
- PFAS-free shipping labels (if available[1]) materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard
- Pen (not Sharpie)
- Nitrile or Latex gloves
- Laboratory prepared deionized, certified PFAS-free water for field blank collection

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.

[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect groundwater samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine.

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

1. Decontaminate slotted lead rod and other downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment* and this SOP.
2. Drive lead probe rod to the desired sampling depth, and withdraw rods 2 to 3 feet to expose the retractable screen to the aquifer formation. Ensure that the screened lead rod has been inserted to the desired sampling depth.
3. Insert the stainless-steel foot valve into the end of the polyethylene sampling tubing and insert tubing through the rods or insert peristaltic pump tubing through rods, depending on which method is used.
4. Purge groundwater and monitor water quality parameters until stable prior to sampling.
5. Fill all sample containers. Samples should be collected in accordance with SOP *Groundwater Sampling when Analyzing for Per- and Polyfluoroalkyl Substances (PFAS)*. Affix labels after bottles have been closed; collect only one sample at a time to avoid mislabeling.

6. Remove polyethylene sampling tubing from the rods. Remove the foot valve and discard polyethylene tubing. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required. Verify that the borehole made during sampling activities has been properly backfilled.

Equipment Decontamination

Ensure that the direct-push operator thoroughly completes the decontamination process between sampling locations. Do not use water from the facility (e.g. fire hydrants) if there is a possibility that the water available is contaminated with PFAS.

Whenever possible, use disposable equipment when collecting groundwater samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

Use of Water Quality Equipment

Water quality meters typically do not contain PFAS. However, consistent with general sampling SOPs, disconnect the water quality meter prior to sampling.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

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

Installation of Vertical Staff Gauges and Measurement of Stream Stage

I. Purpose and Scope

This SOP describes the installation and operation of vertical staff gauges and measurement and recording of stream stage. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- USGS Style A Staff Gauge (https://rickly.com/usgs-style-a-staff-gage/)
- Board or stake large enough to fit the staff gauge
- Fence post or other apparatus to which the gauge board can be secured
- Slotted 2" OD PVC pipe with bottom cap (to house transducer)
- Screws, nails, bolts, cable ties, etc. necessary to fasten gauge board and transducer housing to gauge structure.
- Fence post driver (if using a fence post to secure the gauge board)
- Hand tools (hammer, wrench, screwdriver)
- Other special equipment may be needed depending on the method of securing the gauge
- Data-logging pressure transducer with pressure rating appropriate for the anticipated submergence depth range
- Rugged reader or device to connect to transducer.

Equipment and Materials to Avoid

Equipment and materials used to install the staff gauges should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with Scotch Guard 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 work area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers

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

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures

Gauge Installation

1. Determine the location for the gauge. Preferably the gauge should be mounted to a permanently placed structure such as a pier or beam sunk into bedrock. The gauge should be placed so that the top of the gauge is above the highwater mark, but below the height restrictions for the given distance from the Ault Field flight line. The gauge should be placed so that the water level can be read, and the transducer can be accessed safely from the bank. The gauge should be kept free of obstructions and be in an area readily accessible by personnel.

2. Fasten the USGS Style A Staff Gauge to the board or stake using screws as available.

3. Fasten the gauge to the selected structure. If a suitable structure is not available, a fence post may be driven into the stream bed. The fence post should be driven to a sufficient depth to as to provide sufficient stability for the staff gauge to remain vertical.

4. Fasten the PVC transducer housing to the gauge structure using available methods (screws, cable ties, etc). Set the housing so that the transducer can be completely submerged below the low water mark of the stream.

5. Follow the procedure in the Land Surveying SOP (NAVFAC Northwest, 2014) to obtain a reference elevation of one of the gauge increments (i.e. the one-foot mark).

Transducer Deployment

1. Synchronize time recording devices to the computer that will be used to program the data-logging pressure transducer.

2. Deploy the transducer below the low water mark of the stream.

3. Secure transducer to the gauge structure such that the deployment depth does not shift.

4. Program the transducer to log transducer submergence at 30-minute intervals. A linear scale is generally sufficient for stream stage monitoring.

Manual Stage Gauge Readings

1. Identify and note the surface water height to the nearest 0.01-foot (interpolating between the 0.02-ft increments) on the USGS Style A Staff Gauge at the time of measurement.

2. Calculate the water surface elevation using the reference elevation of the surveyed mark.

IV. Key Checks

- Ensure all materials and tools have been decontaminated and inspected before use.
- Transducers and data loggers must be calibrated and tested.
- Verify that transducers have sufficient memory and battery capacity to store the anticipated measurements

References

Department of the Navy (Navy), 2017. *Interim Per- and Polyfluoralkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update*. 28 September.

Naval Facilities Engineering Command Northwest. 2014. *SOP I-G-1 Land Surveying*. August.

Appendix C
Department of Defense Environmental Laboratory Accreditation Program Accreditation Letters

PERRY JOHNSON LABORATORY ACCREDITATION, INC.

Certificate of Accreditation

Perry Johnson Laboratory Accreditation, Inc. has assessed the Laboratory of:

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061

(Hereinafter called the Organization) and hereby declares that Organization has met the requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the DoD Quality Systems Manual for Environmental Laboratories Version 5.1.1 February 2018 and is accredited is accordance with the:

United States Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP)

This accreditation demonstrates technical competence for the defined scope:

Environmental Testing

(As detailed in the supplement)

Accreditation claims for such testing and/or calibration services shall only be made from addresses referenced within this certificate. This Accreditation is granted subject to the system rules governing the Accreditation referred to above, and the Organization hereby covenants with the Accreditation body's duty to observe and comply with the said rules.

For PJLA:

Initial Accreditation Date:	*Issue Date:*	*Expiration Date:*
November 17, 2016	December 20, 2018	February 28, 2021

Accreditation No.:	*Certificate No.:*
91667	L18-588

Tracy Szerszen
President/Operations Manager

Perry Johnson Laboratory
Accreditation, Inc. (PJLA)
755 W. Big Beaver, Suite 1325
Troy, Michigan 48084

The validity of this certificate is maintained through ongoing assessments based on a continuous accreditation cycle. The validity of this certificate should be confirmed through the PJLA website: www.pjlabs.com

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061

Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-n-hexanoic acid (PFHxA)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-n-heptanoic Acid (PFHpA)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-n-octanoic Acid (PFOA)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluorononanoic acid (PFNA)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-n-decanoic Acid (PFDA)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-n-undecanoic acid (PFUnA)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-n-dodecanoic acid (PFDoA)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-n-tridecanoic acid (PFTrDA)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-n-tetradecanoic acid (PFTeDA)
Drinking Water	EPA 537.1.1	LC/MS/MS	N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)
Drinking Water	EPA 537.1.1	LC/MS/MS	N-ethylperfluoro-octanesulfonamidoacetic acid (NEtFOSAA)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-1-butanesulfonic Acid (PFBS)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-1-hexanesulfonic Acid (PFHxS)
Drinking Water	EPA 537.1.1	LC/MS/MS	Perfluoro-1-octanesulphonic Acid (PFOS)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-octanesulfonamide (PFOSA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Sodium perfluoro-1-pentanesulfonate (PFPeS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-nonanesulfonate (PFNS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-heptanesulfonate (PFHpS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	N-ethylperfluoro-octanesulfonamidoacetic acid (NEtFOSAA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorohexane sulfonate (4:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorooctane sulfonate (6:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorodecane sulfonate (8:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-butanoic Acid (PFBA)

Certificate of Accreditation: Supplement

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Battelle

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Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-pentanoic acid (PFPeA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-hexanoic acid (PFHxA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-heptanoic Acid (PFHpA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-octanoic Acid (PFOA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorononanoic acid (PFNA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-decanoic Acid (PFDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-undecanoic acid (PFUnA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-dodecanoic acid (PFDoA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-tridecanoic acid (PFTrDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-tetradecanoic acid (PFTeDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-butanesulfonic Acid (PFBS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-hexanesulfonic Acid (PFHxS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-octanesulphonic Acid (PFOS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-decanesulfonate (PFDS)

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,3',4,5-Hexachlorobiphenyl (BZ 129)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',6,6'-Heptachlorobiphen yl (BZ 184)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,5'-Tetrachlorobiphenyl (BZ 49)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',5-Trichlorobiphenyl (BZ 18)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3,3',4,4'-Pentachlorobiphenyl (BZ 105)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3',4,4',5-Pentachlorobiphenyl (BZ 118)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4,4'-Trichlorobiphenyl (BZ 28)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDD
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDE
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDT
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-Dichlorobiphenyl (BZ 8)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4',5,5'-Hexachlorobiphenyl (BZ 169)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4',5-Pentachlorobiphenyl (BZ 126)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4'-Tetrachlorobiphenyl (BZ 77)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDD
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDE
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDT
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Aldrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	alpha-BHC (alpha-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	alpha-Chlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	beta-BHC (beta-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Chlorpyrifos
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	cis-Nonachlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Decachlorobiphenyl (BZ 209)

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ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	delta-BHC
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Dieldrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan II
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan I
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan sulfate
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin aldehyde
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin ketone
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	gamma-Chlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Heptachlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Heptachlor epoxide
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Hexachlorobenzene
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Methoxychlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Mirex
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Oxychlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	trans-Nonachlor
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	1,4-Dichlorobenzene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	1-Methylnaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	1-Methylphenanthrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (BZ 206)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5,5'-Octachlorobiphenyl (BZ 194)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl (BZ 207)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5,6-Octachlorobiphenyl (BZ 195)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5-Heptachlorobiphenyl (BZ 170)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',6,6'-Octachlorobiphenyl (BZ 197)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',6-Heptachlorobiphenyl (BZ 171)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (BZ 208)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,5',6-Octachlorobiphenyl (BZ 198)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,5',6'-Octachlorobiphenyl (BZ 199)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,5'-Heptachlorobiphenyl (BZ 172)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,6,6'-Octachlorobiphenyl (BZ 200)

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5',6,6'-Octachlorobiphenyl (BZ 201)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,6-Heptachlorobiphenyl (BZ 173)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,6'-Heptachlorobiphenyl (BZ 174)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5',6-Heptachlorobiphenyl (BZ 175)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5',6'-Heptachlorobiphenyl (BZ 177)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5'-Hexachlorobiphenyl (BZ 130)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,6,6'-Heptachlorobiphenyl (BZ 176)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,6-Hexachlorobiphenyl (BZ 131)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4-Pentachlorobiphenyl (BZ 82)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,5',6,6'-Octachlorobiphenyl (BZ 202)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,5',6-Heptachlorobiphenyl (BZ 178)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,6,6'-Heptachlorobiphenyl (BZ 179)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,6-Hexachlorobiphenyl (BZ 134)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,6'-Hexachlorobiphenyl (BZ 135)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5-Pentachlorobiphenyl (BZ 83)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',6,6'-Hexachlorobiphenyl (BZ 136)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',6-Pentachlorobiphenyl (BZ 84)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3'-Tetrachlorobiphenyl (BZ 40)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5,5',6-Octachlorobiphenyl (BZ 203)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5-Hexachlorobiphenyl (BZ 137)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',6,6'-Heptachlorobiphenyl (BZ 184)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',6-Hexachlorobiphenyl (BZ 139)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',6'-Hexachlorobiphenyl (BZ 140)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4'-Pentachlorobiphenyl (BZ 85)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,5,5',6-Heptachlorobiphenyl (BZ 185)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,5,5'-Hexachlorobiphenyl (BZ 141)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5,5'-Hexachlorobiphenyl (BZ 146)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5,6,6'-Heptachlorobiphenyl (BZ 188)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5',6-Hexachlorobiphenyl (BZ 149)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,5',6-Hexachlorobiphenyl (BZ 144)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5'-Pentachlorobiphenyl (BZ 97)

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Battelle

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',6-Pentachlorobiphenyl (BZ 91)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4-Tetrachlorobiphenyl (BZ 41)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4'-Tetrachlorobiphenyl (BZ 42)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5,5',6-Hexachlorobiphenyl (BZ 151)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5,5'-Pentachlorobiphenyl (BZ 92)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5',6-Pentachlorobiphenyl (BZ 95)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5-Tetrachlorobiphenyl (BZ 43)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,6'-Tetrachlorobiphenyl (BZ 46)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,6-Tetrachlorobiphenyl (BZ 45)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3-Trichlorobiphenyl (BZ 16)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',5,6'-Hexachlorobiphenyl (BZ 154)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',5-Pentachlorobiphenyl (BZ 99)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',6,6'-Hexachlorobiphenyl (BZ 155)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',6-Pentachlorobiphenyl (BZ 100)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4'-Tetrachlorobiphenyl (BZ 47)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,5-Tetrachlorobiphenyl (BZ 48)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,5'-Tetrachlorobiphenyl (BZ 49)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,6,6'-Pentachlorobiphenyl (BZ 104)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,6'-Tetrachlorobiphenyl (BZ 51)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,6-Tetrachlorobiphenyl (BZ 50)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4-Trichlorobiphenyl (BZ 17)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',5,6'-Tetrachlorobiphenyl (BZ 53)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',5-Trichlorobiphenyl (BZ 18)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',6,6'-Tetrachlorobiphenyl (BZ 54)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',6-Trichlorobiphenyl (BZ 19)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2'-Dichlorobiphenyl (BZ 4)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5,5',6-Octachlorobiphenyl (BZ 205)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5,5'-Heptachlorobiphenyl (BZ 189)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5,6-Heptachlorobiphenyl (BZ 190)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5',6-Heptachlorobiphenyl (BZ 191)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5-Hexachlorobiphenyl (BZ 156)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5'-Hexachlorobiphenyl (BZ 157)

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Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',6-Hexachlorobiphenyl (BZ 158)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4'-Pentachlorobiphenyl (BZ 105)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4',5,5',6-Heptachlorobiphenyl (BZ 193)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4',5,6-Hexachlorobiphenyl (BZ 163)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4',5',6-Hexachlorobiphenyl (BZ 164)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4'-Tetrachlorobiphenyl (BZ 56)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,4',5,5'-Hexachlorobiphenyl (BZ 167)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4,4',5,6-Hexachlorobiphenyl (BZ 166)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4,4',5-Pentachlorobiphenyl (BZ 114)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,4',5-Pentachlorobiphenyl (BZ 118)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,4',5'-Pentachlorobiphenyl (BZ 123)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4,4',6-Pentachlorobiphenyl (BZ 115)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4,4'-Tetrachlorobiphenyl (BZ 60)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4',5,5'-Pentachlorobiphenyl (BZ 124)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4',5',6-Pentachlorobiphenyl (BZ 125)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4',5-Tetrachlorobiphenyl (BZ 63)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,5-Tetrachlorobiphenyl (BZ 67)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4',5-Tetrachlorobiphenyl (BZ 70)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4',6-Tetrachlorobiphenyl (BZ 64)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4',6-Tetrachlorobiphenyl (BZ 71)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4'-Trichlorobiphenyl (BZ 22)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4-Trichlorobiphenyl (BZ 25)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4'-Trichlorobiphenyl (BZ 33)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',5-Trichlorobiphenyl (BZ 26)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,5-Trimethylnaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,6-Trichlorobiphenyl (BZ 24)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',6-Trichlorobiphenyl (BZ 27)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3-Dichlorobiphenyl (BZ 5)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3'-Dichlorobiphenyl (BZ 6)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,4',5-Tetrachlorobiphenyl (BZ 74)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,4',6-Tetrachlorobiphenyl (BZ 75)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,4'-Trichlorobiphenyl (BZ 28)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,5-Trichlorobiphenyl (BZ 29)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4',5-Trichlorobiphenyl (BZ 31)

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,6-Trichlorobiphenyl (BZ 30)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4',6-Trichlorobiphenyl (BZ 32)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4'-DDD
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4'-DDE
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4'-DDT
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4-Dichlorobiphenyl (BZ 7)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4'-Dichlorobiphenyl (BZ 8)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,5-Dichlorobiphenyl (BZ 9)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,6-Dimethylnaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2-Chlorobiphenyl (BZ 1)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2-Chloronaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2-Methylnaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2-Methylphenanthrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',4,4',5,5'-Hexachlorobiphenyl (BZ 169)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',4,4',5-Pentachlorobiphenyl (BZ 126)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',4,4'-Tetrachlorobiphenyl (BZ 77)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',4,5,5'-Pentachlorobiphenyl (BZ 127)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',5,5'-Tetrachlorobiphenyl (BZ 80)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3'-Dichlorobiphenyl (BZ 11)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,4,4',5-Tetrachlorobiphenyl (BZ 81)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,4,4'-Trichlorobiphenyl (BZ 37)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,4-Dichlorobiphenyl (BZ 12)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,4'-Dichlorobiphenyl (BZ 13)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,6-Dimethylphenanthrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	4,4'-Dichlorobiphenyl (BZ 15)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	4-Chlorobiphenyl (BZ 3)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Acenaphthene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Acenaphthylene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Anthracene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(a)anthracene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(a)pyrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(b)fluoranthene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(b)thiophene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(e)pyrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(g,h,i)perylene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(k)fluoranthene

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Biphenyl
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Chrysene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	cis-Decalin
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Decachlorobiphenyl (BZ 209)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Dibenz(a,h)anthracene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Dibenzofuran
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Dibenzothiophene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Fluoranthene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Fluorene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	lndeno(l,2,3-cd)pyrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Naphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Perylene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Phenanthrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Pyrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	trans-Decalin

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Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 3510 C	Separatory Funnel	Prep
Aqueous	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Aqueous	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Solid	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Solid	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Solid	NOAA NOS ORCA 71	Orbital Shaker	Prep
Tissue	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Tissue	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Tissue	NOAA NOS ORCA 71	Tissuemizer	Prep

Appendix D
Laboratory Standard Operating Procedures

Sampling and Analysis Plan
Phase 2 Site Inspection Ault Field
Naval Air Station Whidbey Island
Oak Harbor, Washington

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

FOIA Exemption 4 (5 USC 552(b)(4))
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