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NRL CHESAPEAKE BEACH, MD
SSIC 5000-33a

FINAL SAMPLING AND ANALYSIS PLAN SITE 10 FIRE TESTING AREA SITE INSPECTION CHESAPEAKE BAY DETACHMENT NRL CHESAPEAKE BEACH MD

08/01/2020

CH2M HILL

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Naval Facilities Engineering Command Washington
Washington, DC

Final

Sampling and Analysis Plan
Site 10 Fire Testing Area Site Inspection

Naval Research Laboratory – Chesapeake Bay Detachment
Chesapeake Beach, Maryland

August 2020

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SAP Worksheet #1—Title and Approval Page

Naval Facilities Engineering Command Washington
Washington, DC

Final

Sampling and Analysis Plan
Site 10 Fire Testing Area Site Inspection

Naval Research Laboratory – Chesapeake Bay Detachment
Chesapeake Beach, Maryland

August 2020

Prepared for NAVFAC Washington
by CH2M HILL, Inc.
Herndon, Virginia
Contract N62470-16-D-9000
Contract Task Order 4532

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Signature Page

Quality Assurance Approval:

*

Naval Facilities Engineering Command Quality Assurance Officer/Date

Quality Assurance Review:

Jeff Woodward
CH2M Activity Quality Manager/Date

Other Approval Signatures:

Ryan Mayer
Naval Facilities Engineering Command Washington Remedial Project Manager/Date

Peggy Williams
Maryland Department of the Environment Remedial Project Manager/Date

*Pre-draft digitally signed by Naval Facilities Engineering Command Quality Assurance Officer on 3/18/20

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Executive Summary

This Uniform Federal Policy (UFP) Sampling and Analysis Plan (SAP) outlines the sampling activities in support of a Site Inspection (SI) for per- and polyfluoroalkyl substances (PFAS) at Site 10 - Fire Testing Area (FTA) at the Naval Research Laboratory – Chesapeake Bay Detachment (NRL-CBD) in Chesapeake Beach, Maryland. CH2M HILL, Inc. (CH2M) prepared this document under the U.S. Department of the Navy (Navy), Naval Facilities Engineering Command, Comprehensive Long-term Environmental Action—Navy Contract N62470-16-D-9000, Contract Task Order 4532, in accordance with the Navy's SAP policy guidance to help ensure that environmental data collected are scientifically sound, of known and documented quality, and suitable for intended purposes. The objectives and technical approach included in this SAP were jointly scoped by the NRL-CBD Partnering Team, which includes representatives from the Navy and the Maryland Department of the Environment.

NRL-CBD is approximately 40 miles from Washington, DC, and occupies approximately 160 acres along the western shoreline of the Chesapeake Bay in Maryland. Established in the early 1940s, the mission of NRL-CBD is to provide and maintain facilities for use by the research divisions of the NRL in Washington, DC for the testing, development, and evaluation of radar, radio, optical, and fire control equipment, among other research projects.

Site 10 – FTA, previously known as Area of Concern A, encompasses 3.408 acres and is located the center of NRL-CBD. Fire suppressant testing has been conducted at the site since 1968, resulting in the release of aqueous film-forming foam, which contains PFAS, to the environment (CH2M, 2009). Because of the use of aqueous film-forming foam at Site 10, a groundwater investigation was conducted in 2017 that determined Site 10 was the source of PFAS contamination in shallow groundwater (CH2M, 2018a). The highest concentrations of PFAS were observed in the monitoring wells closest to Site 10, with concentrations in groundwater decreasing with distance from the site. The investigation found that the surficial aquifer was isolated from the underlying Piney Point aquifer by the clay confining unit (Calvert confining unit) present beneath the site. The results of the investigation determined that additional sampling of on-Base groundwater was warranted (CH2M, 2018a).

In 2018, off-Base drinking water samples were collected from 42 private wells north and south of NRL-CBD and analyzed for 14 PFAS. PFAS were detected in three of the private drinking water supply wells; detections of perfluorooctanoic acid and perfluorooctanesulfonic acid were below the lifetime health advisory. As such, no further action was warranted for the off-Base drinking water wells (CH2M, 2019). Additionally, kerosene, gasoline, and jet propulsion fuels continue to be burned on the site during fire testing activities, potentially leading to total petroleum hydrocarbon (TPH) contamination in shallow groundwater. TPH was previously detected in four on-Base shallow groundwater samples in 2009, and while the extent of TPH contamination at the source area was not delineated, no further assessment was recommended since the ratios of the maximum detected concentrations to risk-based concentrations (hazard index of 0.9) did not exceed risk-based concentrations based on a hazard quotient of 1.0 (CH2M, 2009). Additional sampling is necessary to further characterize the nature of TPH contamination. As a result, an SI is warranted.

The objectives of this SI are to:

- Determine whether PFAS are present in soil, surface water, and/or sediment, and if present, determine whether concentrations exceed the project action limits (PALs) for soil, surface water, and/or sediment
- Further refine the lateral and vertical extents of PFAS in groundwater in the surficial aquifer on-Base and determine whether current concentrations of PFAS exceed the PALs for groundwater

- Determine the current concentrations of PFAS in the Piney Point aquifer[1], and if present, whether current concentrations exceed the PALs
- Determine the potential for PFAS in groundwater, and if present in surface water, to migrate off-Base
- Further characterize the nature of TPH contamination from kerosene, gasoline, and jet propulsion fuel burning in the shallow groundwater at the site

Activities to be completed to accomplish the objectives of the SI include:

- Collecting co-located surface and subsurface soil samples
- Installing shallow monitoring wells on the Base
- Completing a groundwater level survey of the new and existing monitoring wells on the Base
- Collecting groundwater samples from the new and existing monitoring wells installed on the Base
- Installing stream gauges in drainage areas downgradient of the site
- Collecting surface water samples and sediment samples from drainage areas downgradient of the site

Groundwater, surface water, and sediment samples will be collected and analyzed for the 18 PFAS listed in Method 537.1 via liquid chromatography tandem mass spectrometry compliant with Quality Systems Manual, Version 5.1.1, Table B-15. Seven groundwater samples also will be analyzed for TPH (gasoline range organics and diesel range organics).

This SAP consists of the 37 worksheets specific to the Navy's SAP guidance (Navy, 2018). The figures are included following the worksheets. The December 2018 Site 10 SI SAP scoping session presentation is included in **Appendix A**, and ecological screening values are in **Appendix B.** The field standard operating procedures for this work are included in **Appendix C,** and the laboratory Department of Defense Environmental Laboratory Accreditation Program documentation is included in **Appendix D**.

The laboratory information cited in this SAP is specific to Battelle Memorial Institute in Norwell, Massachusetts and AEL in Jacksonville, Florida. If additional laboratory services are requested requiring modification to the existing SAP, revised SAP worksheets will be submitted to the Navy and regulatory agencies for approval.

[1] When the original on-site PFAS evaluation was conducted in 2017, only three PFAS analytes were included in the analysis. Since then, the Navy has updated its guidance and the current analyte list now includes 18 PFAS analytes.

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B Ecological Screening Values
C Field Standard Operating Procedures
D Laboratory DoD ELAP Accreditation Letters

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

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2 Fire Testing Area Site Location and Layout Map
3 2017 PFBS, PFOA, and PFAS Analytical Results and Proposed Monitoring Well Locations
4 One-mile Off-Base Boundary
5 Off-Base Drinking Water Sampling Results through November 2018
6 Proposed Soil Sample Locations
7 Proposed Staff Gauge, Surface Water, and Sediment Sample Locations

Abbreviations and Acronyms

°C	degrees Celsius
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
11Cl-PF3OUdS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid
9Cl-PF3ONS	9-chlorohexadecafluoro-3-oxanone-1-sulfonic
ADONA	4,8-dioxa-3H-perfluorononanoic acid
AFFF	aqueous film forming foam
AM	Activity Manager
amu	atomic mass unit
AQM	Activity Quality Manager
Battelle	Battelle Memorial Institute
bgs	below ground surface
CA	corrective action
CAS	Chemical Abstracts Service
CCV	continuing calibration verification
CH2M	CH2M HILL, Inc.
CLEAN	Comprehensive Long-term Environmental Action—Navy
COPC	contaminant of potential concern
CSM	conceptual site model
DL	detection limit
DO	dissolved oxygen
DoD	Department of Defense
DPT	direct-push technology
DQI	data quality indicator
DRO	diesel range organics
DV	data validator
EB	equipment blank
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
ESV	ecological screening value
FD	field duplicate
FID	flame ionization detector
FTA	Fire Testing Area
FTL	field team leader
GC	gas chromatograph
GRO	gasoline range organics
GW	groundwater
H&S	health and safety
HDPE	high-density polyethylene
HFPO-DA	hexafluoropropylene oxide dimer acid
HQ	hazard quotient

HSM	health and safety manager
ICAL	initial calibration
ICV	initial calibration verification
ID	identification
IDW	investigation-derived waste
IS	internal standard
ISC	instrument sensitivity check
JP	jet propulsion fuel
LC-MS/MS	liquid chromatography and tandem mass spectrometry
LCS	laboratory control sample
LIMS	Laboratory Information Management System
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MDE	Maryland Department of the Environment
mL	milliliter(s)
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NEtFOSAA	n-ethylperfluoroctansulfonamid
ng/L	nanogram(s) per liter
NIRIS	Naval Installation Restoration Information System
NMeFOSAA	n-methyl perfluorooctanesulfonamidoacetic acid
NRL-CBD	Naval Research Laboratory – Chesapeake Bay Detachment
NTR	Navy Technical Representative
ORP	oxidation-reduction potential
PAL	project action limit
PC	project chemist
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFDA	perfluorodecanoic acid
PFDoA	perfluorododecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFTA or PFTeDA	perfluorotetradecanoic acid
PFTrDA	perfluorotridecanoic acid
PFUnA	perfluoroundecanoic acid
PID	photoionization detector

PJLA	Perry Johnson Laboratory Accreditation, Inc.
PKP	potassium bicarbonate
PM	project manager
POC	point of contact
ppm	parts per million
PQL	project quantitation limit
PQO	project quality objective
PVC	polyvinyl chloride
QA	quality assurance
QAO	quality assurance officer
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
QSM	Quality Systems Manual
RI	Remedial Investigation
RPD	relative percent difference
RPM	remedial project manager
RSD	relative standard deviation
RSL	regional screening level
RT	retention time
SAP	Sampling and Analysis Plan
SB	soil boring
SBO	safe behavior observation
SD	sediment
SI	Site Investigation
SME	subject matter expert
SOP	standard operating procedure
SPE	solid phase extraction
SS	surface soil
SSC	site safety coordinator
STC	senior technical consultant
SVOC	semivolatile organic compound
SW	surface water
TBD	to be determined
TPH	total petroleum hydrocarbons
USEPA	U.S. Environmental Protection Agency
VOA	volatile organic analysis
VOC	volatile organic compound

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SAP Worksheet #2—SAP Identifying Information

Site Name/Number:	Site 10 – Fire Testing Area (FTA), Navy Research Laboratory – Chesapeake Bay Detachment (NRL-CBD), Chesapeake Beach, Maryland
Operable Unit:	Not applicable (NA)
Contractor Name:	CH2M HILL, Inc. (CH2M)
Contract Number:	N62470-16-D-9000
Contract Title:	Comprehensive Long-term Environmental Action—Navy (CLEAN) 9000
Work Assignment Number (optional):	Contract Task Order 4532

1. This Sampling and Analysis Plan (SAP) was prepared in accordance with the following guidance documents:
   - *Guidance for Quality Assurance Project Plans* (U.S. Environmental Protection Agency [USEPA], 2002)
   - *Uniform Federal Policy for Quality Assurance Plans* (USEPA, 2005)
   - *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)
   - *Interim Per-and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)* (Navy, 2017)
   - *Environmental Restoration Program Manual* (Navy, 2018)
2. Identify regulatory program:
   - Comprehensive Environmental Response Compensation, and Liability Act of 1980
3. This document is a project-specific SAP.
4. List dates if scoping sessions held:
   - December 6, 2018
5. List organizational partners (stakeholders) and connection with lead organization:

Organization Partners/Stakeholders	Connection
Naval Facilities Engineering Command (NAVFAC), Washington	Lead Organization
Maryland Department of the Environment (MDE)	State Regulatory Agency

6. If any required SAP elements or 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 below:
   - All required information is included in this SAP; therefore, the crosswalk table is not necessary for this project.

SAP Worksheet #2—SAP Identifying Information (continued)

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

- *Sampling and Analysis Plan, Site Inspection for Perfluorinated Compounds in Groundwater, Naval Research Laboratory, Chesapeake Bay Detachment, Chesapeake Beach, Maryland* (CH2M, 2017)
- *Final Sampling and Analysis Plan, Base-wide Expanded Site Inspection, Naval Research Laboratory – Chesapeake Bay Detachment, Chesapeake Beach, Maryland* (CH2M, 2018b)
- *Final Addendum, Sampling and Analysis Plan, Site Inspection for Per- and Polyfluoroalkyl Substances in Groundwater, Naval Research Laboratory-Chesapeake Bay Detachment, Chesapeake Beach, Maryland* (CH2M, 2018c).

SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number	E-mail Address or Mailing Address
Ryan Mayer	Navy RPM	NAVFAC Washington	(202) 685-8455	ryan.mayer@navy.mil
Peggy Williams	MDE RPM	MDE	(410) 537-3493	peggy.williams@maryland.gov
Andrew Bogdanski	Activity Manager (AM)	CH2M	(703) 376-5038	andrew.bogdanski@ch2m.com
Laura Lampshire	Project Manager (PM)	CH2M	(301) 580-0027	laura.lampshire@ch2m.com
Jeff Woodward	Activity Quality Manager (AQM)/Senior Technical Consultant (STC)	CH2M	(703) 376-5293	jeff.woodward@ch2m.com
Katie Tippin	CLEAN Program SAP Reviewer/PFAS Subject Matter Expert (SME)	CH2M	(757) 671-6258	katie.tippin@ch2m.com
Anita Dodson	CLEAN Program Chemist/SAP Reviewer	CH2M	(757) 671-6218	anita.dodson@ch2m.com
Roni Warren	Human Health Risk Assessor	CH2M	(814) 364-2454	roni.warren@ch2m.com
Kelly Teplitsky	Ecological Risk Assessor	CH2M	(720) 935-3395	kelly.teplitsky@ch2m.com
Michael Zamboni	Project Chemist (PC)	CH2M	(703) 376-5301	michael.zamboni@ch2m.com
Carl Woods	Health and Safety Manager (HSM)	CH2M	(513) 889-5771	carl.woods@ch2m.com
To be determined (TBD)	Field Team Leader (FTL)/ Site Safety Coordinator (SSC)	CH2M	TBD	TBD
TBD	Field Team Member(s)	CH2M	TBD	TBD
Jonathan Thorn	Laboratory PM	Battelle Memorial Institute (Battelle)	(781) 681-5565	thorn@battelle.org
Craig Myers	Laboratory PM	AEL	(904) 363-9350	cmyers@aellab.com
TBD	Data Validator (DV)	TBD	TBD	TBD

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SAP Worksheet #4—Project Personnel Sign-Off Sheet

Each organization will read the SAP and provide an original copy of the sign-off sheet to the PM for maintenance in the CH2M project file.

Name	Organization/Title/Role	Telephone Number	Signature/E-mail receipt	SAP Section Reviewed	Date SAP Read
Andrew Bogdanski	CH2M/AM	(703) 376-5038			
Laura Lampshire	CH2M/PM	(301) 570-1042			
Jeff Woodward	CH2M/STC and AQM	(703) 376-5293			
Laura Cook	CH2M/STC	(757) 671-6214			
Katie Tippin	CH2M/SAP Reviewer/PFAS SME	(757) 671-6258			
Anita Dodson	CH2M/Navy Program Chemist	(757) 671-6218			
Michael Zamboni	CH2M/PC	(703) 376-5301			
Roni Warren	Human Health Risk Assessor	(814) 364-2454			
Kelly Teplitsky	Ecological Risk Assessor	(720) 935-3395			
TBD	FTL/Field Quality Manager	TBD			
TBD	Field Team Member/SSC	TBD			
TBD	Field Team member(s)	TBD			
Ryan Mayer	Navy RPM	(202) 685-8455			
Peggy Williams	MDE RPM	(410) 537-3493			
TBD	Navy Chemist/Quality Assurance Officer (QAO)	TBD			
Subcontractors					
Jonathan Thorn	Analytical Laboratory/Battelle	(781) 681-5565			
Craig Myers	Analytical Laboratory/AEL	(904) 363-9350			
TBD	DV	TBD			

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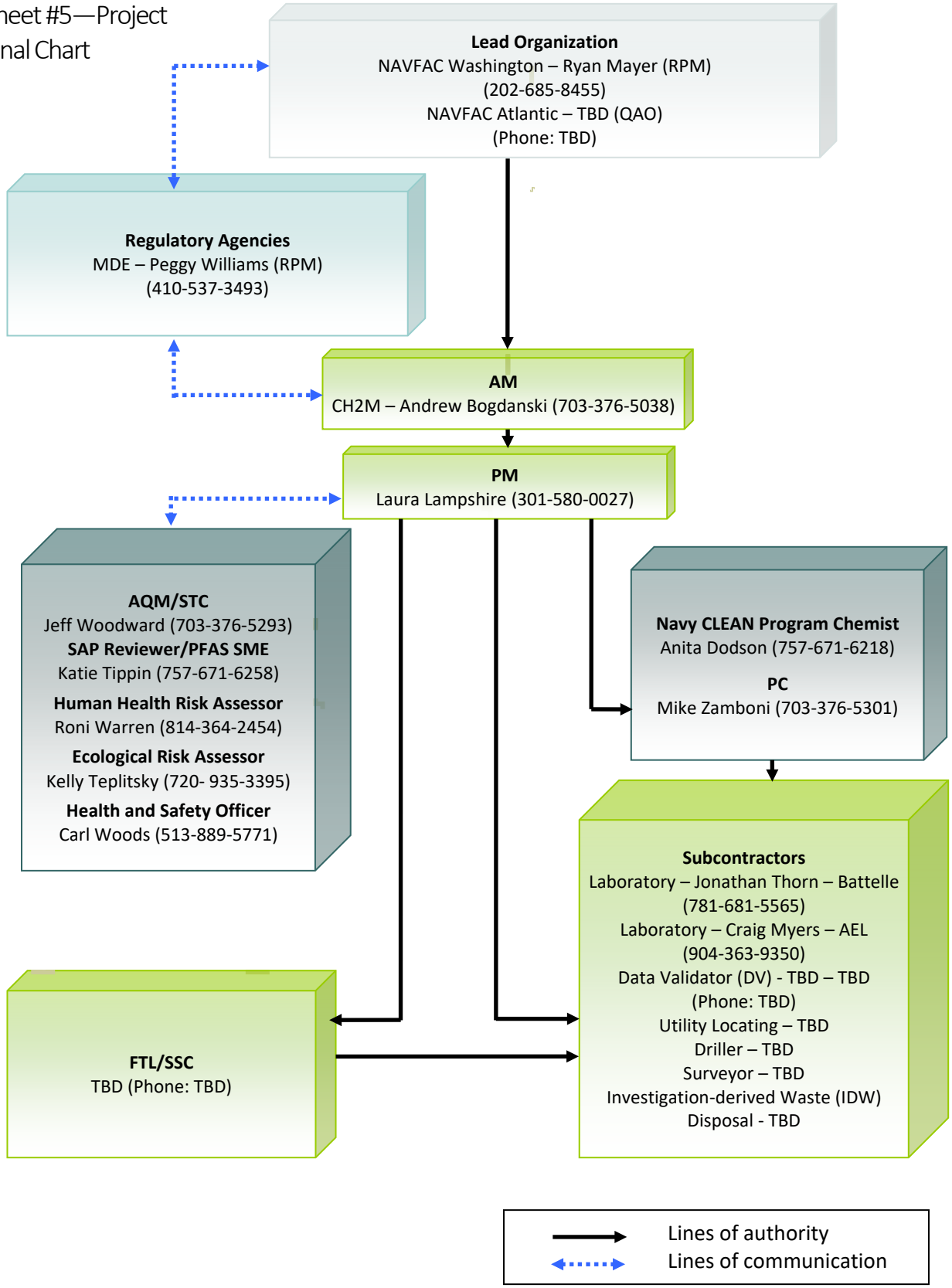
SAP Worksheet #5—Project Organizational Chart



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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number and/or E-mail	Procedure
Communication with the Navy (lead agency)	Navy Technical Representative (NTR)/RPM	Ryan Mayer	(202) 685-8455 ryan.mayer@navy.mil	Primary point of contact (POC) for Navy; can delegate communication to other internal or external POCs. Any issues that may impact project work are to be reported to the NTR/RPM immediately. The NTR/RPM will notify USEPA and MDE via email or telephone within 24 hours of field changes affecting the scope or implementation of the work. Navy will have 30 days for SAP review.
Communication with MDE	MDE RPM	Peggy Williams	(401) 537-3493 peggy.williams@maryland.gov	Primary POC for MDE; can delegate communication to other internal or external POCs. Upon notification of field changes, MDE will have 24 hours to approve or comment on the field changes. Responses will be communicated via email or phone.
Navy quality assurance (QA)/quality control (QC) input	Navy Chemist/QAO	TBD	TBD	Provides review comments to Navy contractor on pre-draft SAP via email through Navy RPM. Provides overall Navy guidance via direct communication with Navy contractor chemist, as warranted.
Communication regarding overall project status and implementation and primary POC with RPM, PM, and project team	CH2M AM	Andrew Bogdanski	(703) 376-5038 andrew.bogdanski@ch2m.com	Primary POC for stakeholder and agency managers; can delegate agency communication to other contract staff as appropriate. Oversees project and will be informed of project status by the PM. If field changes occur, the AM will work with the Navy NTR/RPM to communicate field changes to MDE via email within 24 hours.
Communications regarding project management and implementation	CH2M PM	Laura Lampshire	(301) 570-1042 laura.lampshire@ch2m.com	Primary modes of communication are phone, email, letter, document submittal; timing dependent on nature of communication and predefined schedule as applicable and as requested by stakeholder agencies. The PM will have 24 hours to respond to the request for field corrective actions (CAs). Responses will be communicated to the FTL via phone. All information and materials about the project will be forwarded to the AM daily.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Phone Number and/or E-mail	Procedure
Technical communications for project implementation, and data interpretation	CH2M AQM/STC CH2M PFAS SME	Jeff Woodward Katie Tippin	(703) 376-5293 jeff.woodward@ch2m.com (757) 671-6258 katie.tippin@ch2m.com	Team members will contact the STC and PFAS SME regarding questions and issues encountered in the field, input on data interpretation, and so forth, as needed. The STC and PFAS SME will have 24 hours to respond to technical field questions as necessary. Responses will be communicated to the PM via email or phone. In addition, the STC and PFAS SME will review data and deliverables as necessary before Partnering Team discussion or distribution.
Implementation of sampling activities; SAP changes in the field; field CAs; daily field progress reports	FTL	TBD	TBD	Documentation of deviations from Work Plan made in field logbooks and rationale for deviations, made within 24 hours of deviation; assistance in material procurement and delivery; injection oversight and implementation; deviations made only with approval from contractor PM and/or AM (**Worksheets #32** and **#32-1**). The FTL will email daily field progress reports to contractor PMs daily; telephone communication with PMs as needed.
Field progress reports	FTL	TBD	TBD	Email or fax daily field progress reports to contractor PMs weekly; telephone communication with PMs as needed.
Stop work because of safety issues	SSC	TBD	TBD	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 CH2M PM and AM immediately, along with the Navy RPM. Ultimately, the FTL, PM, and AM can stop work for a period of time. NAVFAC Washington can stop work at any time.
Health and safety (H&S) expectations and procedures	CH2M HSM	Carl Woods	(513) 319-5771 carl.woods@ch2m.com	Review of Accident Prevention Plan and H&S Plan. Direct communication (via email, telephone, hard copy, or in person, will be notified within 24 hours of incident) to/from Navy contractor project staff to ensure implementation of appropriate H&S procedures.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Phone Number and/or E-mail	Procedure
SAP/Work Plan changes in the field	FTL	TBD	TBD	Notify the PM by phone and email of changes to the SAP made in the field and the reasons within 24 hours. Documentation of deviations from the SAP will be kept in the field logbook; deviations made only with the approval of the PM. Approvals will be made via email or phone.
Communications regarding SAP changes	CH2M Program Chemist	Anita Dodson	(757) 671-6218	Changes to the project that would prompt a SAP that would prompt Navy QAO review and approval include adding analytes or an analytical suite not previously included in the SAP, adding an environmental matrix not previously included in the SAP, laboratory accreditation to a new Department of Defense (DoD) QSM version, including a new laboratory into the SAP, updates to the conceptual site model (CSM) that prompt new data quality objectives. Updated laboratory limit of quantitation (LOQ), limit of detection (LOD), and detection limit (DL) values will not prompt a SAP change or update for Navy QAO review and approval unless those changes negatively impact the ability to meet project action levels.
Field CAs	FTL	TBD	TBD	The need for CA for field or analytical issues will be determined by the FTL and/or senior risk assessors and STC. Senior support will ensure SAP requirements are met by the field staff. The FTL will notify the PM via phone of any need for CA within 4 hours.
Reporting laboratory data quality issues	Laboratory PM	Jonathan Thorn - Battelle	(781) 681-5565 thorn@battelle.org	All QA/QC issues with project field samples will be reported within 1 day to the PC by the laboratory. Should analytical laboratory issues affect data usability by rendering a significant amount of rejectable or unusable data, such that the project completeness goal cannot be obtained, the PC will notify the project team, including the Navy NTR/RPM and Navy QAO.
		Craig Myers - AEL	(904) 363-9350 cmyers@aellab.com	
Reporting data validation issues	DV	TBD	TBD	All completeness and data issues will be addressed with the laboratory. The DV should copy the CH2M PC on all communications to the laboratory. The validated data package will be due within 14 calendar days of data receipt by the DV.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Entity	Name	Phone Number and/or E-mail	Procedure
Data validation CAs	PC	Michael Zamboni	(703) 376-5301 michael.zamboni@ch2m.com	All issues discovered during data validation will be reported to the PC. CAs (revisions and additional information, if necessary) will be requested from the laboratory. The PC will review the data validation narrative and request CA from the DV if necessary.
Data tracking from field collection to database upload	PC	Michael Zamboni	(703) 376-5301 michael.zamboni@ch2m.com	The PC tracks the data and informs the PM and PC of potential problems or issues. The PM and AM are informed within 24 hours to pass on communications to the Navy and regulators as appropriate.

SAP Worksheet #7—Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Ryan Mayer	RPM	NAVFAC Washington	Oversees project, provides Base-specific information, and coordinates with the Base environmental manager.
Scott Lonesome	NRL-CBD Facility Contact	NRL-CBD	Coordinates environmental activities at NRL-CBD.
Peggy Williams	MDE RPM	MDE Land and Materials Administration, Land Restoration Program	Oversees project from a state regulatory agency standpoint.
TBD	QAO	NAVFAC Atlantic	Navy review of SAP and QA input.
Andrew Bogdanski	AM	CH2M	Coordinates with RPM, PM, and field team. Provides Base-specific information.
Jeff Woodward	AQM/STC	CH2M	Provides senior technical support for project approach and execution. Provides QA oversight.
Katie Tippin	PFAS SME/SAP Reviewer	CH2M	Provides technical support and senior technical oversight and provides program-level review of the SAP.
Laura Lampshire	PM	CH2M	Monitors project performance; directs and oversees project staff.
Kelly Teplitsky	Ecological Risk Assessor	CH2M	Conducts ecological risk assessment to identify possible impacts to ecological receptors.
Roni Warren	Human Health Risk Assessor	CH2M	Conducts human health risk assessment to identify possible impacts to human receptors.
Carl Woods	HSM	CH2M	Prepares the Health and Safety Plan and oversees H&S for the field activities.
Anita Dodson	Navy Program Chemist	CH2M	Provides SAP project delivery support, reviews and approves SAPs, and performs final data evaluation and QA oversight.
Michael Zamboni	PC	CH2M	Prepares chemistry-specific SAP worksheets. Responsible for coordination of laboratory deliverables. Manages sample tracking and data management; coordinates with laboratory and DV.
TBD	DV	TBD	Validate laboratory data from an analytical before data use.

SAP Worksheet #7—Personnel Responsibilities Table (continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
TBD	FTL	CH2M	Coordinates the field activities and sampling.
TBD	Field Staff	CH2M	Conducts field activities.
Jonathan Thorn	Laboratory PM	Battelle	Manages analytical projects from initiation to completion.
Craig Myers	Laboratory PM	AEL	Manages analytical projects from initiation to completion.

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
Not applicable						

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SAP Worksheet #9—Project Scoping Session Participants Sheet Summary

Project Name: Site 10 – FTA Site Inspection (SI) for PFAS **Projected Date(s) of Sampling:** Fall 2020 **PM:** Laura Lampshire	**Site Name:** Site 10 – FTA **Site Location:** NRL-CBD, Chesapeake Beach, Maryland
Date of Session: December 6, 2018 **Scoping Session Purpose:** Team discussion and agreement on the sample locations, analytic parameters, and objectives for the Site 10 SI	

Name	Project Role	Affiliation	Phone Number	Email Address
Ryan Mayer	RPM, NRL-CBD	NAVFAC Washington	(202) 685-8455	ryan.mayer@navy.mil
Peggy Williams	State RPM	MDE	(410) 537-3493	peggy.williams@maryland.gov
Andrew Bogdanski	AM	CH2M	(703) 376-5038	andrew.bogdanski@ch2m.com
Laura Lampshire	PM	CH2M	(301) 570-1042	laura.lampshire@ch2m.com

Overview of Discussion

During the December 2018 NRL-CBD Tier 1 Partnering Team meeting, the Team discussed the path forward for the FTA SI, including the objectives, sample media, number and locations of samples, and analytical parameters that needed to be included in the SI. The December 2018 Site 10 SI scoping session presentation is included in **Appendix A.**

The Team reviewed the FTA site boundary. It was proposed that the boundary be revised to include the test structure southeast of the FTA since it had been noted that this test structure was used in past fire testing operations. The Team agreed to expand the current boundary to incorporate the test structure.

Soil at the FTA was previously investigated for petroleum related constituents (VOCs and lead) between 1988 and 1989. During this timeframe MDE and NRL exchanged a series of correspondence that led to NRL installing four soil borings around the collection pit with analytical samples collected at 2, 4, 8, and 10 feet below ground surface and analyzed for VOCs and EP lead. The results of the analyses indicated that that other than 2-butanone, which was also detected in the blanks, none of the parameters tested were present in any of the soil samples. Based on the analytical results, MDE concluded that no evidence of soil or groundwater contamination was apparent at the site and no further assessment was warranted (MDE, 1989). As such, petroleum related analysis for soils were not carried forward in this SI.

For the proposed SI soil sampling, the Team agreed to collect one surface and one subsurface soil sample at each proposed sample location, and that the subsurface soil sample will be collected above the soil/groundwater interface and submitted for analysis of PFAS. The subsurface soil interval will be placed at the depth interval that shows signs of contamination (photoionization detector [PID] readings, soil staining, etc.); in the absence of observed contamination, the subsurface soil sample will be collected immediately above the water table.

The Team noted that if the subsurface soil samples were collected just above the water table, there is a possibility that the sample depth will be below the maximum depth interval (8 to 10 feet below ground surface [bgs]) typically used for human health risk evaluations. Therefore, the Team agreed to collect an additional subsurface soil sample at five locations: Building 314, the test structure in the southeastern corner of the site, the Fire 1 Test

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

Chamber, Building 313, and the Fire Test Pad (for a total of five additional subsurface soil samples). The five additional subsurface soil samples will be placed at boring locations leading to the interior of the site (toward the wastewater collection pit). The additional subsurface soil samples will be collected from the 8- to 10-foot bgs interval (average depth of building foundations). In total, 29[2] co-located surface and subsurface soil samples are proposed, with 5 of these locations to include a third subsurface soil sample to be collected at 8 to 10 feet bgs.

The Team preferred that samples be collected in grassy areas to avoid having to bore through concrete. (Note: Some of the co-located sample locations may need to be moved/revised based on field conditions).

The Team then discussed whether the two deep monitoring wells that were recommended as a result of the 2017 PFAS groundwater investigation (CH2M, 2018a) were necessary. In the time since the last round of on-Base sampling, the deep aquifer groundwater flow has been determined to flow northeast, and the results of the 2018 off-Base drinking water sampling (especially in the Locust Grove neighborhood southeast of Site 10) were nondetect; therefore, the Team agreed that the two additional deep monitoring wells will not be installed at this time. The Navy proposed to resample the existing monitoring well network for the 14 compound PFAS list[3] (previous sampling was only for perfluorooctanoic acid [PFOA], perfluorooctanesulfonic acid [PFOS], and perfluorobutanesulfonic acid [PFBS]). Ryan requested, and the Team agreed, to sample six[4] monitoring wells for total petroleum hydrocarbons (TPH), as kerosene, gasoline, and some fuels are still being used for fire testing. The monitoring wells to be sampled will be located in the "hot spot" area.

The Team discussed installing stream gauges in the streams north and south of the site to verify the hydrogeologic conditions and whether the streams were receiving groundwater. Ryan asked if the surface water samples should be collected after a rain storm, and Andy replied that since it is anticipated that groundwater is moving into surface water, and not surficial runoff into the stream, the surface water samples should not be collected after a rain storm. Peggy asked why the north-central stream at the northern site boundary was not being sampled, and Andy replied that a field reconnaissance is necessary to determine whether this is a perennial stream. Andy further noted that based on the current direction of surface runoff from the FTA, PFAS would need to cross several drainage areas to enter this stream; from a surface water perspective, this does not appear plausible.

Consensus Statement

The Team agreed with the following general path forward for preparing the draft SAP for the Site 10 SI:

- Expand the FTA site boundary to incorporate the test structure to the southeast.
- Collect co-located surface and subsurface soil samples at 29 locations. Surface soil samples will be collected from 0 to 6 inches bgs, and subsurface soil samples will be collected at the depth interval with evidence of contamination (for example, PID readings, observed soil staining), or in the absence of observed contamination, immediately above the water table. An additional subsurface soil will be collected from the 8- to 10-foot bgs interval (average depth of a building foundation) at 5 of the 29 soil sample locations: Building 314, the fire structure in the southeastern corner of the site, the Fire 1 Test Chamber, Building 313, and the Fire Test Pad. All soil samples will be analyzed for 14[3] PFAS.
- Install five shallow monitoring wells.

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2 In the December 2018 scoping session presentation, 29 soil sample locations were proposed; however, this was inadvertently documented as 28 soil sample locations in the final December 2018 meeting minutes.

3 Method 537.1 now includes 18 PFAS; therefore, analysis for PFAS described herein will be for 18 PFAS.

4 At the request of the Navy on 1/29/20, an additional monitoring well (S03-MW-01) was proposed for TPH analysis; therefore, groundwater from seven monitoring wells will be sampled for TPH.

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

- Conduct one synoptic groundwater gauging event.
- Sample groundwater from 27 monitoring wells (23 shallow wells, 4 deep wells).
  - All groundwater samples will be analyzed for 14 PFAS[3].
  - A subset of six[4] shallow monitoring wells will be analyzed for TPH (gasoline range organics [GRO] and diesel range organics [DRO]).
- Install five stream gauges: Two stream gauges within the north stream and three stream gauges within the south stream.
- Collect four[5] surface water samples north of the FTA and six surface water samples south of the FTA.
  - All surface water samples will be analyzed for 14 PFAS[3].
- Collect two sediment samples north of the FTA (these samples will be co-located with two of the four[5] surface water samples north of the FTA), and two sediment samples south of the FTA (these samples will be co-located with two of the six surface water samples south of the FTA).
  - All sediment samples will be analyzed for 14 PFAS[3].

Action Item

CH2M will begin preparing the SAP for the Site 10 SI.

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3 Method 537.1 now includes 18 PFAS; therefore, analysis for PFAS described herein will be for 18 PFAS.

5 At the request of the Navy on 2/25/20, an additional surface water sample (CBD-AOA-SW11) was proposed for PFAS analysis; therefore, five surface water samples will be collected north of the FTA.

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SAP Worksheet #10—Conceptual Site Model

NRL-CBD is in Chesapeake Beach, Maryland (**Figure 1**). **Figure 2** presents the site layout. **Table 10-1** presents the CSM.

Table 10-1. Conceptual Site Model
NRL-CBD, Chesapeake Beach, Maryland

Site Name		Site 10 – FTA
Site Location		NRL-CBD is approximately 40 miles from Washington, DC, and occupies approximately 160 acres along the western shoreline of the Chesapeake Bay (**Figure 1**). The facility is divided into an eastern and western portion, bisected by Bayside Road (Maryland State Route 261). Site 10 (previously identified as Area of Concern A) is on the western portion of NRL-CBD (**Figure 2**). Navy Court bisects the site, separating the larger, northern area of the site from its smaller, southern area.
Site History		Since approximately 1968, Site 10 has been used to test extinguishing agents on fires started with various fuel sources (Price, 1988a, 1988b; MDE, 1988). The tests were conducted by creating a fire on a concrete testing pad by the open burning of petroleum products that included gasoline, diesel, jet propulsion fuel, Grade 4 (JP-4), and jet propulsion fuel, Grade 5 (JP-5) (Price, 1988b). As reported in the *Initial Assessment Study* (Naval Energy and Environmental Support Activity, 1984), "Fire testing operations are currently conducted at NRL-CBD. These operations utilize two open burning areas and two smokehouses. Fire suppressants tested include AFFF (aqueous film-forming foam), PKP (potassium bicarbonate), halons, and protein foam ("bean soup"). Typically, wastewater containing these solutions is drained into a holding pit and allowed to absorb slowly into the soil." In the mid-to-late 1980s, several improvements were made to Site 10, including a new testing pad, a concrete-lined collection pit, and new conveyance piping from the FTA structures to the new collection pit.
Current Use		Site 10 is used as a fire suppression testing area. Kerosene, gasoline, and other fuels continue to be used at the FTA for fire testing activities.
Site Conditions	**Physical Characteristics**	The topography of Site 10 gently slopes to the east, with grassy areas separating the Fire Testing Pad, Fire 1 Test Chamber, Building 313 Fire Testing Building, Pump House, and Wastewater Collection Pit (concrete-lined) in the northern area of the site, and Building 314 Fire Testing Building in the southern area of the site (**Figure 2**).
	Geology and Hydrogeology	The surficial geology is composed of clayey silt, poorly graded silty sands, and silty clays underlain by silty lean-to-fat clays. Depth-to-shallow (surficial) groundwater ranges from 6 to 37 feet bgs across the Base, with the saturated thickness of the shallow aquifer between 1.7 and 20 feet; in general, the surficial aquifer tends to be a low yield aquifer. The surficial aquifer is underlain by the Calvert confining unit, which consists of fat-to-lean clay and is continuous across the Base. The confining unit varies in thickness from approximately 66 to 113 feet (CH2M, 2018a). Below this confining unit is the Piney Point aquifer. A middle confining bed, comprised of the Nanjemoy Formation and Marlboro Clay, underlies the Piney Point aquifer from approximately 230 to 400 feet bgs, which in turn is underlain by the Aquia aquifer at approximately 400 to 600 feet bgs (Achmad and Hansen, 1997). Groundwater flow in the surficial aquifer is generally north-northeast toward the stormwater pond approximately 700 feet north-northeast of Site 10. A groundwater divide is south and east of the site, along Navy Court, with flow north of the road migrating toward the north-northeast and flow south of the road migrating to the south-southeast (**Figure 3**). Shallow groundwater flow is controlled by surface water features such as ponds, ravines, and the Chesapeake Bay. While the gradient between the shallow and deep aquifers is downward, the surficial aquifer is isolated from the underlying Piney Point aquifer by the clay confining unit (Calvert confining unit) present beneath the site. Therefore, the transport pathway between the surficial aquifer and the underlying Piney Point aquifer does not appear to be complete. The underlying Piney Point aquifer consists of a poorly graded, grey sand.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Conceptual Site Model
NRL-CBD, Chesapeake Beach, Maryland

Site Conditions (con't)	**Geology and Hydrogeology (con't)**	Groundwater flow in the Piney Point aquifer is generally to the northeast (**Figure 4**). It is possible that deep groundwater flow may have a stronger eastward component not observable with the current well network, or that flow to the northeast is driven by a paleochannel or pumping of the many Piney Point drinking water supply wells to the northeast.
Previous Investigations		The 1984 *Initial Assessment Study* first documented historical activities and potential for hazardous releases at the FTA. Soil at the FTA was investigated for petroleum related constituents (VOCs and lead) between 1988 and 1989. During this timeframe MDE and NRL exchanged a series of correspondence that led to NRL installing four soil borings around the collection pit with analytical samples collected at 2, 4, 8, and 10 feet below ground surface and analyzed for VOCs and EP lead. The results of the analyses indicated that that other than 2-butanone, which was also detected in the blanks, none of the parameters tested were present in any of the soil samples. Based on the analytical results, MDE concluded that no evidence of soil or groundwater contamination was apparent at the site and no further assessment was warranted (MDE, 1989). In 2009, a Site Assessment was performed to assess the presence of shallow groundwater contamination at and downgradient of the FTA. The concentrations of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals were below conservative tap water ingestion-based evaluation criteria in samples from shallow groundwater monitoring wells at the FTA. Additionally, TPH-DRO and TPH-GRO were detected in groundwater; however, the cumulative hazard index from the noncarcinogenic constituents (including TPH-DRO and TPH-GRO) was 0.9, which was below the hazard index value of 1 that USEPA and MDE use as a threshold to indicate the potential for noncancer adverse health effects. Soil did not appear to be contaminated based on field screening performed during the Site Assessment; this determination also was supported by previous soil sampling performed in November 1989 (CH2M, 2009). In 2017, an on-Base investigation for PFAS in shallow (surficial aquifer) and deep (Piney Point aquifer) groundwater was conducted. Analysis of PFAS in groundwater was limited to PFOA, PFOS, and PFBS (CH2M, 2018a). The results indicated PFAS are present in shallow groundwater but were not detected in the deeper Piney Point aquifer (CH2M, 2018). Concentrations of PFOS ranged between 1.01 and 234,000 nanograms per liter (ng/L). Concentrations of PFOA ranged between 21.5 and 14,900 ng/L. Concentrations of PFBS ranged between 7.09 and 1,220 ng/L. The highest PFAS concentrations detected in shallow groundwater were from monitoring wells near the center of Site 10, and concentrations decreased with distance from Site 10 (**Figure 3**). The assessment concluded that the FTA was clearly the source of PFAS contamination in groundwater. Additionally, the assessment determined the surficial aquifer is isolated from the underlying Piney Point aquifer by the clay confining unit (Calvert confining unit) present beneath the site. Therefore, the transport pathway into downgradient private water supply wells near NRL-CBD did not appear to be complete based on available data, and no off-Base drinking water sampling was recommended. However, additional monitoring well installation and soil and groundwater sampling were recommended at the site to verify there are no continuing soil sources and to define the extent of PFAS contamination in groundwater (CH2M, 2018a).
Drinking Water Source Evaluation		***On-Base Drinking Water*** Drinking water at NRL-CBD is supplied by two on-Base production wells, CA-CC-39 and CA-CC-41, installed in 1953 at depths of 514 and 540 feet bgs, respectively, within the Aquia aquifer (Maryland Geological Survey, 1984). Samples were collected from the on-Base drinking water source in September 2016 and analyzed only for PFOA and PFOS; there were no detections of either PFOA or PFOS (Chesapeake Environmental Lab, Inc., 2016).
		Off-Base Drinking Water The residential areas adjacent to and within 1 mile of NRL-CBD (**Figure 4**) are not connected to municipal water and use private wells for drinking water supply (Calvert County Department of Community Planning & Building and Department of Public Works, 2015). These private wells average 300 feet deep and are believed to be screened in the Piney Point aquifer.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Conceptual Site Model
NRL-CBD, Chesapeake Beach, Maryland

Drinking Water Source Evaluation (con't)	In early May 2018, a resident informed the Navy of a shallow drinking water well south of the Base. This new information about the potential for shallow drinking water wells resulted in sampling of off-Base private drinking water wells. Drinking water samples were collected from 42 private wells north and south of NRL-CBD and analyzed for 14 PFAS, including PFOA, PFOS, PFBS, n-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA), n-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA), perfluorodecanoic acid (PFDA), perfluorododecanoic acid (PFDoA), perfluoroheptanoic acid (PFHpA), perfluorohexanesulfonic acid (PFHxS), perfluorohexanoic acid (PFHxA), perfluorononanoic acid (PFNA), perfluorotetradecanoic acid (PFTeDA), perfluorotridecanoic acid (PFTrDA), and perfluoroundecanoic acid (PFUnA). PFAS was detected in three of the privately owned, off-Base drinking water supply wells; detections of PFOA and PFOS were below the lifetime health advisory. As such, no further action was warranted for the off-Base drinking water wells (CH2M, 2019) (**Figure 5**). As shown on **Figure 4**, most of the parcels with private drinking water wells within 1 mile of NRL-CBD are upgradient or sidegradient of NRL-CBD and Site 10; as such, it is unlikely that off-Base drinking water in these areas would be impacted. Downgradient off-Base drinking water wells were identified and sampled for PFAS in 2018 (**Figure 5**). Based on current information, there is no potential for exposure to PFAS in drinking water outside the previously identified sampling areas shown on **Figure 5**.
Source Area	Site 10 – FTA
Contaminants of Potential Concern (COPCs)	PFOS, PFOA PFBS, NEtFOSAA NMeFOSAA, PFDA PFDoA, PFHpA PFHxS, PFHxA PFNA, PFTA PFTrDA, PFUnA Hexafluoropropylene oxide dimer acid (HFPO-DA) 4,8-dioxa-3H-perfluorononanoic acid (ADONA) 11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS) 9-chlorohexadecafluoro-3-oxanone-1-sulfonic (9Cl-PF3ONS) TPH
Extent of PFAS and TPH in Groundwater	PFBS, PFOA, and PFOS were detected on-Base in the shallow aquifer in 2017, with the highest concentrations observed in the monitoring wells closest to Site 10 (that is, CBD-AOA-MW01, CBD-AOA-MW02, CBD-AOA-MW03, and CBD-AOA-MW04) with concentrations in groundwater decreasing with distance from the site (CH2M, 2018a). There were no detections of PFBS, PFOA, or PFOS in the Piney Point aquifer. PFAS were detected in three of the private drinking water supply wells; detections of PFOA and PFOS were below the lifetime health advisory (CH2M, 2019). TPH was detected in four on-Base shallow groundwater samples in 2009 (**Figure 3**) (CH2M, 2009). However, while the extent of TPH contamination at the source area was not delineated, no further assessment was recommended since the ratios of the maximum detected concentrations to risk-based concentrations (hazard index of 0.9) did not exceed risk-based concentrations based on a hazard quotient (HQ) of 1.0.
Migration Pathways	• Direct release of COPCs to surface and/or subsurface soils • Leaching of COPCs currently and/or historically in soil to groundwater and transport of COPCs via advection in groundwater • Direct release of COPCs to drainage ditches or discharge of groundwater containing COPCs to surface water and sediment • Overland flow/runoff containing COPCs to surface soil, surface water, and sediment

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Conceptual Site Model
NRL-CBD, Chesapeake Beach, Maryland

Potential Receptors/ Exposure Routes	***Human Health*** • Residents – Future residents[a] who use groundwater as a potable water source[b] – Future residents through dermal contact with surface soil or subsurface soil – Future residents through incidental ingestion of surface soil, subsurface soil, sediment, and/or surface water • Workers[c] – Current and future industrial and construction workers through dermal contact with surface soil, subsurface soil, and/or sediment – Current and future industrial and construction workers through incidental ingestion of surface soil, subsurface soil, sediment, and/or surface water • Trespassers/Visitors – Current and future trespassers and visitors through dermal contact with surface soil and/or sediment – Current and future trespassers and visitors through incidental ingestion of surface soil, sediment, and/or surface water ***Ecological*** Groundwater is not typically an exposure medium for ecological receptors, but ecological exposures may occur if groundwater discharges to a surface water body. In addition, ecological receptors (such as terrestrial and aquatic plants; soil, aquatic, and benthic invertebrates; fish; amphibians; and reptiles) may be directly exposed to PFAS in surface and shallow subsurface soil, surface water, and/or sediment. There is also evidence that PFAS may enter food webs, and thus ecological receptors (such as birds and mammals) and humans may be exposed to these constituents via this pathway.

Notes:

[a] Exposure to current receptors has been addressed by the off-Base drinking water sampling conducted in 2018. For future off-Base drinking water users, a different SAP will be prepared if additional health advisories are issued for PFAS not currently under advisory.

[b] There are no regulatory screening levels or other criteria for inhalation of PFAS or dermal contact with PFAS in groundwater.

[c] Groundwater from the surficial and Piney Point aquifers is not used as a potable water supply on-Base. Potential contamination in these aquifers would not reach the underlying Aquia aquifer that is used as the on-Base drinking water source.

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

Problem Statement and Objectives

It is unknown whether historical and current use of aqueous film-forming foam at Site 10 has resulted in a release of PFAS soil, surface water, or sediment at Site 10. The extent of PFAS and TPH in the surficial aquifer, and current concentrations in the surficial and Piney Point aquifers at NRL-CBD are unknown. The objectives, environmental questions, investigation approach, and project quality objectives (PQOs) for this SI are presented in **Table 11-1**.

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

Objective	Environmental Questions	General Investigation Approach	PQO
Determine whether PFAS are present in soil, surface water, and/or sediment, and if present, determine whether concentrations exceed the project action limits (PALs) for soil, surface water, and/or sediment.	What are the concentrations of PFAS analytes within surface water, sediment, and soil, and if present, do the concentrations exceed the PALs?	Soil samples will be collected from Site 10. Surface water and sediment samples also will be collected from downgradient locations. Proposed soil sample locations are presented on **Figure 6**, and proposed surface water and sediment locations on presented on **Figure 7**, which also depicts the defined drainage area boundaries for the site (see **Worksheet #17** for the sampling design and rationale). Results will be compared to the PALs (**Worksheet #15**).	• If PFOA, PFOS, and/or PFBS are not detected, then no further action is warranted. • If PFOA, PFOS, and/or PFBS are detected, but are below the RSLs (**Worksheet #15**), the Team will reconvene to determine whether additional samples should be collected to help the Team refine the CSM and make decisions regarding either no further action or proceeding to a Remedial Investigation (RI). If the Team determines that additional data are needed to refine the CSM, additional samples will be collected as part of this SAP. • If PFOA, PFOS, and/or PFBS are greater than the RSLs (**Worksheet #15**), then additional investigation of soil, surface water, and/or sediment will be conducted as part of a PFAS RI. PFAS data for the remaining 15 PFAS will be archived for possible future use and evaluation, including screening of possible human health and ecological risk[6].
Further refine the lateral and vertical extents of PFAS in groundwater in the surficial aquifer on-Base and determine whether current concentrations of PFAS exceed the PALs for groundwater.	What are the horizontal and vertical extents of PFAS in the surficial aquifer at the Base? If PFAS are present, do they exceed the PALs?	Five new shallow wells will be installed and screened within the surficial aquifer downgradient of Site 10 (**Figure 3**). Groundwater samples will be collected from the 5 new shallow wells and 18 existing shallow wells (**Figure 3**) (see **Worksheet #17** for the sampling design and rationale). All samples will be analyzed for 18 PFAS. Results will be compared to the PALs (**Worksheet #15**).	• If PFOA, PFOS, and/or PFBS are not detected, then no further action is warranted. • If PFOA, PFOS, and/or PFBS are detected, but are below the RSL (**Worksheet #15**), the Team will reconvene to determine whether additional samples should be collected to help the Team refine the CSM and make decisions regarding either no further action or proceeding to an RI. If the Team determines that additional data are needed to refine the CSM, additional samples will be collected as part of this SAP. • If PFOA, PFOS, and/or PFBS are greater than the RSL (**Worksheet #15**), then additional investigation of groundwater will be conducted as part of a PFAS RI. • If PFOA and/or PFOS exceed the lifetime health advisory (**Worksheet #15**), an evaluation will be conducted by the Partnering Team to determine if additional off-base drinking water sampling is warranted. • If PFOA and/or PFOS are either not detected or detected below the lifetime health advisory (**Worksheet #15**), no further action for off-base drinking water is warranted. PFAS data for the remaining 15 PFAS will be archived for possible future use and evaluation, including screening of possible human health and ecological risk[6].
Determine the current concentrations of PFAS[7] in the Piney Point aquifer, and if present, whether current concentrations exceed the PALs.	What are the current concentrations of PFAS in the Piney Point aquifer? Do current concentrations of PFOA, PFOS, and/or PFBS exceed the PALs?	Groundwater samples will be collected from four existing deep wells (**Figure 3**) (see **Worksheet #17** for the sampling design and rationale). All samples will be analyzed for 18 PFAS. Results will be compared to the PALs (**Worksheet #15**).	• If PFOA, PFOS, and/or PFBS are not detected, then no further action is warranted. • If PFOA, PFOS, and/or PFBS are detected, but are below the RSLs (**Worksheet #15**), the Team will reconvene to determine whether additional samples should be collected to help the Team refine the CSM and make decisions regarding either no further action or proceeding to an RI. If the Team determines that additional data are needed to refine the CSM, additional samples will be collected as part of this SAP. • If PFOA, PFOS, and/or PFBS are greater than the RSLs (**Worksheet #15**), then additional investigation of groundwater will be conducted as part of a PFAS RI. • If PFOA and/or PFOS exceed the lifetime health advisory (**Worksheet #15**), an evaluation will be conducted by the Partnering Team to determine if additional off-base drinking water sampling is warranted. • If PFOA and/or PFOS are either not detected or detected below the lifetime health advisory (**Worksheet #15**), no further action for off-base drinking water will be warranted. PFAS data for the remaining 15 PFAS will be archived for possible future use and evaluation, including screening of potential risk to human health[8].

6 There are no promulgated screening values for the 15 PFAS. The literature-based ecological screening values provided in **Worksheet #15** are included to ensure adequate analytical sensitivity.

7 When the original on-site PFAS evaluation was conducted in 2017, only three PFAS analytes were included in the analysis. Since then, the Navy has updated its guidance and the current analyte list now includes 18 PFAS analytes.

8 Complete screening values for human health and ecological receptors have not yet been released by USEPA. The literature-based ecological screening values provided in **Worksheet #15** are included to ensure adequate analytical sensitivity.

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

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

Problem Definition/ Objective	Environmental Question	General Investigation Approach[4]	PQO
Determine the potential for PFAS in groundwater, and if present in surface water, to migrate off Base.	What are the groundwater flow directions in the surficial and Piney Point aquifers? What are the surface water elevations and flow directions at the Base?	After installing additional wells around Site 10, the new and existing wells presented on **Figure 3** will be gauged for the depth to groundwater, and groundwater contour maps will be created to further refine the groundwater flow direction onsite within the surficial aquifer and confirm the groundwater flow direction within the Piney Point aquifer. Five stream gauges will be installed in surface water bodies shown on **Figure 7**. The stream elevations will be gauged and the results will be recorded.	This information will be used to assess the potential for on- and off-Base migration of PFAS contamination and will be used to scope additional investigation or action, as warranted.
Further characterize the nature of TPH contamination from kerosene, gasoline, and jet propulsion fuel burning in the shallow groundwater at the site.	What are the current concentrations of TPH in the surficial aquifer at the site and do they exceed the PALs?	Seven groundwater samples will be collected from new and existing wells. Proposed locations (monitoring wells CBD-AOA-MW01 through CBD-AOA-MW04, CBD-AOA-MW08, CBD-S03-MW01, and CBD-S03-MW02) are presented on **Figure 3** (see **Worksheet #17** for the sampling rationale). Samples will be analyzed for TPH.	• If TPH is detected within groundwater at concentrations that exceed the PALs, then additional investigation of groundwater and other media may be conducted as part of a future investigation in consultation with the NRL-CBD Tier I Partnering Team. • If TPH concentrations do not exceed the PALs, then no further action will be taken.

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

What are the Project Action Limits (PALs)?

The PALs for data collected are provided in **Worksheet #15** and summarized as follows:

Human Health PALs

- **Groundwater** data will be screened against the following PALs:
  - The USEPA lifetime health advisory for PFOA and PFOS is 70 ng/L individually; if both chemicals are detected, then 70 ng/L is the lifetime health advisory for the cumulative concentration of the two chemicals. PFBS results will be compared to the current USEPA tap water regional screening level (RSL) (based on an HQ of 0.1). The USEPA RSL calculator was used to calculate tap water RSLs for PFOS and PFOA (based on an HQ of 0.1). There are no PALs for any other analytes.
  - The Maryland Cleanup Standards, residential cleanup standards for gasoline range TPH and diesel range TPH are the PALs for TPH-GRO and TPH-DRO. There are no USEPA tap water RSLs for TPH-GRO or TPH-DRO.
- **Surface and Subsurface Soil** data will be screened against the following PALs:
  - PFBS results will be compared to the current USEPA residential soil RSL (based on an HQ of 0.1). The USEPA RSL calculator was used to calculate residential soil RSLs for PFOS and PFOA (based on an HQ of 0.1). There are no PALs for any other analytes.
- **Surface Water** data will be screened against the following PALs:
  - PFBS results will be compared to the current USEPA tap water RSL (based on an HQ of 0.1) multiplied by 10. The USEPA RSL calculator was used to calculate tap water RSLs for PFOS and PFOA (based on an HQ of 0.1), which was then multiplied by 10. There are no PALs for any other analytes. The RSLs are multiplied by 10 to account for exposure to surface water, which would be much less than exposure to groundwater.
- **Sediment** data will be screened against the following PALs:
  - PFBS results will be compared to the current USEPA residential soil RSL (based on an HQ of 0.1) multiplied by 10. The USEPA RSL calculator was used to calculate residential soil RSLs for PFOS and PFOA (based on an HQ of 0.1), which was then multiplied by 10. There are no PALs for any other analytes. The RSLs are multiplied by 10 to account for exposure to sediment, which would be much lower than exposure to soil.

Ecological PALs

The literature-based ecological screening values (ESVs) are provided in **Worksheet #15** for PFOS and PFOA in groundwater (transport to surface water), surface water, sediment, and surface soil (up to 24 inches bgs). The sources for these medium-specific ESVs are included in **Appendix B**. Because ecological risk assessment for PFAS and PFOA is emerging and the available screening values for PFOS and PFOA are limited and not comprehensive, an ecological risk assessment will not be conducted at this time. However, ESVs have been included as part of this SAP so the data are adequate for future risk assessment efforts, if needed. No ecological PALs are available for TPH.

What will the data be used for?

The 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**.

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

What types of data are needed?

Worksheets #14, #15, #17, and **#18** contain detailed information on the types of data needed for this project.

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

Offsite laboratory analytical data will be of the quantity and quality necessary to provide technically sound and defensible assessments with respect to the aforementioned project objectives. Additionally, laboratory-specific LODs will be less than the RSLs and calculated RSLs as shown on Worksheet #15-1 and Worksheet #15-3. USEPA lifetime health advisory for PFOA and PFOS of 70 ng/L or 0.07 µg/L is for the sum of the two chemicals. The lifetime health advisory is applicable because samples will be collected from aquifers that are used for drinking water off base and has the potential future use for on-base drinking water. 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 latest version of the DoD Quality Systems Manual (QSM), as applicable, and laboratory in-house limits where the QSM does not apply.

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

Worksheets #14, #17, and **#18** describe how the groundwater, surface and subsurface soil, surface water, and sediment samples will be sampled and for what parameters. Detailed information on how data will be collected is provided on **Worksheet #14,** following the standard operating procedures (SOPs) listed in **Worksheet #21.** The proposed sample locations are illustrated on **Figures 3, 6,** and **7**. The project schedule is provided in **Worksheet #16**.

SAP Worksheet #12-1—Field Quality Control Samples

(UFP-QAPP Manual Section 2.6.2)

Matrix: Groundwater (GW), Surface Water (SW)
Analytical Group: PFAS
Analytical Method: LC-MS/MS Compliant with QSM, Version 5.1.1 Table B-15

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	MPC
Field Duplicate	PFAS	One per 10 normal field samples.	Precision	%RPD < 25% for waters
Matrix Spike (MS)/Matrix Spike Duplicate (MSD)		One per 20 normal field samples.	Accuracy/Precision	See **Worksheet #15-1**
Equipment Blank		One per day for decontaminated equipment. One per event for disposable equipment.	Contamination	No target analytes detected > 1/2 LOQ
Field Blank		One per site.	Bias/Contamination	No target analytes detected > 1/2 LOQ
Temperature Blank		One per cooler.	Representativeness	≤ 10°C at laboratory receipt, storage in the laboratory ≤ 6°C, but not frozen

°C = degrees Celsius
LC-MS/MS = liquid chromatography tandem mass spectrometry
QAPP = Quality Assurance Project Plan
RPD = relative percent difference

SAP Worksheet #12-2—Field Quality Control Samples

(UFP-QAPP Manual Section 2.6.2)

Matrix: GW
Analytical Group: TPH-GRO and TPH-DRO
Analytical Method: SW-846 8015C

QC Sample	Analytical Group	Frequency	DQIs	MPC
Field Duplicate	TPH	One per 10 normal field samples.	Precision	%RPD < 25% for waters
MS/MSD		One per 20 normal field samples.	Accuracy/Precision	See **Worksheet #15-2**
Equipment Blank		One per day for decontaminated equipment. One per event for disposable equipment.	Contamination	No target analytes detected > 1/2 LOQ
Trip Blank		One per cooler with TPH-GRO.	Bias/Contamination	No target analytes detected > 1/2 LOQ
Temperature Blank		One per cooler.	Representativeness	≤ 6°C but not frozen

SAP Worksheet #12-3—Field Quality Control Samples

(UFP-QAPP Manual Section 2.6.2)

Matrix: Surface Soil (SS), Soil Boring (SB), Sediment (SD)
Analytical Group: PFAS
Analytical Method: LC-MS/MS Compliant with QSM 5.1.1 Table B-15

QC Sample	Analytical Group	Frequency	DQIs	MPC
Field Duplicate	PFAS	One per 10 normal field samples.	Precision	%RPD < 35% for soils
MS/MSD		One per 20 normal field samples.	Accuracy/Precision	See **Worksheet #15-3**
Equipment Blank		One per day for decontaminated equipment. One per event for disposable equipment.	Contamination	No target analytes detected > 1/2 LOQ
Field Blank		One per site.	Bias/Contamination	No target analytes detected > 1/2 LOQ
Temperature Blank		One per cooler.	Representativeness	≤ 10°C at laboratory receipt, storage in the laboratory ≤ 6°C, but not frozen

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SAP Worksheet #13—Secondary Data Criteria and Limitations Table

This worksheet identifies the secondary data and information that will be used for the project, including the originating source of the data. This worksheet documents how the existing data will be used and the limitations to using the existing data.

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
On-Base drinking water	*Water Analysis Report for Navy Research Laboratory – CBD* (Chesapeake Environmental Laboratory, 2016)	Chesapeake Environmental Laboratory, drinking water samples from on-Base supply wells, September 2016	The drinking water analytical data will be used to complete the CSM.	None
Off-Base drinking water	*Draft Results of Investigation of Per- and Polyfluoroalkyl Substances in Off-Base Drinking Water, Naval Research Laboratory-Chesapeake Bay Detachment, Chesapeake Beach, Maryland* (CH2M, 2019)	Navy, drinking water samples from private wells north and south of NRL-CBD, July and September 2018	The drinking water analytical data will be used to complete the CSM.	None
Groundwater	*Final Fire Testing Area Site Assessment Report, Naval Research Laboratory Chesapeake Bay Detachment, Chesapeake Beach, Maryland* (CH2M, 2009)	Navy, groundwater samples from multiple wells in the shallow aquifer at NRL-CBD, August 2009	The groundwater analytical data from the investigation was used to identify potential source areas as well as the basis for not proposing TPH-related constituent sampling for groundwater.	None
Groundwater	*Evaluation of Per- and Polyfluoroalkyl Substances in Groundwater, National Research Laboratory – Chesapeake Bay Detachment, Chesapeake Beach, Maryland* (CH2M, 2018a)	Navy, groundwater samples from multiple wells in both the shallow and deep aquifers at NRL-CBD, March 2017	The groundwater analytical data from the investigation will be used to identify potential source areas as well as create a basis for installing additional monitoring wells to determine hydraulic characteristics of Site 10 and delineate the PFAS plume.	None
Soil	*Personal communication (letters) between NRL and MDE* (Price, 1988a; Price, 1988c; Price, 1988d; and Pittman, 1989)	Navy, soil samples collected from inside and outside the pumping station structure (May, 1988) and soil samples collected from boreholes adjacent to the "Fire Test Facility" (October, 1988)	The soil analytical data from the investigation was used to document the concentrations of VOCs and lead in the vicinity of the pumping station structure and fire testing building and the determination for no further action in soils for TPH related constituents.	None

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SAP Worksheet #14—Summary of Project Tasks

The technical approach for the proposed field activities at NRL-CBD is detailed in this worksheet. The fieldwork will be completed in accordance with the applicable SOPs tabulated in **Worksheet #21** and provided in **Appendix C.**

Pre-sampling Tasks

Subcontractor Procurement

- Analytical laboratory
- Utility locator
- Driller
- Surveyor
- IDW transportation and disposal contractor
- DV

Fieldwork 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, worker responsibilities, and familiarize workers with the Health and Safety Plan.

Utility Clearance

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 subsurface utilities near the proposed monitoring well locations. Any proposed direct-push technology (DPT) or monitoring well locations within 5 feet of utility locations will be relocated to avoid impact to utilities. If a DPT monitoring well location needs to be relocated, the field team will use its best judgment in relocating the well and will notify the CH2M PM of its new location. The utility clearance subcontractor has not been selected for this sampling event; however, once the subcontractor is identified, the Navy will be notified.

Monitoring Well Installation

The monitoring wells will be installed in accordance with the State of Maryland well construction standards by a Maryland-licensed driller. Monitoring wells will be installed hollow stem auger drilling techniques in accordance with the SOP listed in **Worksheet #21** and provided in **Appendix C**.

Five shallow monitoring wells will be constructed with a 2-inch inside-diameter Schedule 40 polyvinyl chloride (PVC) riser connected to a 10-foot, 2-inch inside-diameter factory-slotted (0.010-inch or 10-slot) PVC screen with a bottom cap. Subsurface soil cores will be collected at each monitoring well location using a 4- or 5-foot-long core barrel with new disposable acetate liners. Continuous soil cores will be collected for lithology. Soil cores will be retrieved from each boring in accordance with the field SOP (**Appendix C**). Soil descriptions, including grain size, color, moisture content, relative density, consistency, soil structure, minerology, and other relevant information, will be noted in the field logbook. Drilling and well construction materials will be free of fluorine. No fluorine-containing greases, bentonite, or other materials will be used.

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

The shallow wells are to be screened across first encountered groundwater within the shallow aquifer. The top of the 10-foot screen will be set just above the water table. A sand filter pack will be placed around the annular space of the well screen from the bottom of the boring and extend to a minimum height of 2 feet above the top of the well screen. A fluorine-free bentonite seal, at least 2 feet thick, will be placed above the top of the sand pack. After the bentonite has been hydrated, a cement-bentonite grout will be placed in the remaining annular space. The locations of the proposed monitoring wells are provided on **Figure 3**.

The monitoring wells will be constructed as either flush-mounted or stick-up/aboveground completions, depending on site conditions, set in 2-foot by 2-foot by 4-inch-thick concrete pads. Flush-mounted well completions will include 8-inch-diameter steel, bolt-down lids, and stick-up wells will be furnished with a steel protective casing surrounded by steel bollards, as needed. A locking watertight cap will be placed on the PVC pipe, and the wells will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the well identification. The drilling subcontractor has not been selected for this sampling event; however, once the subcontractor is identified, the Navy will be notified.

Well Development

After completing the well installation, the drilling subcontractor will develop each monitoring well using a combination of surging and pumping throughout the well screen. During monitoring well development, the CH2M field crew will measure water quality parameters, including pH, temperature, conductivity, and turbidity with a water quality meter. Development will continue for a minimum of 1 hour and until the turbidity of the water removed from the well is as clear as practicable, using professional judgment. Surge blocks and pumps with Teflon parts will be avoided during development.

Development information, including turbidity, pH, specific conductivity, temperature, and gallons of water removed will be recorded as field notes on loose-leaf notebook paper. In addition, the water quality meter will be calibrated daily (at a minimum), and the calibration will be documented in the field notes.

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

Water-level Survey

Following monitoring well installation and development, and before starting groundwater sampling or after completing groundwater sampling, a complete water-level survey at the wells will be conducted in accordance with the SOP (**Worksheet #21** and **Appendix C**). An electronic water-level meter with a probe that is not coated with Teflon or other fluorinated polymers will be used to measure the depth to water from the top of casing to the nearest 0.01 foot.

Monitoring Well Groundwater Sampling

Groundwater samples will be collected from new and existing monitoring wells as presented on **Figure 3**. Groundwater samples will be collected using low-flow sampling methodology and in accordance with the SOPs. A peristaltic pump will be used to collect samples for wells with a sampling depth of 30 feet or shallower, and a PFAS-free submersible pump will be used for wells screened at deeper depths. The peristaltic tubing or pump will be set in the middle of the well screen. Teflon-lined tubing will not be used during groundwater sampling to prevent cross-contamination with groundwater while sampling for PFAS analytes. Seven of the monitoring wells (CBD-AOA-MW01 through CBD-AOA-MW04, CBD-AOA-MW08, CBD-S03-MW01, and CBD-S03-MW02) will be sampled for TPH in addition to PFAS.

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

Groundwater quality parameters (pH, conductivity, turbidity, dissolved oxygen [DO], temperature, salinity, and oxidation-reduction potential [ORP]) will be collected during purging of each well using a water quality meter and a flow-through cell. Water quality readings will be collected once one volume of the sampling tube and flow-through cell has been purged. Purging will continue until water quality readings collected 5 minutes apart are stabilized to within 10% of one another. Once parameters have stabilized, the flow-through cell will be disconnected, and samples will be collected into laboratory-prepared, pre-preserved sample bottles and packed on ice for overnight shipment. Samples for PFAS analysis will be shipped to Battelle, and samples for TPH analysis will be shipped to AEL in Jacksonville, Florida.

Soil Sampling

Twenty-nine locations are proposed for soil sample collection (**Figure 6**). Soil borings will be advanced using a DPT drill rig to a maximum depth of 45 feet bgs. Subsurface soil cores will be collected at each location using a 4- or 5-foot-long core barrel with new disposable acetate liners. Continuous soil cores will be collected for lithology. Soil cores will be retrieved from each boring in accordance with the field SOP (**Appendix C**). Soil descriptions, including grain size, color, moisture content, relative density, consistency, soil structure, minerology, and other relevant information will be noted in the field logbook. At each soil boring location, surface and subsurface soil samples will be co-located and collected.

Surface Soil Samples

Surface soil samples will be collected at each soil boring location. For this investigation, surface soil is defined as 0 to 6 inches bgs. Surface soil samples will be collected using acetate sleeves following soil sampling protocol.

Subsurface Soil Samples

Subsurface soil samples will be collected at each soil boring location. Soil samples will be collected from intervals displaying evidence of contamination (soil staining, PID readings, etc.) as determined during soil characterization. If no evidence of contamination is observed, a single subsurface soil sample will be collected directly above the water table. At five locations (proposed sample locations CBD-AOA-SO25 through CBD-AOA-SO29 on **Figure 6**), an additional subsurface sample will be collected from the 8- to 10-foot bgs interval. Subsurface soil samples will be collected using acetate sleeves following soil sampling protocol.

Surface Water Sampling

Surface water samples will be collected at 11 locations[9] identified on **Figure 7**. Before collecting samples, water quality readings (pH, conductivity, turbidity, DO, temperature, salinity, and ORP) will be obtained with a Horiba U-52 or similar water quality meter, and water depth and flow rate will be measured. Surface water samples will be collected using a peristaltic pump and disposable tubing.

9 If surface water is not present on the day of sample collection, the site will be revisited to recollect samples.

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

Sediment Sampling

Sediment samples will be collected from four locations as identified on **Figure 7**. Sediment samples will be collected from 0 to 6 inches bgs using a stainless-steel trowel, disposable scoop, hand auger, or other appropriate tool, and will be collected regardless of whether water is present. The sediment samples will be collected into approved laboratory containers and analyzed for PFAS and total organic carbon. Cross-contamination of PFAS analytes will be avoided during sampling in accordance with the SOP (**Appendix C**).

Stream Gauge Installation

Stream gauges will be installed at five locations shown on **Figure 7**. The stream gauges will consist of a standard staff gauge attached to a wooden stake and installed vertically in stream sediment at the shown location. The gauge height and water levels will be recorded once after installation, concurrently with the synoptic well gauging. Gauging will not be performed within 24 hours of a precipitation event.

Equipment Decontamination

Nondisposable sampling equipment will be decontaminated immediately after each use in accordance with the SOP. Nondisposable equipment will be decontaminated using the following solutions in this order:

1. Distilled water (laboratory certified PFAS-free) and Liquinox solution
2. Distilled water (laboratory certified PFAS-free) rinse – 10% isopropanol and distilled water solution and air-dried
3. Laboratory grade deionized water (laboratory certified PFAS-free)

Decontamination fluids will be contained in 55-gallon drums and disposed of offsite as described below. Cross-contamination of the 18 PFAS analytes in accordance with the SOP will be avoided during equipment decontamination.

Investigation-derived Waste Management

IDW is expected to consist of drill cuttings from the soil borings advanced for monitoring well installations, purge water from well development and groundwater sampling, and decontamination fluids. Aqueous and soil IDW will be contained in 55-gallon drums. If PFAS concentrations in aqueous IDW accumulated during field activities exceed the lifetime health advisory of 70 ng/L for individual or combined PFOA or PFOS analytes, the PFAS IDW SOP will be followed. Before initiating fieldwork, a location at NRL-CBD will be identified where IDW will be stored temporarily. IDW drums will be labeled in accordance with the SOP.

Disposable equipment, including personal protective equipment, will be decontaminated in accordance with the SOP and disposed of with normal facility trash. The IDW subcontractor has not been selected for this sampling event; however, once the subcontractor is identified, the Navy will be notified.

PFAS Field Blank Collection

To collect a PFAS field blank for non-drinking water samples, PFAS-free laboratory-supplied water will be slowly poured directly into Trizma-free laboratory-provided sample containers (**Worksheet #19**). (The preservative Trizma is only required for aqueous samples collected from drinking water sources. Since the field samples are not from drinking water sources, the laboratory-supplied PFAS-free water for the PFAS field blanks for non-drinking water samples, as well as the sample containers, do not contain Trizma.)

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

Surveying

Following sample collection, the soil sample locations will be marked in the field using pin flags, with the sample station clearly labeled, and global positioning system coordinates will be collected. A Maryland-licensed surveyor will survey each new monitoring well and stream gauge location vertically and horizontally using the Maryland State Plane Coordinate System. Specifically, the elevation for each monitoring well will be established at the top of each monitoring well's inner PVC casing (this elevation point will be designated by a permanent notch placed on the top of each well's inner casing) and at ground surface. The surveying subcontractor has not been selected for this sampling event; however, once the subcontractor is identified, the Navy will be notified.

Analytical and Validation Tasks

- **Quality control**
  - SOPs for field (**Worksheet #21**) and laboratory activities (**Worksheet #23**) being performed will be implemented.
  - QC samples to be collected are outlined on **Worksheet #20**.
- **Analytical tasks**
  - The laboratory will maintain, test, inspect, and calibrate analytical instruments (**Worksheets #24** and **#25**).
  - The laboratory will process and prepare samples for analysis.
  - The laboratory will analyze samples as shown on **Worksheet #18**.
- **Procedures for recording data, including guidelines for recording and correcting data**
  - Project assessment and audit (**Worksheets #31** and **#32**)
  - Data review
  - Data validation (**Worksheets #35** and **#36**)
  - Data usability assessment (**Worksheet #37**)
- **Procedures for recording data, including guidelines for recording and correcting data**
  - Project assessment and audit (**Worksheets #31** and **#32**)
  - Data review
  - Data validation (**Worksheets #35** and **#36**)
  - Data usability assessment (**Worksheet #37**)

Demobilization

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

- Chain-of-custody records will be reviewed to verify that the samples were collected as planned and submitted for appropriate analyses.
- Restoration of the site to an appropriate level (for example, repair of deep ruts) will be verified by the CH2M FTL.
- Equipment will be inspected, packaged, and shipped to the appropriate location.

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

Reporting

An SI report will be prepared to document the findings of the SI and will include a summary of the field activities, evaluation of the collected data, and identify if a release has occurred that poses a potential unacceptable risk. Release mechanisms and potential receptors will be identified.

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

Analytical Group: PFAS (LC-MS/MS Compliant with QSM v5.1.1 Table B-15)
Matrix: Groundwater and Surface water

Analyte	CAS No.	Lifetime Health Advisory (µg/L)	RSLs Tap Water[a] (HQ = 0.1), May 2020 (µg/L)	Fresh Surface Water ESVs (µg/L)	PAL (µg/L)	PQL Goal[b,c] (µg/L)	Laboratory-Specific Limits (µg/L)			Accuracy Control Limit (%R)[d]		Precision Control Limit (% RPD)
							LOQs	LODs	DLs			
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	0.07	0.04	5.1	0.04	0.02	0.005	0.0005	0.00019	40	144	30
Perfluorooctanoic acid (PFOA)	335-67-1	0.07	0.04	2,900	0.04	0.02	0.005	0.0005	0.00018	49	141	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	--	40	24,000	40	200	0.005	0.0005	0.00013	56	134	30
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	--	--	--	0.005	0.005	0.001	0.00049	51	131	30
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	--	--	--	0.005	0.005	0.002	0.00056	50	146	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	--	--	0.005	0.005	0.0005	0.00016	59	135	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	--	--	0.005	0.005	0.0005	0.00018	75	131	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	--	--	0.005	0.005	0.0005	0.00016	48	136	30
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	--	--	--	--	0.005	0.005	0.0004	0.00011	52	128	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	--	--	0.005	0.005	0.0005	0.00019	51	137	30
Perfluorononanoic acid (PFNA)	375-95-1	--	--	--	--	0.005	0.005	0.001	0.00026	58	122	30
Perfluorotetradecanoic acid (PFTA)	376-06-7	--	--	--	--	0.005	0.005	0.001	0.00025	42	158	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	--	--	0.005	0.005	0.0005	0.00015	42	148	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	--	--	0.005	0.005	0.001	0.00029	64	134	30
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	--	--	0.005	0.005	0.0004	0.0002	70	130	30
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	--	--	0.005	0.005	0.0004	0.00018	70	130	30
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	--	--	0.005	0.005	0.0004	0.00018	70	130	30
9-Chlorohexadecafluoro-3-oxanone-1-sulfonic (9Cl-PF3ONS)	756426-58-1	--	--	--	--	0.005	0.005	0.0004	0.0001	70	130	30

Notes:
[a] RSLs for PFOA and PFOS were calculated using the RSL calculator on March 29, 2019.
[b] The PAL for groundwater is the minimum of lifetime health advisory, RSLs tap water and fresh surface water ESVs. Refer to **Worksheets #1**0 and **#11** for a detailed discussion on development of PALs.
[c] The project quantitation limit (PQL) goal is 1/2 the PAL, the PAL, or the laboratory-specific LOQ, as applicable.
[d] In-house laboratory limits are the basis for laboratory control sample (LCS) and MS/MSD limits.
µg/L = microgram(s) per liter
CAS = Chemical Abstracts Service

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

Analytical Group: TPH
Matrix: Groundwater

Analyte	CAS No.	Maryland Cleanup Standards	PAL (µg/L)	PQL Goal[a,b] (µg/L)	Laboratory-Specific Limits (µg/L)			Accuracy Control Limit (%R)[c]		Precision Control Limit (% RPD)
					LOQs	LODs	DLs			
TPH-gas range	TPH-GRO	47	47	200	200	90	45	40	144	30
TPH-diesel range	TPH-DRO	47	47	175	175	90	45	49	141	30
4-Bromofluorobenzene [SURR]	*460-00-4*	--	--	--	--	--	--	*69*	*133*	--
o-Terphenyl [SURR]	*84-15-1*	--	--	--	--	--	--	*56*	*125*	--

Notes:
Shading indicates cells where the LOD is greater than the PQL Goal.
[a] The PAL for GW is the Maryland Cleanup Standard. Refer to **Worksheets #10** and **#11** for a detailed discussion on development of PALs.
[b] The PQL goal is 1/2 the PAL, the PAL, or the laboratory-specific LOQ, as applicable.
[c] In-house laboratory limits are the basis for LCS and MS/MSD limits.

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

Analytical Group: PFAS (LC-MS/MS Compliant with QSM v5.1.1 Table B-15)
Matrix: Surface Soil, Subsurface Soil, and Sediment

Analyte	CAS No.	Residential Soil RSLs[a] (HQ = 0.1), May 2020 (µg/kg)	Soil ESVs (µg/kg)	Freshwater Sediment ESVs (µg/kg)	PAL (µg/kg)	PQL Goal[b,c] (µg/kg)	Laboratory-Specific Limits (µg/kg)			Accuracy Control Limit (%R)[d]		Precision Control Limit (% RPD)
							LOQs	LODs	DLs			
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	130	4,600	220	130	65	5	1	0.27	50	130	30
Perfluorooctanoic acid (PFOA)	335-67-1	130	16,000	--	130	65	5	1	0.5	56	136	30
Perfluorobutanesulfonic acid (PFBS)	375-73-5	130,000	--	--	130,000	65,000	5	1	0.36	57	145	30
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	--	--	--	--	5	2	0.57	54	124	30
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	--	--	--	--	5	2.5	1.12	52	146	30
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	--	--	--	5	1	0.27	55	141	30
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	--	--	--	5	0.5	0.24	62	134	30
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	--	--	--	5	1	0.44	60	128	30
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	--	--	--	--	--	5	0.5	0.22	52	132	30
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	--	--	--	5	1	0.33	45	135	30
Perfluorononanoic acid (PFNA)	375-95-1	--	--	--	--	--	5	1	0.43	54	130	30
Perfluorotetradecanoic acid (PFTA)	376-06-7	--	--	--	--	--	5	2	0.63	34	162	30
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	--	--	--	5	1	0.28	51	127	30
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	--	--	--	5	1	0.41	57	137	30
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	--	--	--	5	2	0.57	70	130	30
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	--	--	--	5	1	0.32	70	130	30
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	--	--	--	5	1	0.4	70	130	30
9-Chlorohexadecafluoro-3-oxanone-1-sulfonic (9Cl-PF3ONS)	756426-58-1	--	--	--	--	--	5	1	0.45	70	130	30

Notes:
[a] RSLs for PFOA and PFOS were calculated using the RSL calculator on March 29, 2019 because there are no RSLs for PFOA and PFOS on the current RSL table.
[b] The PAL for soil and sediment is the residential soil RSL. Refer to **Worksheets #10** and **#11** for a detailed discussion on development of PALs.
[c] The PQL goal is 1/2 the PAL, the PAL, or the laboratory-specific LOQ, as applicable.
[d] In-house laboratory limits are the basis for laboratory control sample (LCS) and MS/MSD limits.
µg/kg = microgram(s) per kilogram

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SAP Worksheet #16—Project Schedule/Timeline Table

Activities	Dates	
	Anticipated Date(s) of Initiation	**Anticipated Date of Completion**
Submit Pre-Draft SAP	March 2019	November 2019
Base and Navy Review of SAP	November 2019	February 2020
Prepare and Submit Draft SAP	March 2020	March 2020
MDE Review of SAP	March 2020	April 2020
Prepare and Submit Final SAP	April 2020	August 2020
Anticipated Fieldwork	September 2020	October 2020
SI Report	October 2020	April 2021

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SAP Worksheet #17—Sampling Design and Rationale

Matrix	Depth of Samples	Analyses	Method	Approximate Number of Samples	Strategy and Rationale
Groundwater	Middle of screen (**Worksheet #18**)	PFAS (**Worksheet #15-1**)	LC-MS/MS compliant with QSM Version 5.1.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection (PFAS)	27	The 2017 investigation of PFAS in groundwater recommended additional well installation and sampling of groundwater to delineate the extent of PFAS in shallow groundwater. Samples from the surficial aquifer will be collected from 18 existing and 5 newly installed monitoring wells as presented on **Figure 3** and as follows to delineate extent and determine current concentrations: • 18 existing shallow monitoring wells (AOA-MW01 through AOA-MW10, SO3-MW01, SO3-MW02, S04-MW01, BKG-MW01 through BKG-MW03, HVGGW09, and HVGGW10) • 5 new shallow monitoring wells (CBD-AOA-MW15 through CBD-AOA-MW19) Samples will be collected from four existing deep (Piney Point aquifer) monitoring wells to determine the current concentrations of PFAS in the Piney Point aquifer. Additional groundwater samples may be collected, if warranted, under this SAP to achieve the SI objectives.
		TPH-GRO and TPH-DRO (**Worksheet #15-2**)	SW-846 8015C (TPH)	7	Samples from seven shallow wells (CBD-AOA-MW01 through CBD-AOA-MW04, CBD-AOA-MW08, CBD-S03-MW01, and CBD-S03-MW02) will be analyzed for TPH to characterize the nature of TPH contamination.
Surface Soil	0 to 6 inches bgs	PFAS (**Worksheet #15-3**)	LC-MS/MS compliant with QSM Version 5.1.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	29	Twenty-nine surface soil samples (co-located with subsurface soil samples) will be collected from the known source area to evaluate and determine the extent of contamination in surface soil. Proposed surface soil locations are presented on **Figure 6**. Additional surface soil samples will be collected, if warranted, under this SAP to achieve the SI objectives.
Subsurface Soil	Field-observed contaminated interval, or directly above the water table (29 samples) 8 to 10 feet bgs (5 samples)	PFAS (**Worksheet #15-3**)	LC-MS/MS compliant with QSM Version 5.1.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	34	Thirty-four subsurface soil samples (co-located with surface soil samples) will be collected from 29 locations in the known source area to evaluate and determine the extent of contamination in subsurface soil. An additional subsurface sample will be collected from 8 to 10 feet bgs at five locations (CBD-AOA-SO25 through CBD-AOA-SO29). Proposed subsurface soil locations are presented on **Figure 6**. Additional subsurface soil samples will be collected if warranted to achieve the SI objectives.
Surface Water	First encountered surface water	PFAS (**Worksheet #15-1**)	LC-MS/MS compliant with QSM Veresion 5.1.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	11	Eleven surface water samples will be collected. Five surface water samples will be collected north of Site 10, and six surface water samples will be collected south of Site 10. Sample results will be used to evaluate the potential impact of PFAS to surface water. Sample locations are presented on **Figure 7**. Additional surface water samples will be collected if warranted to achieve the SI objectives.
Sediment	0 to 6 inches bgs	PFAS (**Worksheet #15-3**)	LC-MS/MS compliant with QSM Version 5.1.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	4	Four sediment samples will be collected (co-located with surface water sample locations). Two sediment samples will be collected north of Site 10, and two sediment samples will be collected south of Site 10. Sample results will be used to evaluate the potential impact of PFAS to sediment. Sample locations are presented on **Figure 7**. Additional sediment samples will be collected if warranted to achieve the SI objectives.

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

(UFP-QAPP Manual Section 3.1.1)

Station ID	Sample ID[a]	Matrix	Depth	Analytical Group	Number of Samples[a,b]	Sampling SOP Reference
Soil Sampling						
CBD-AOA-SO01	CBD-AOA-SS01-000H	SS	0 - 6"	PFAS	1	See **Worksheet #21**
	CBD-AOA-SS01P-000H				1 (FD)	
	CBD-AOA-SB01-TDBD	SB	TBD		1	
CBD-AOA-SO02	CBD-AOA-SS02-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB02-TDBD	SB	TBD		1	
CBD-AOA-SO03	CBD-AOA-SS03-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB03-TDBD	SB	TBD		1	
CBD-AOA-SO04	CBD-AOA-SS04-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB04-TDBD	SB	TBD		1	
CBD-AOA-SO05	CBD-AOA-SS05-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB05-TDBD	SB	TBD		1	
CBD-AOA-SO06	CBD-AOA-SS06-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB06-TDBD	SB	TBD		1	
CBD-AOA-SO07	CBD-AOA-SS07-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB07-TDBD	SB	TBD		1	
CBD-AOA-SO08	CBD-AOA-SS08-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB08-TDBD	SB	TBD		1	
CBD-AOA-SO09	CBD-AOA-SS09-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB09-TDBD	SB	TBD		1	
CBD-AOA-SO10	CBD-AOA-SS10-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB10-TDBD	SB	TBD		1	

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

(UFP-QAPP Manual Section 3.1.1)

Station ID	Sample ID[a,b]	Matrix	Depth	Analytical Group	Number of Samples[a,c]	Sampling SOP Reference
CBD-AOA-SO11	CBD-AOA-SS11-000H	SS	0 - 6"	PFAS	1	See **Worksheet #21**
	CBD-AOA-SS11-000H-MS				1 (MS)	
	CBD-AOA-SS11-000H-MSD				1 (MSD)	
	CBD-AOA-SB11-TDBD	SB	TBD		1	
CBD-AOA-SO12	CBD-AOA-SS12-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB12-TDBD	SB	TBD		1	
CBD-AOA-SO13	CBD-AOA-SS13-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB13-TDBD	SB	TBD		1	
CBD-AOA-SO14	CBD-AOA-SS14-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB14-TDBD	SB	TBD		1	
CBD-AOA-SO15	CBD-AOA-SS15-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB15-TDBD	SB	TBD		1	
CBD-AOA-SO16	CBD-AOA-SS16-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB16-TDBD	SB	TBD		1	
CBD-AOA-SO17	CBD-AOA-SS17-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SS17P-000H				1 (FD)	
	CBD-AOA-SB17-TDBD	SB	TBD		1	
CBD-AOA-SO18	CBD-AOA-SS18-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB18-TDBD	SB	TBD		1	
CBD-AOA-SO19	CBD-AOA-SS19-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB19-TDBD	SB	TBD		1	
CBD-AOA-SO20	CBD-AOA-SS20-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB20-TDBD	SB	TBD		1	
CBD-AOA-SO21	CBD-AOA-SS21-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB21-TDBD	SB	TBD		1	

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

(UFP-QAPP Manual Section 3.1.1)

Station ID	Sample ID[a,b]	Matrix	Depth	Analytical Group	Number of Samples[a,c]	Sampling SOP Reference
	CBD-AOA-SB21P-TDBD				1 (FD)	
CBD-AOA-SO22	CBD-AOA-SS22-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB22-TDBD	SB	TBD		1	
CBD-AOA-SO23	CBD-AOA-SS23-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB23-TDBD	SB	TBD		1	
CBD-AOA-SO24	CBD-AOA-SS24-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB24-TDBD	SB	TBD		1	
CBD-AOA-SO25	CBD-AOA-SS25-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SS25-000H-MS				1 (MS)	
	CBD-AOA-SS25-000H-MSD				1 (MSD)	
	CBD-AOA-SB25-0810	SB	8' - 10'		1	
	CBD-AOA-SB25-TDBD	SB	TBD		1	
CBD-AOA-SO26	CBD-AOA-SS26-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB26-0810	SB	8' - 10'		1	
	CBD-AOA-SB26-TDBD	SB	TBD		1	
CBD-AOA-SO27	CBD-AOA-SS27-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB27-0810	SB	8' - 10'		1	
	CBD-AOA-SB27-TDBD	SB	TBD		1	
CBD-AOA-SO28	CBD-AOA-SS28-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB28-0810	SB	8' - 10'		1	
	CBD-AOA-SB28-TDBD	SB	TBD		1	
CBD-AOA-SO29	CBD-AOA-SS29-000H	SS	0 - 6"	PFAS	1	
	CBD-AOA-SB29-0810	SB	8' - 10'		1	
	CBD-AOA-SB29-TDBD	SB	TBD		1	

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

(UFP-QAPP Manual Section 3.1.1)

Station ID	Sample ID[a,b]	Matrix	Depth	Analytical Group	Number of Samples[a,c]	Sampling SOP Reference
Groundwater Sampling						
Shallow Wells - Existing						
CBD-AOA-MW01	CBD-AOA-MW01-MMYY	GW	--	PFAS, TPH	1	See **Worksheet #21**
	CBD-AOA-MW01P-MMYY				1 (FD)	
CBD-AOA-MW02	CBD-AOA-MW02-MMYY	GW	--	PFAS, TPH	1	
CBD-AOA-MW03	CBD-AOA-MW03-MMYY	GW	--	PFAS, TPH	1	
CBD-AOA-MW04	CBD-AOA-MW04-MMYY	GW	--	PFAS, TPH	1	
CBD-AOA-MW05	CBD-AOA-MW05-MMYY	GW	--	PFAS	1	
CBD-AOA-MW06	CBD-AOA-MW06-MMYY	GW	--	PFAS	1	
CBD-AOA-MW07	CBD-AOA-MW07-MMYY	GW	--	PFAS	1	
CBD-AOA-MW08	CBD-AOA-MW08-MMYY	GW	--	PFAS, TPH	1	
	CBD-AOA-MW08-MMYY-MS				1 (MS)	
	CBD-AOA-MW08-MMYY-MSD				1 (MSD)	
CBD-AOA-MW09	CBD-AOA-MW09-MMYY	GW	--	PFAS	1	
CBD-AOA-MW10	CBD-AOA-MW10-MMYY	GW	--	PFAS	1	
CBD-BKG-MW01	CBD-BKG-MW01-MMYY	GW	--	PFAS	1	
CBD-BKG-MW02	CBD-BKG-MW02-MMYY	GW	--	PFAS	1	
CBD-BKG-MW03	CBD-BKG-MW03-MMYY	GW	--	PFAS	1	
CBD-HVGGW09	CBD-HVGGW09-MMYY	GW	--	PFAS	1	
CBD-HVGGW10	CBD-HVGGW10-MMYY	GW	--	PFAS	1	
CBD-S04-MW01	CBD-S04-MW01-MMYY	GW	--	PFAS	1	
CBD-S03-MW01	CBD-S03-MW01-MMYY	GW	--	PFAS, TPH	1	
CBD-S03-MW02	CBD-S03-MW02-MMYY	GW	--	PFAS, TPH	1	
	CBD-S03-MW02P-MMYY				1 (FD)	

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

(UFP-QAPP Manual Section 3.1.1)

Station ID	Sample ID[a,b]	Matrix	Depth	Analytical Group	Number of Samples[a,c]	Sampling SOP Reference
Deep Wells - Existing						
CBD-AOA-MW11	CBD-AOA-MW11-MMYY	GW	--	PFAS	1	See **Worksheet #21**
	CBD-AOA-MW11P-MMYY	GW	--		1 (FD)	
CBD-AOA-MW12	CBD-AOA-MW12-MMYY	GW	--	PFAS	1	
CBD-AOA-MW13	CBD-AOA-MW13-MMYY	GW	--	PFAS	1	
CBD-AOA-MW14	CBD-AOA-MW14-MMYY	GW	--	PFAS	1	
Shallow Wells - New						
CBD-AOA-MW15	CBD-AOA-MW15-MMYY	GW	--	PFAS	1	See **Worksheet #21**
CBD-AOA-MW16	CBD-AOA-MW16-MMYY	GW	--	PFAS	1	
	CBD-AOA-MW16-MMYY-MS				1 (MS)	
	CBD-AOA-MW16-MMYY-MSD				1 (MSD)	
CBD-AOA-MW17	CBD-AOA-MW17-MMYY	GW	--	PFAS	1	
CBD-AOA-MW18	CBD-AOA-MW18-MMYY	GW	--	PFAS	1	
CBD-AOA-MW19	CBD-AOA-MW19-MMYY	GW	--	PFAS	1	
Sediment and Surface Water Sampling						
CBD-AOA-SW01	CBD-AOA-SW01-MMYY	SW	--	PFAS	1	See **Worksheet #21**
CBD-AOA-SWSD02	CBD-AOA-SW02-MMYY	SW	--	PFAS	1	
	CBD-AOA-SW02P-MMYY		--		1 (FD)	
	CBD-AOA-SD02-TDBD	SD	TBD		1	
CBD-AOA-SW03	CBD-AOA-SW03-MMYY	SW	--	PFAS	1	
CBD-AOA-SWSD04	CBD-AOA-SW04-MMYY	SW	--	PFAS	1	
	CBD-AOA-SD04-TDBD	SD	TBD		1	
	CBD-AOA-SD04-TDBD-MS				1 (MS)	
	CBD-AOA-SD04-TDBD-MSD				1 (MSD)	
CBD-AOA-SW05	CBD-AOA-SW05-MMYY	SW	--	PFAS	1	
CBD-AOA-SWSD06	CBD-AOA-SW06-MMYY	SW	--	PFAS	1	

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

(UFP-QAPP Manual Section 3.1.1)

Station ID	Sample ID[a,b]	Matrix	Depth	Analytical Group	Number of Samples[a,c]	Sampling SOP Reference
	CBD-AOA-SD06-TDBD	SD	TBD		1	
CBD-AOA-SW07	CBD-AOA-SW07-MMYY	SW	--	PFAS	1	
CBD-AOA-SWSD08	CBD-AOA-SW08-MMYY	SW	--	PFAS	1	
	CBD-AOA-SD08-TDBD	SD	TBD		1	
	CBD-AOA-SD08P-TDBD				1 (FD)	
CBD-AOA-SW09	CBD-AOA-SW09-MMYY	SW	--	PFAS	1	
CBD-AOA-SW10	CBD-AOA-SW10-MMYY	SW	--	PFAS	1	
	CBD-AOA-SW10-MMYY-MS		--		1 (MS)	
	CBD-AOA-SW10-MMYY-MSD		--		1 (MSD)	
CBD-AOA-SW11	CBD-AOA-SW11-MMYY	SW	--	PFAS	1	
	CBD-AOA-SW11P-MMYY			PFAS	1 (FD)	
Field QC						
CBD-AOA-QC	CBD-AOA-EB01-MMDDYY-SO	QC	--	PFAS	7 (EB)	See **Worksheet #21**
	CBD-AOA-EB01-MMDDYY-SW				1 (EB)	
	CBD-AOA-EB01-MMDDYY-GW				3 (EB)	
				PFAS, TPH	1 (EB)	
	CBD-AOA-FB01-MMDDYY			PFAS	3 (FB)	

Notes:

[a] Quantities shown for blanks are estimated. Refer to **Worksheet #28** for the required frequencies.

[b] Subsurface soil will be collected from intervals displaying evidence of contamination (soil staining, PID readings, etc.) as determined during soil characterization. If no evidence of contamination is observed, a single subsurface soil sample will be collected directly above the water table. At five locations (proposed sample locations CBD-AOA-SO25 through CBD-AOA-SO29 on **Figure 6**), an additional subsurface sample will be collected from the 8- to 10-foot bgs interval.

[c] Locations for FDs and MS/MSDs are shown for convenience. In practice, the field team can collect these wherever there is sufficient volume. Refer to **Worksheet #28** for the required frequencies.

EB = equipment blank

FD = field duplicate

ID = identification

SAP Worksheet #19—Analytical SOP Requirements Table

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference[a]	Containers (number, size, and type)	Sample Volume[b] (units)	Preservation Requirements (chemical, temperature, light-protected)	Maximum Holding Time[c] (preparation / analysis)
GW	TPH	SW-846 8015C / VOC-014	Two of 40-mL VOA vials	40 mL (per vial)	≤ 6°C, but no frozen	14 days
		SW-846 8015C / SVOC-001, SVOC-040	Two of 1-liter Amber	1 liter		7 days, 40 days
GW, SW	PFAS	LC-MS/MS Compliant with QSM Version 5.1.1 Table B-15/ SOP 5-370-07, SOP 5-369-06	Two of 250-mL HDPE	250 mL	≤ 10°C at laboratory receipt, storage in the laboratory ≤ 6°C, but not frozen	14 days, 28 days
SS, SB, SD			One of 8-ounce HDPE Jar	30 grams		14 days, 28 days

Notes:

[a] Specify the appropriate reference letter or number from the Analytical SOP References table (**Worksheet #23**).

[b] Minimum volume required. Fill containers to capacity.

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

HDPE = high-density polyethylene

mL = milliliter(s)

VOA = volatile organic analysis

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SAP Worksheet #20—Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations[a]	No. of Field Duplicates	No. of MS/MSDs[b]	No. of Trip Blanks[c]	No. of Field Blanks	No. of Equip. Blanks[c]	Total No. of Samples to Lab
Soil Sampling								
SS	PFAS	29	3	2		1	3	40
SB		34	4	2			3	45
Groundwater Sampling								
GW	TPH	7	1	1	1		1	12
	PFAS	27	3	2		1	3	38
Sediment/Surface Water Sampling								
SD	PFAS	4	1	1			1	8
SW		11	2	1		1	1	17

Notes:

[a] If samples will be collected at different depths at the same location, count each discrete sampling depth as a separate sampling location or station.

[b] Although the MS/MSD is not typically considered a field QC, it is included here because location determination is often established in the field.

[c] The number of equipment blanks and trip blanks is based on a fundamental assumption of the number of sampling days each site will require. It was assumed that the soil sampling will occupy a total of 6 days. It was assumed that the groundwater sampling will occupy a total of 1 day.

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SAP Worksheet #21—Project Sampling SOP References Table

Title, Revision Date, and / or Number[a]	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
Locating and Clearing Underground Utilities, QC and reviewed 10/2018	CH2M	(Various – see Attachment C of SOP)	N	
Decontamination of Personnel and Equipment, QC and revised 10/2018	CH2M	Deionized water, distilled water, potable water, 2.5% Liquinox and water solution, methanol, plastic pails, 55-gallon drum for waste, nitrile gloves, decontamination pad, steam cleaner	Y	No PFAS-containing materials
Disposal of Waste Fluids and Solids, QC and reviewed 10/2018	CH2M	Fluids: 55-gallon drum, tools to secure drum, funnel, labels, marking pen (not Sharpies or other PFAS-containing pens), seals for drum Solids: 55-gallon drum, tools to secure drum, plastic sheets, labels, marking pen (not Sharpies or other PFAS-containing pens)	Y	No PFAS-containing materials
Decontamination of Drilling Rigs and Equipment, QC and reviewed 10/2018	CH2M	Steam cleaner, potable water, Liquinox, buckets, brushes, distilled water, methanol, deionized water, aluminum foil (non-coated foil)	Y	No PFAS-containing materials
Logging of Soil Borings, QC and reviewed 10/2018	CH2M	Indelible pens (not Sharpies or other PFAS-containing pens), tape measure, loose leaf paper and clipboard, spatula, hydrochloric acid, 10% solution, squirt bottle, rock or soil color chart, grain size chart, hand lens, Unified Soil Classification System index charts and tables	Y	No PFAS-containing materials
Preparing Field Log Books, QC and reviewed 10/2018	CH2M	Loose leaf paper and clip board, black indelible pen (not Sharpies or other PFAS-containing pens)	Y	No PFAS-containing materials
Chain-of-Custody, QC and reviewed 10/2018	CH2M	Chain-of-custody, indelible pen (not Sharpies or other PFAS-containing pens)	Y	No PFAS-containing materials
Equipment Blank and Field Blank Preparation, QC and reviewed 10/2018	CH2M	Sample bottles as appropriate, gloves, blank liquid, preservatives as appropriate	Y[1]	
Field Measurement of pH, Specific Conductance, Turbidity, DO, ORP, and Temperature Using A Water Quality Parameter Meter with Flow-through Cell, QC and reviewed 10/2018	CH2M	Water quality parameter meter such as a Horiba U-22 Water Quality Monitoring System or YSI with flow-through cell, calibration standard solutions (provided by rental company), deionized water in squirt bottle	N	
Water-Level Measurements, QC and reviewed 10/2018	CH2M	PFAS-free electronic water-level meter with 100-foot tape, interface probe	Y	No PFAS-containing materials
General Guidance for Monitoring Well Installation, QC and reviewed 10/2018	CH2M	Drilling rig, PFAS-free well construction materials, development equipment	Y	No PFAS-containing materials
Soil Sampling, QC and reviewed 10/2018	CH2M	Stainless-steel trowel, shovel, scoop, coring device, hand auger, or other appropriate hand tool; thin-walled sampling tubes; drilling rig or soil-coring rig; stainless-steel pan/bowl; sample bottles	Y	No PFAS-containing materials
Soil Sampling for Per- and Polyfluoroalkyl Substances, QC and reviewed 10/2019	CH2M	Stainless-steel auger and extensions, stainless steel spatula, pin flags, fiberglass measuring tape and PFAS-free shipping materials and equipment	N	
Direct-Push Soil Sample Collection, QC and reviewed 10/2018	CH2M	Truck-mounted hydraulic percussion hammer, sampling rods, sampling tubes and acetate liners, pre-cleaned sample containers and stainless-steel sampling implements, personal protective equipment	Y	No PFAS-containing materials
Surface Water Sampling for Per- and Polyfluoroalkyl Substances, QC and reviewed 10/2019	CH2M	Gloves, sample containers, meters for DO, pH, etc., and PFAS-free shipping materials and equipment	N	
Sediment Sampling for Per- and Polyfluoroalkyl Substances, QC and reviewed 10/2019	CH2M	Sample collection device, stainless steel spoon, measuring tape, materials for classifying soils, sample jars, PFAS-free shipping materials and equipment	N	
Homogenization of Soil and Sediment Samples, QC and reviewed 10/2018	CH2M	Sample containers, stainless steel spoons or spatulas, stainless steel pans, disposable scoop/trowel, and dedicated sealable bag	Y	No PFAS-containing materials
Groundwater Sampling for Per- and Polyfluoroalkyl Substances, QC and reviewed 10/2019	CH2M	Flow-through cell, water level indicator, filter (if necessary), adjustable rate, PFAS-free pump, Teflon-free tubing, plastic sheets, well construction info, measuring cup, bucket, PFAS-free sample containers and PFAS-free shipping materials and equipment	N	

SAP Worksheet #21—Project Sampling SOP References Table (continued)

Title, Revision Date, and / or Number[1]	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
Sampling Contents of Tanks and Drums, QC'ed and reviewed 10/2018	CH2M	Drum/tank, sampling instrument, gloves, plastic sheets, labels, monitoring instrument	Y	No PFAS-containing materials
Management of Liquid Waste Containing Per- and Polyfluoroalkyl Substances (PFAS), QC and reviewed 2/2019	CH2M	(Equipment not listed- sample the drummed purged water as directed by your environmental manager)	N	
Packaging and Shipping Procedures for Low-Concentration Samples, QC and reviewed 10/2018	CH2M	Coolers, clear tape, strapping tape, contractor bags, absorbent pads or equivalent, resealable bags, bubble bags, bubble wrap, ice, chain-of-custody form, custody seals	Y	No PFAS-containing materials

Note:

[a] Laboratory-supplied, PFAS-free water will be used in place of ASTM International Type II or laboratory grade water to prepare the PFAS Field Reagent Blanks.

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

Field Equipment	Activity[a]	Frequency	Acceptance Criteria	CA	Responsible Person	Comments
Horiba U-22 pH probe	Calibration and verification of calibration	Calibrate daily, before use and verify as needed	pH reads 4.0 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	**Worksheet #21** and **Appendix C**
Horiba U-22 Specific conductance probe	Calibration and verification of calibration	Calibrate daily, before use and verify as needed	Conductivity reads 4.49 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	**Worksheet #21** and **Appendix C**
Horiba U-22 Turbidity probe	Calibration and verification of calibration	Calibrate daily, before use and verify as needed	Turbidity reads 0 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	**Worksheet #21** and **Appendix C**
Horiba U-22 DO and Temperature Probes	Calibration and verification of calibration	Calibrate daily, before use and verify as needed	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	**Worksheet #21** and **Appendix C**
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	**Worksheet #21** and **Appendix C**
Mini-RAE PID	Maintenance- Check mechanical and electronic parts, verify system continuity, check battery, and clean filter (change if clogged or dirty) Calibration check	Daily before use, at the end of the day, and when unstable readings occur	Fresh air calibration reads 0.0 parts per million (ppm) Span gas calibration (isobutylene) reads 100.0 ppm All within ±3.0 ppm	Replace filter, clean airway, and check for obstructions. Use external filter if there is high humidity or if it is raining. Do not use instrument if not able to calibrate properly.	FTL	

Note:

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

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SAP Worksheet #23—Analytical SOP References Table

(UFP-QAPP Manual Section 3.2.1)

Lab SOP Number	Title, Revision Date, and/or Number	Date Last Revisited if not Revised[a]	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis[b]	Variance to QSM	Modified for Project Work?
5-369-07	PFAS Analytical; March 2019; Rev. 7	--	Definitive	GW, SW, SS, SB, SD / PFAS	LC-MS/MS	Battelle	None	N
5-370-08	PFAS Sample Preparation; April 2019; Rev. 8	--	Definitive	GW, SW, SS, SB, SD / PFAS	NA	Battelle	None	N
6-010-18	Sample Receipt, Custody, and Handling; April 2018; Rev. 18	--	NA	NA	NA	Battelle	None	N
SVOC-001	Method 3510C Separatory Funnel Liquid-Liquid Extraction; April 2019; Rev. 6	--	Definitive	GW / TPH	GC/FID	AEL	None	N
SVOC-040	Method for Determination of Diesel Range Organics (DRO) using GC/FID; April 2019; Rev. 1	--	Definitive	GW / TPH	GC/FID	AEL	None	N
VOC-014	Method for Determination of Gasoline Range Organics (GRO) using GC/FID; May 2019; Rev. 1	--	Definitive	GW / TPH	GC/FID	AEL	None	N
ADMIN-005	Sample Receipt, Handling, Storage, and Log In; April 2019; Rev. 7	--	NA	NA	NA	AEL	None	N
ADMIN-018	Waste Disposal and Pollution Prevention; June 2019; Rev. 6	--	NA	NA	NA	AEL	None	N

Notes:

[a] **Worksheet #23** is a snapshot as it pertains to laboratory SOPs.

[b] Battelle's DoD Environmental Laboratory Accreditation Program (ELAP) accreditation through Perry Johnson Laboratory Accreditation, Inc. (PJLA) is granted through February 28, 2021. AEL's DoD ELAP accreditation through PJLA is granted through June 29, 2020. Refer to **Appendix D**.

GC = gas chromatograph

FID = flame ionization detector

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SAP Worksheet #24—Analytical Instrument Calibration Table

Instrument[a]	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA[b]	SOP Reference[c]
LC-MS/MS (for PFAS)	Initial Calibration (ICAL)	At instrument set-up and after ICV or CCV failure, before sample analysis. Calibration can be linear (minimum of 5 standards) or quadratic (minimum of 6 standards); weighting is allowed.	The isotopically labeled analog of an analyte (extracted internal standard analyte) must be used for quantitation if commercially available (isotope dilution quantitation). 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 quantification. For analytes having a promulgated standard, (for example, lifetime health advisory levels for PFOA and PFOS) the qualitative (confirmation) transition ion must have a S/N Ratio of ≥ 3:1. The %RSD of the response factors for all analytes must be <20%. Linear or nonlinear calibrations must have $r^2 \geq 0.99$ for each analyte. Analytes must be within 70% to 130% of their true value for each calibration standard. Isotope dilution or internal standard calibration is required for all analytes. External calibration is not allowed.	Correct problem then repeat ICAL. Flagging is not appropriate. No samples shall be analyzed until ICAL has passed.	Analyst	5-369-07
	Initial Calibration Verification (ICV)	Once after each ICAL, analysis of a second source standard before sample analysis.	Analyte concentrations must be within ±30% of their true value. No samples shall be analyzed until calibration has been verified.	Correct problem, rerun ICV. If problem persists, repeat ICAL. Flagging is not appropriate.		
	Continuing Calibration Verification (CCV)	Before sample analysis, after every 10 field samples, and at the end of the analytical sequence.	Concentration of analytes must range from the LOQ to the mid-level calibration concentration. Analyte concentrations must be within ±30% of their true value. Instrument sensitivity check (ISC) can serve as a bracketing CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails or if two consecutive CCVs cannot be run, perform CA(s) and repeat CCV and all associated samples since last successful CCV. Alternatively, recalibrate if necessary; then reanalyze all associated samples since last acceptable CCV. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. Results may not be reported without valid CCVs.		
	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 tuning redone. Flagging criteria are not appropriate. No samples shall be analyzed without a valid tune.		
	Mass Calibration	Initially before 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.	Flagging is not appropriate.		
	Mass Spectral Acquisition Rate	Each analyte, extracted internal standard analyte, and injection internal standard analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	Flagging is not appropriate.		
	Calibration, Calibration Verification, and Spiking Standards	All analytes.	Standards containing both branched and linear isomers must be used when commercially available. 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 (for example, PFOA). Standards containing both branched and linear isomers are to be used during method validation to ensure the total response is quantitated for that analyte. Technical grade standards cannot be used for quantitative analysis.	Flagging is not appropriate.		

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

Instrument[a]	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA[b]	SOP Reference[c]
	Ion Transitions (Parent -> Product)	Before 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. To avoid biasing results high because of known inferences for some transitions, the following transitions must be used for the quantification of the following analytes: PFOA: 413 —› 369 PFOS: 499 —› 80 PFHxS: 399 —› 80 PFBS: 299 —› 80 4:2 FTS: 327 —› 307 6:2 FTS: 427 —› 407 8:2 FTS: 527 —› 507 NEtFOSAA: 584 —› 419 NMeFOSAA: 570 —› 419 If these transitions are not used, the reason must be technically justified and documented (for example, alternate transition was due to observed interferences).	Flagging is not appropriate.		
	ISC	Before analysis and at least once every 12 hours.	Analyte concentrations must be at LOQ; concentrations must be within ±30% of their true values. No samples shall be analyzed until ISC has met acceptance criteria. ISC can serve as the initial daily CCV.	Correct problem, rerun ISC. If problem persists, repeat ICAL. Flagging is not appropriate.		
GC/FID (For TPH-GRO and TPH-DRO)	ICAL	At instrument setup and after ICV or CCV failure, before sample analysis.Minimum 5 levels for linear and 6 levels for quadratic.	ICAL must meet one of the three options:Option 1: RSD for each analyte ≤ 20%; Option 2: linear least squares regression for each analyte: $r^2 \geq 0.99$;Option 3: non-linear least squares regression (quadratic) for each analyte: r2 ≥ 0.99.Results may not be quantitated using a single point.	Correct problem then repeat ICAL. Flagging is not appropriate. No samples shall be analyzed until ICAL has passed.	Analyst	VOC-014, SVOC-040
	ICV	Once after each ICAL, analysis of a second source standard before sample analysis.	All reported analytes within established RT windows. All reported analytes within ± 20% of true value.	Correct problem, rerun ICV. If that fails, repeat ICAL. Flagging is not appropriate. No samples shall be analyzed until calibration has been verified with a second source.		
	CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence	All reported analytes and surrogates within established RT windows. All reported analytes within ± 20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails or if two consecutive CCVs cannot be run, perform CA(s) and repeat CCV and all associated samples since last successful CCV. Alternatively, recalibrate if necessary; then reanalyze all associated samples since last acceptable CCV. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. Results may not be reported without valid CCVs. Flagging is only appropriate in cases where the samples cannot be reanalyzed.		
	Retention Time (RT) Window Position Establishment	Once per ICAL and at the beginning of the analytical sequence	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	NA. Calculated for each analyte and surrogate.		
	RT Window Width	At method set-up and after major maintenance	RT width is ± 3 times standard deviation for each analyte RT from the 72-hour study or 0.03 minute, whichever is greater.	NA. Calculated for each analyte and surrogate.		

Notes:

[a] DoD QSM Version 5.1.1 is the basis for specifications for PFAS, and DoD QSM Version 5.1 is the basis for specifications for TPH on this table.

[b] Name or title of responsible person may be used.

[c] Specify the appropriate reference letter or number from the Analytical SOP References table (**Worksheet #23**).

RSD = relative standard deviation

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

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	Responsible Person[a]	SOP Reference[b]
LC-MS/MS	Clean curtain plate	PFAS	Visual inspection of curtain plate for residue.	As needed when curtain plate has visible residue present.	No visible residue on curtain plate.	Remove and clean the instrument curtain plate.	Analyst	5-369-06
	Preventative maintenance	PFAS	Degradation of instrument performance	Every 6 months or when instrument performance deteriorates.	ICAL within acceptance criteria on **Worksheet #24** and internal standards (IS) recovery within acceptance criteria on **Worksheet #28.**	Service provider performs preventative maintenance and mass calibration. Run tune check. Reanalyze samples with new ICAL, ICC, ISC, and instrument blank.		
	Replace analytical column	PFAS	Review peak shape, retention times, and peak separation on ICAL, ICC, and CCV samples.	Performed when chromatography deteriorates.	ICAL within acceptance criteria on **Worksheet #24** and IS recovery within acceptance criteria on **Worksheet #28.**	Replace analytical column. Reanalyze samples with new ICAL, ICC, ISC, and instrument blank.		
GC/FID	Replace or cut GC column as needed. Bake out trap and column. Change trap as needed.	TPH	Trap, column, column flow.	Before ICAL and/or as necessary.	Acceptable calibration or CCV.	Correct the problem and repeat calibration or CCV.	Analyst	VOC-014, SVOC-040

Notes:

[a] Name or title of responsible person may be used.

[b] Specify the appropriate reference letter or number from the Analytical SOP References table (**Worksheet #23**).

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SAP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): FTL (TBD)/CH2M
Sample Packaging (Personnel/Organization): Sample Processor or Field Team Member (TBD)/CH2M
Coordination of Shipment (Personnel/Organization): Sample Processor or Field Team Member (TBD)/CH2M
Type of Shipment/Carrier: Overnight/FedEx
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Receipt Personnel/ Battelle, AEL
Sample Custody and Storage (Personnel/Organization): Sample Receipt Personnel/ Battelle, AEL
Sample Preparation (Personnel/Organization): Extractions Personnel/ Battelle, AEL
Sample Determinative Analysis (Personnel/Organization): Analyst/ Battelle, AEL
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 90 days
Sample Extract/Digestate Storage (No. of days from extraction/digestion): Extracts may be disposed of 90 days after extraction.
Biological Sample Storage (No. of days from sample collection): NA
SAMPLE DISPOSAL
Personnel/Organization: Environmental Health and Safety Office/ Battelle, AEL
Number of Days from Analysis: Samples may be disposed of 90 days after report mail date

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SAP Worksheet #27—Sample Custody Requirements Table

Sample Labeling

Sample labels will include, at a minimum, client name, site, sample ID, date/time collected, analysis group or method, preservative, and sampler's initials. Labels will be taped to the jar to ensure that they do not separate. If tape is not used, labels will be completed with a ballpoint pen (non-waterproof ink). Every effort will be made to identify and use PFAS-free sample labels; however, information on PFAS-free labels and mounting paper for label is scarce and inconsistent. Consequently, labels will be affixed to sample containers once lids are secured. Samples will be collected one at a time to avoid sample ID errors.

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 containers so they do not separate. Samples will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples less than 6°C until they are received by the laboratory.

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

Chain-of-Custody Procedures

The chain-of-custody record will document the transfer of sample custody from the time of sample collection to laboratory receipt and will accompany the samples from the field to the analytical laboratory. Samples will be shipped directly from the field to AEL and Battelle, as appropriate.

When custody of the samples is relinquished from one party to another, the individuals involved will sign, date, and record the time of transfer on the chain-of-custody record. The chain-of-custody records may consist of an original top copy and two carbonless copies, or the records may be in a pre-populated electronic format. When using the carbonless chain-of-custody format, the original and first copies will be transmitted to the primary analytical laboratory with the samples. The second copy will be retained in project files for the FTL and PC. Upon transfer of the samples to the analytical laboratory, field personnel will sign and date the chain-of-custody forms. Field personnel will make a copy of the signed form and scan a copy of each chain-of-custody record to be saved electronically in the project files under the associated sampling event files.

The chain-of-custody record will be completed by using waterproof ink. Corrections will be made with a single line-out, the error will be initialed and dated, and then the correct information will be entered. Empty fields on the chain-of-custody record will be crossed out with a single line or "Z'd" out, with the date and signature entered by the field sampling team. If samples are to be delivered to the laboratory by an overnight carrier, the airbill number will be recorded, and the chain-of-custody records will be placed in a waterproof plastic bag and taped to the inside lid of the sample cooler before sealing with appropriate secure tape and custody seals. These requirements will be fulfilled by the CH2M field sampling personnel.

The chain-of-custody forms will include, at a 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 will link location of the sample from the field logbook to the laboratory receipt of the sample. The laboratory will use the sample information to populate the Laboratory Information Management Systems (LIMS) database for each sample.

SAP Worksheet #27—Sample Custody Requirements Table (continued)

Custody Seals

Custody seals will be placed on the outside of each sample cooler so that the seals must be broken to open. After field samples are placed into coolers or shipping containers, two or more custody seals will be placed on the outside of the cooler before shipment or transport. Each custody seal will be initialed and dated by the field sampling team, affixed to the cooler, and taped over using clear strapping tape.

SAP Worksheet #28-1—Laboratory QC Samples Table

Matrix: Groundwater and Surface water
Analytical Group: PFAS
Analytical Method/ SOP Reference: LC-MS/MS Compliant with QSM Version 5.1.1 Table B-15 / SOP 5-369-06

QC Sample[a]	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPC
Instrument Blanks	Immediately following the highest standard analyzed and daily before sample analysis.	Concentration of each analyte must be ≤ 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 are 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 samples at which carryover does not occur. If acceptance criteria are not met after a sample, additional instrument blanks must be analyzed until acceptance criteria are met. Additional samples shall not be analyzed until acceptance criteria are met. Flagging is only appropriate in cases when the sample cannot be reanalyzed and when there is no more sample left. Note: Successful analysis following the highest standard analyzed determines the highest concentration that carryover does not occur. The highest standard analyzed may not be analyzed as part of the calibration curve or following the calibration curve. If analyzed following the calibration curve, it is not used to extend out the calibration range. It is used only to document a higher concentration at which carryover still does not occur. if sample concentrations exceed this range and the sample(s) following exceed this acceptance criteria (>1/2 LOQ), they must be reanalyzed.	Analyst	Precision/Accuracy/Bias	Concentration of each analyte must be ≤ 1/2 the LOQ.
Extracted Internal Standard Analytes	Every field sample, standard, blank, and QC sample.	Added to sample before extraction. For aqueous samples prepared by serial dilution instead of solid phase extraction (SPE), added to samples before 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 QC samples, correct problem, and reanalyze all associated failed field samples. Apply Q-flag and discuss in the Case Narrative only if reanalysis confirms failures in exactly the same manner. Failing analytes shall be thoroughly documented in the Case Narrative.		Accuracy	Added to sample before extraction. For aqueous samples prepared by serial dilution instead of SPE, added to samples before analysis. Extracted internal standard analyte recoveries must be within 50% to 150% of the true value.
Injection Internal Standard Analytes	Every field sample, standard, blank, and QC sample.	Added to aliquot of sample dilutions, QC samples, and standards before analysis. Peak areas must be within -50% to +50% of the area measured in the ICAL midpoint standard. On days when ICAL is not preformed, the peak areas must be within -50% to +50% of the peak area measured in the daily initial CCV.	If peak areas are not acceptable, analyze a second aliquot of the extract or sample if enough 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. Apply Q-flag and discuss in the Case Narrative. Alternate Injection Internal Standard Analytes are recommended when there is obvious chromatographic interference.		Accuracy	Added to aliquot of sample dilutions, QC samples, and standards before analysis. Peak areas must be within -50% to +50% of the area measured in the ICAL midpoint standard. On days when ICAL is not preformed, the peak areas must be within -50% to +50% of the peak area measured in the daily initial CCV.
Method Blank (MB)	One per preparatory batch.	No analytes detected >1/2 LOQ or >1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.	Correct problem. If required, reprep and reanalyze MB and all QC samples and field samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply B-Flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. Results may not be reported without a valid MB. Flagging is only appropriate in cases where the samples cannot be reanalyzed.		Bias/Contamination	No analytes detected >1/2 LOQ or >1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.

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

Matrix: Groundwater and Surface water
Analytical Group: PFAS
Analytical Method/ SOP Reference: LC-MS/MS Compliant with QSM 5.1.1 Table B-15 / SOP 5-369-06

QC Sample[a]	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPC
LCS	One per preparatory batch.	QC acceptance criteria specified in **Worksheet #15-1.**	Correct problem, then reanalyze the LCS and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.	Analyst	Accuracy/Bias	QC acceptance criteria specified in **Worksheet #15-1.**
MS	1 per batch maximum of 20 samples	QC acceptance criteria specified in **Worksheet #15-1.**	Examine the project-specific requirements. Contact the client as to additional measures to be taken. For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative. For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference (that is, matrix effect or analytical error).		Accuracy	QC acceptance criteria specified in **Worksheet #15-1.**
MSD	1 per batch maximum of 20 samples		Examine the project-specific requirements. Contact the client as to additional measures to be taken. For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative. The data shall be evaluated to determine the source of difference.		Accuracy/Precision	
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% to 130% of its true value.	When analyte concentrations are calculated as "<LOQ," and the spike recovery does not meet the 70% to 130% acceptance criteria, the sample, sample duplicate, and post spike sample must be reanalyzed at consecutively higher dilutions until the criteria are met. Flagging is not appropriate. When analyte concentrations are calculated as "<LOQ," results may not be reported without acceptable post spike recoveries.		Accuracy	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% to 130% of its true value.
LOD Verification	Quarterly for every analyte	Spike a quality system matrix at concentration 2 to 4 times the DL. Must meet 3:1 S/N, or for data systems that do not measure noise, results must be at least 3 standard deviations greater than the mean MB concentration.	If verification fails, the DL determination must be repeated and a LOD verification. Alternatively pass two consecutive LOD verification at a higher spike and set the LOD at the higher concentration.		Accuracy	Spike a quality system matrix at concentration 2 to 4 times the DL. Must meet 3:1 S/N, or for data systems that do not measure noise, results must be at least 3 standard deviations greater than the mean MB concentration.
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	Spike a quality system matrix at a concentration equal to or greater than the low point of the calibration curve.
Results reported between DL and LOQ	--	Apply J-flag to all results between DL and LOQ. Nondetect results are reported as U-values at the LOD.	--		Accuracy	--

Note:
[a] DoD QSM Version 5.1.1 is the basis for specifications on this table.

SAP Worksheet #28-2—Laboratory QC Samples Table

Matrix: Groundwater
Analytical Group: TPH
Analytical Method/ SOP Reference: SW-846 8015C / VOC-014, SVOC-040

QC Sample[a]	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPC
MB	One per preparatory batch.	No analytes detected >1/2 LOQ or >1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.	Correct problem. If required, reprep and reanalyze MB and all QC samples and field samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply B-Flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. Results may not be reported without a valid MB. Flagging is only appropriate in cases where the samples cannot be reanalyzed.	Analyst	Bias/Contamination	No analytes detected >1/2 LOQ or >1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.
LCS	One per preparatory batch.	QC acceptance criteria specified in **Worksheet #15-2.**	Correct problem, then reanalyze the LCS and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.		Accuracy/Bias	QC acceptance criteria specified in **Worksheet #15-2.**
MS	1 per batch maximum of 20 samples		For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative. For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference (that is, matrix effect or analytical error).		Accuracy	
MSD	1 per batch maximum of 20 samples		For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative. The data shall be evaluated to determine the source of difference.		Accuracy/Precision	
Surrogate Spike	All field and QC samples.		Correct problem, then reprep and reanalyze all failed samples for all surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary. Apply Q-flag to all associated analytes if acceptance criteria are not met and explain in the case narrative. Alternative surrogates are recommended when there is obvious chromatographic interference.		Accuracy	
Confirmation of positive results (second column)	All results > the DL must be confirmed	Calibration and QC criteria for second column are the same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.	When results between the primary and secondary column RPD≤ 40%, project-specific reporting requirements will be applied; higher result will be reported. When results between the primary and secondary column RPD> 40%, guidance from Method 8000D will be applied; chromatography evaluation to determine the appropriate result. If there is no evidence of chromatographic problems, it may be appropriate to report the lower result.		Accuracy	Calibration and QC criteria for second column are the same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.
Results reported between DL and LOQ	--	Apply J-flag to all results between DL and LOQ. Nondetect results are reported as U-values at the LOD.	--		Accuracy	--

Notes:

[a] DoD QSM Version 5.1 is the basis for specifications on this table.

SAP Worksheet #28-3—Laboratory QC Samples Table

Matrix: Surface Soil, Subsurface Soil, and Sediment
Analytical Group: PFAS
Analytical Method/ SOP Reference: LC-MS/MS Compliant with QSM 5.1.1 Table B-15 / SOP 5-369-06

QC Sample[a]	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPC
Instrument Blanks	Immediately following the highest standard analyzed and daily before sample analysis.	Concentration of each analyte must be ≤ 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 are 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 samples at which carryover does not occur. If acceptance criteria are not met after a sample, additional instrument blanks must be analyzed until acceptance criteria are met. Additional samples shall not be analyzed until acceptance criteria are met. Flagging is only appropriate in cases when the sample cannot be reanalyzed and when there is no more sample left. Note: Successful analysis following the highest standard analyzed determines the highest concentration that carryover does not occur. The highest standard analyzed may not be analyzed as part of the calibration curve or following the calibration curve. If analyzed following the calibration curve, it is not used to extend out the calibration range. It is used only to document a higher concentration at which carryover still does not occur. if sample concentrations exceed this range and the sample(s) following exceed this acceptance criteria (>1/2 LOQ), they must be reanalyzed.	Analyst	Precision/Accuracy/Bias	Concentration of each analyte must be ≤ 1/2 the LOQ.
Extracted Internal Standard Analytes	Every field sample, standard, blank, and QC sample.	Added to sample before extraction. For aqueous samples prepared by serial dilution instead of SPE, added to samples before 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 QC samples, correct problem, and reanalyze all associated failed field samples. Apply Q-flag and discuss in the Case Narrative only if reanalysis confirms failures in exactly the same manner. Failing analytes shall be thoroughly documented in the Case Narrative.		Accuracy	Added to sample before extraction. For aqueous samples prepared by serial dilution instead of SPE, added to samples before analysis. Extracted Internal Standard Analyte recoveries must be within 50% to 150% of the true value.
Injection Internal Standard Analytes	Every field sample, standard, blank, and QC sample.	Added to aliquot of sample dilutions, QC samples, and standards before analysis. Peak areas must be within -50% to +50% of the area measured in the ICAL midpoint standard. On days when ICAL is not preformed, the peak areas must be within -50% to +50% of the peak area measured in the daily initial CCV.	If peak areas are not acceptable, analyze a second aliquot of the extract or sample if enough 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. Apply Q-flag and discuss in the Case Narrative. Alternate Injection Internal Standard Analytes are recommended when there is obvious chromatographic interference.		Accuracy	Added to aliquot of sample dilutions, QC samples, and standards before analysis. Peak areas must be within -50% to +50% of the area measured in the ICAL midpoint standard. On days when ICAL is not preformed, the peak areas must be within -50% to +50% of the peak area measured in the daily initial CCV.
MB	One per preparatory batch.	No analytes detected >1/2 LOQ or >1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.	Correct problem. If required, reprep and reanalyze MB and all QC samples and field samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply B-Flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. Results may not be reported without a valid MB. Flagging is only appropriate in cases where the samples cannot be reanalyzed.		Bias/Contamination	No analytes detected >1/2 LOQ or >1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.

SAP Worksheet #28-3—Laboratory QC Samples Table (continued)

Matrix: Surface Soil, Subsurface Soil, and Sediment
Analytical Group: PFAS
Analytical Method/ SOP Reference: LC-MS/MS Compliant with QSM 5.1.1 Table B-15 / SOP 5-369-06

QC Sample[a]	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPC
LCS	One per preparatory batch.	QC acceptance criteria specified in **Worksheet #15-3.**	Correct problem, then reanalyze the LCS and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.		Accuracy/Bias	QC acceptance criteria specified in **Worksheet #15-3.**
MS	1 per batch maximum of 20 samples		Examine the project-specific requirements. Contact the client as to additional measures to be taken. For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative. For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference (that is, matrix effect or analytical error).		Accuracy	
MSD	1 per batch maximum of 20 samples		Examine the project-specific requirements. Contact the client as to additional measures to be taken. For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative. The data shall be evaluated to determine the source of difference.		Accuracy/Precision	
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% to 130% of its true value.	When analyte concentrations are calculated as "<LOQ," and the spike recovery does not meet the 70% to 130% acceptance criteria, the sample, sample duplicate, and post spike sample must be reanalyzed at consecutively higher dilutions until the criteria are met. Flagging is not appropriate. When analyte concentrations are calculated as "<LOQ," results may not be reported without acceptable post spike recoveries.		Accuracy	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% to 130% of its true value.
LOD Verification	Quarterly for every analyte	Spike a quality system matrix at concentration 2 to 4 times the DL. Must meet 3:1 S/N, or for data systems that do not measure noise, results must be at least 3 standard deviations greater than the mean MB concentration.	If verification fails, the DL determination must be repeated and a LOD verification. Alternatively pass two consecutive LOD verification at a higher spike and set the LOD at the higher concentration.		Accuracy	Spike a quality system matrix at concentration 2 to 4 times the DL. Must meet 3:1 S/N, or for data systems that do not measure noise, results must be at least 3 standard deviations greater than the mean MB concentration.
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	Spike a quality system matrix at a concentration equal to or greater than the low point of the calibration curve.
Results reported between DL and LOQ	--	Apply J-flag to all results between DL and LOQ. Nondetect results are reported as U-values at the LOD.	--		Accuracy	--

Notes:

[a] DoD QSM Version 5.1.1 is the basis for specifications on this table.

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SAP Worksheet #29—Project Documents and Records Table

Document	Where Maintained[a]
• Field Notebooks • Chain-of-Custody Records • Air Bills • Custody Seals • CA Forms • Electronic Data Deliverables (EDDs) • Identification of QC Samples • Meteorological Data from Field • Sampling Instrument Calibration Logs • Sampling Locations and Sampling Plan • Sampling Notes and Drilling Logs • Water Quality Parameters • Sample Receipt, Chain-of-Custody, and Tracking Records • Standard Traceability Logs • Equipment Calibration Logs • Sample Prep 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/Cleanup Records • Raw Data (stored on disk) • Data Validation Reports	• Field data deliverables (logbooks entries, chains-of-custody, air bills, EDDs) will be kept on CH2M's local intranet server. • Field parameter data will be loaded with the analytical data into Data Warehouse. • Analytical laboratory hard copy deliverables and data validation reports will be saved on the network server. • Electronic data from the laboratory will be loaded into the Data Warehouse and Naval Installation Restoration Information System (NIRIS).

Note:

[a] Offsite documents, except for analytical laboratory data, are archived with Iron Mountain Inc., which is headquartered at 1000 Campus Drive. Collegeville, PA 19426. Analytical laboratory data are archived with the Federal Records Center.

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SAP Worksheet #30—Analytical Services Table

Matrix	Analytical Group	Sample Locations/ID Number	Analytical Method	Data Package Turnaround Time	Laboratory / Organization (name and address, contact person, and telephone number)	Backup Laboratory / Organization[a] (name and address, contact person, and telephone number)
GW, SW, SS, SB, SD	PFAS	Refer to **Worksheet #18**	PFAS by LC-MS/MS Compliant with QSM Version 5.1.1 Table B-15	28 Calendar-days	Battelle 141 Longwater Drive, Suite 202 Norwell, MA 02061 Jonathan Thorn (781) 681-5565	Vista Analytical
GW	TPH		SW-846 8015C		AEL 6681 Southpoint Parkway Jacksonville, FL 32216 Craig Myers (904) 363-9350	TBD

Note:

[a] A backup laboratory is provided for PFAS only. If a backup laboratory is needed for TPH, one will be determined at that time.

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SAP Worksheet #31—Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person Responsible for Performing Assessment	Person Responsible for Responding to Assessment Findings	Person Responsible for Identifying and Implementing CA	Person Responsible for Monitoring Effectiveness of CA
Offsite Laboratory Technical Systems Audit (applies to definitive data only)	Laboratory must have current DoD ELAP accreditation letter, which will identify the period of performance. The laboratory must be re-evaluated before expiration of period of performance.	External	PJLA	PJLA	Respective Laboratory QAO	Respective Laboratory QAO	PJLA
Field Performance Audit	One during each sampling event.	Internal	CH2M	PM CH2M	FTL CH2M	PM CH2M	PM CH2M
Safe Behavior Observation (SBO)	One during each sampling event.	Internal	CH2M	SSC CH2M	Field Team Member CH2M	HSM CH2M	SSC CH2M
Field Document Review	Daily during each sampling event.	Internal	CH2M	PM or Task Manager CH2M	FTL CH2M	PM CH2M	PM CH2M

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SAP Worksheet #32—Assessment Findings and Corrective Action Responses

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

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SAP Worksheet #32-1—Laboratory Corrective Action Form

Person initiating corrective action (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 _____

_____

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

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

Comments _____

_____

Yes No 7) Are photographs taken and documented?

Comments _____

_____

Document Control

Yes No 1) Have any accountable documents been lost?

Comments _____

_____

Yes No 2) Have any accountable documents been voided?

Comments _____

_____

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

Comments _____

_____

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

Comments _____

_____

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

Comments _____

_____

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

Comments _____

_____

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

Comments _____

_____

SAP Worksheet #32-3—Safe Behavior Observation Form

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

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

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

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SAP Worksheet #33—Quality Assurance Management Reports Table

Type of Report	Frequency	Projected Delivery Date	Person Responsible for Report Preparation	Report Recipient(s)
Final SI Report	Post-field Event	May 2020	Laura Lampshire/CH2M	Stakeholders; see **Worksheet #4**

Note:

The SI report will address the following:

- Summary of project QA/QC requirements/procedures
- Conformance of project to SAP requirements/procedures
- Status of project schedule
- Deviations from the SAP and approved amendments that were made
- Results of data review activities (how much usable data were generated)
- CAs if needed and their effectiveness
- Data usability with regard to precision, accuracy, representativeness, completeness, comparability, and sensitivity
- Limitations on data use

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SAP Worksheet #34-36—Data Verification and Validation Process Table

(UFP-QAPP Manual Section 5.2.1) (UFP-QAPP Manual Section 5.2.2) (Figure 37 UFP-QAPP Manual) (Table 9 UFP-QAPP Manual)

Data Review Input	Description	Responsible for Verification	Step I / IIa / IIb[a]	Int. / Ext
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	FTL/CH2M (TBD)	Step I	Internal
Chains-of-Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody will be initialed by the reviewer, a copy of the chain-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment.	FTL/CH2M (TBD) Michael Zamboni/CH2M (PC)	Step I	Internal / External
Sample Condition Upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the project data manager in the form of laboratory logins.	Michael Zamboni/CH2M (PC)	Step I	External
Documentation of Laboratory Method Deviations	Laboratory method deviations not included in the laboratory SOP and therefore not included in the DoD ELAP Accreditation letter, will be discussed with and approved by the Navy Chemist. Documentation will be incorporated into the case narrative which becomes part of the final hard copy data package.	Michael Zamboni/CH2M (PC)	Step I	External
EDDs	EDDs will be compared against hard copy laboratory results (10% check). If a problem is noted, the laboratory will make a correction and re-report the data set. The check is then repeated to verify that the problem has been corrected.	Michael Zamboni/CH2M (PC)	Step I	External
Case Narrative	Case narratives will be reviewed by the DV during the data validation process. This is verification that they were generated and applicable to the data packages.	DV (TBD)	Step I	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy before submittal.	Jonathan Thorn/Battelle (Laboratory PM) Craig Myers/AEL (Laboratory PM)	Step I	Internal
Laboratory Data	The data will be verified for completeness by the project chemist.	Michael Zamboni/CH2M (PC)	Step I	External
CA 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.	Laura Lampshire/CH2M (PM) Michael Zamboni/CH2M (PM)	Step I	Internal / External
	CA reports will be reviewed by the project chemist or PM and placed into the project file for archival at project closeout.	Laura Lampshire/CH2M (PM) Michael Zamboni/CH2M (PC)	Step I	External
Laboratory Methods	Ensure the laboratory analyzed samples using the correct methods.	Michael Zamboni/CH2M (PC)	Step IIa	External
Target Compound List	Ensure the laboratory reported all analytes from each analysis group per **Worksheet #15**.	Michael Zamboni/CH2M (PC)	Step IIa	External
RLs	Ensure the laboratory met the project-designated reporting limits as per **Worksheet #15**. If reporting limits were not met, the reason will be determined and documented.	Michael Zamboni/CH2M (PC)	Step IIb	External
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	DV (TBD)	Step IIa	External
Sample Chronology	Holding times from collection to extraction or analysis and from extraction to analysis will be considered by the DV during the data validation process.	DV (TBD)	Step IIa / IIb	External
Raw Data[b]	10% of results will receive Stage 4 validation, which includes recalculation from the raw data to confirm laboratory calculations; all other definitive data will receive Stage 2B validation.	DV (TBD)	Step IIa	External
Onsite Screening	All non-analytical field data will be reviewed against UFP-SAP requirements for completeness and accuracy based on the field calibration records.	FTL/CH2M (TBD)	Step IIb	Internal
Documentation of Method QC Results	Establish that all required QC samples were run and met limits.	DV (TBD)	Step IIa	External
Documentation of Field QC Sample Results	Establish that all required UFP-SAP QC samples were run and met limits.	Michael Zamboni/CH2M (PC) DV (TBD)	Step IIb	External

SAP Worksheet #34-36—Data Verification and Validation Process Table (continued)

(UFP-QAPP Manual Section 5.2.1) (UFP-QAPP Manual Section 5.2.2) (Figure 37 UFP-QAPP Manual) (Table 9 UFP-QAPP Manual)

Data Review Input	Description	Responsible for Verification	Step I / IIa / IIb[1]	Int. / Ext
Data Validation for PFAS, TPH[b,c]	Analytical methods and laboratory SOPs will be evaluated against QA/QC criteria to ensure compliance, as presented in this SAP. QA/QC criteria for field QC samples are presented in **Worksheet #12**. LOQs, LODs, and DLs are presented in **Worksheet #15**. QA/QC criteria for calibrations are presented in laboratory SOPs (referenced in **Worksheet #23**) and **Worksheet #24**. QA/QC criteria for laboratory QC samples are presented in **Worksheet #28**. Data may be qualified if QA/QC exceedances have occurred. Guidance and qualifiers from *United States Department of Defense General Data Validation Guidelines* (DoD, 2019) will be applied as appropriate. As specific modules for the analytical methods in this project are published, the DVs will refer to those modules for guidance. Currently, the only available module is Module 1 for GC/mass spectrometer analysis and this will be used as appropriate. If specific guidance is not given for these methods in the General Data Validation Guidelines, the DV may adapt the guidance from *National Functional Guidelines for Superfund Organic Methods Data Review* (USEPA, 2017).	DV (TBD)	Step IIa and IIb	External

Notes:

[a] I = verification
IIa = compliance with methods, procedures, and contracts [see Table 10, page 117, UFP-QAPP manual, V.1, March 2005.]
IIb = comparison with measurement performance criteria in the UFP-SAP [see Table 11, page 118, UFP-QAPP manual, V.1, March 2005]

[b] 90% of definitive data will undergo Stage 2B validation and 10% will undergo Stage 4 validation. Manual validation is planned.

[c] Data validation guidance documents are subject to update.

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:

- Nondetected site contaminants will be evaluated to verify PQL goals 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, J+, J-, or UJ. These qualifiers represent minor QC deficiencies that 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. If R-qualified data are used in evaluations and, ultimately, project decisions, the rationale for their use will be included in the investigation report
  - J = Analyte present. Reported value may or may not be accurate or precise.
  - UJ = Analyte not detected. QL may be inaccurate or imprecise.
  - J+ = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
  - J- = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
  - X = Recommend rejected result by DV.
  - R = Rejected result by project team. Result not reliable. Project team as a whole will determine if the final qualifier will become an R qualifier for rejection or will be qualified as estimated with one of the qualifiers listed above.
- If statistical comparisons are necessary, nondetect values will be represented by a concentration equal to one-half the sample reporting limit. For duplicate sample results, the most conservative value will be used for project decisions.
- Additional qualifiers that may be given by the validator are:
  - N = Tentative identification. Consider present. Special methods may be needed to confirm its presence or absence in future sampling efforts
  - NJ = Qualitative identification questionable because of 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. These checks include comparison of hard copy data and qualifiers to the EDD. Once the data have been uploaded into the electronic database, another check will be performed to verify the results were loaded accurately.
- Field and laboratory precision will be compared as the 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 are available for decision making, the data will be compared to a 95% completeness goal and will be reconciled with MPC following validation and review of DQIs.

SAP Worksheet #37—Usability Assessment (continued)

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

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

- Data tables will be produced to reflect detected and nondetected analytes. Data qualifiers will be reflected in the tables and discussed in the data quality evaluation.
- A data quality evaluation will be provided as part of the SI report.
- The SI report will identify any data usability limitations and make recommendations for CA if necessary.

Identify the personnel responsible for performing the usability assessment.

The PM, PC, and other team members will be responsible for compiling the data. The data will then be presented to the NRL-CBD Partnering Team, which will evaluate the data usability according to project objectives.

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Figures

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Legend

Road

Naval Research Laboratory-Chesapeake Bay Detachment (NRL-CBD) Base Boundary

N

0 200 400 Feet

1 inch = 400 feet

Imagery: Calvert County, MD - 2017

Figure 1
Base Location Map
Site 10 Fire Testing Area Site Inspection SAP
NRL-CBD
Chesapeake Beach, Maryland

ch2m

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Legend

- Existing Deep Monitoring Well Location
- Existing Shallow Monitoring Well Location
- Elevation Contour - 10ft Interval
- Surface Water
- Fire Testing Area Boundary
- NRL-CBD Base Boundary

N

0 150 300 Feet

1 in = 300 ft

Figure 2
Fire Testing Area Site Location and Layout Map
Site 10 Fire Testing Area Site Inspection SAP
NRL-CBD
Chesapeake Beach, Maryland

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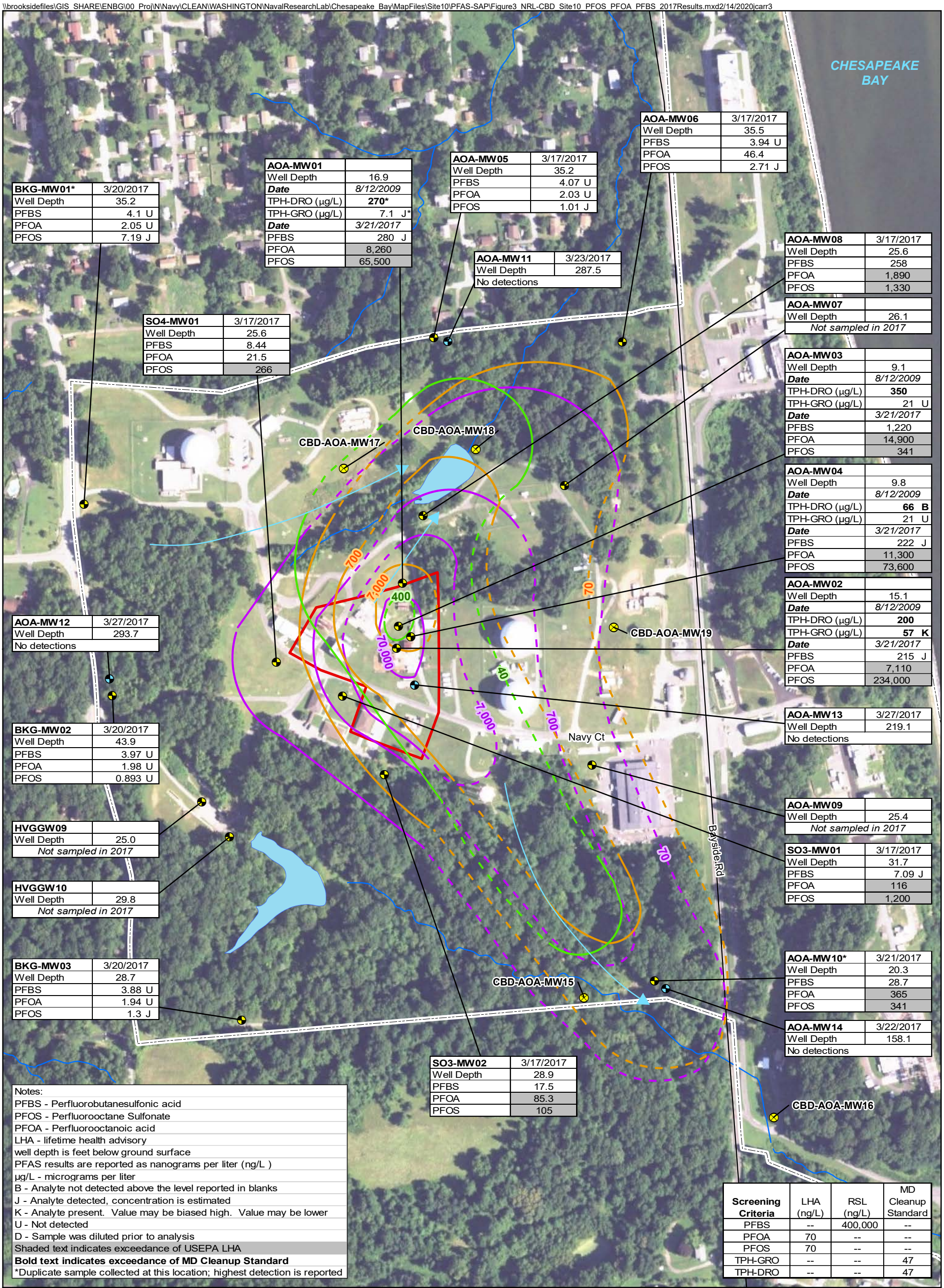

BKG-MW01*	3/20/2017
Well Depth	35.2
PFBS	4.1 U
PFOA	2.05 U
PFOS	7.19 J

AOA-MW01	
Well Depth	16.9
Date	*8/12/2009*
TPH-DRO (µg/L)	**270***
TPH-GRO (µg/L)	7.1 J*
Date	*3/21/2017*
PFBS	280 J
PFOA	8,260
PFOS	65,500

AOA-MW05	3/17/2017
Well Depth	35.2
PFBS	4.07 U
PFOA	2.03 U
PFOS	1.01 J

AOA-MW06	3/17/2017
Well Depth	35.5
PFBS	3.94 U
PFOA	46.4
PFOS	2.71 J

AOA-MW11	3/23/2017
Well Depth	287.5
No detections	

AOA-MW08	3/17/2017
Well Depth	25.6
PFBS	258
PFOA	1,890
PFOS	1,330

AOA-MW07	
Well Depth	26.1
Not sampled in 2017	

SO4-MW01	3/17/2017
Well Depth	25.6
PFBS	8.44
PFOA	21.5
PFOS	266

AOA-MW03	
Well Depth	9.1
Date	*8/12/2009*
TPH-DRO (µg/L)	**350**
TPH-GRO (µg/L)	21 U
Date	*3/21/2017*
PFBS	1,220
PFOA	14,900
PFOS	341

AOA-MW04	
Well Depth	9.8
Date	*8/12/2009*
TPH-DRO (µg/L)	**66 B**
TPH-GRO (µg/L)	21 U
Date	*3/21/2017*
PFBS	222 J
PFOA	11,300
PFOS	73,600

AOA-MW02	
Well Depth	15.1
Date	*8/12/2009*
TPH-DRO (µg/L)	**200**
TPH-GRO (µg/L)	**57 K**
Date	*3/21/2017*
PFBS	215 J
PFOA	7,110
PFOS	234,000

AOA-MW12	3/27/2017
Well Depth	293.7
No detections	

AOA-MW13	3/27/2017
Well Depth	219.1
No detections	

BKG-MW02	3/20/2017
Well Depth	43.9
PFBS	3.97 U
PFOA	1.98 U
PFOS	0.893 U

AOA-MW09	
Well Depth	25.4
Not sampled in 2017	

HVGGW09	
Well Depth	25.0
Not sampled in 2017	

SO3-MW01	3/17/2017
Well Depth	31.7
PFBS	7.09 J
PFOA	116
PFOS	1,200

HVGGW10	
Well Depth	29.8
Not sampled in 2017	

AOA-MW10*	3/21/2017
Well Depth	20.3
PFBS	28.7
PFOA	365
PFOS	341

BKG-MW03	3/20/2017
Well Depth	28.7
PFBS	3.88 U
PFOA	1.94 U
PFOS	1.3 J

AOA-MW14	3/22/2017
Well Depth	158.1
No detections	

SO3-MW02	3/17/2017
Well Depth	28.9
PFBS	17.5
PFOA	85.3
PFOS	105

Notes:
PFBS - Perfluorobutanesulfonic acid
PFOS - Perfluorooctane Sulfonate
PFOA - Perfluorooctanoic acid
LHA - lifetime health advisory
well depth is feet below ground surface
PFAS results are reported as nanograms per liter (ng/L)
µg/L - micrograms per liter
B - Analyte not detected above the level reported in blanks
J - Analyte detected, concentration is estimated
K - Analyte present. Value may be biased high. Value may be lower
U - Not detected
D - Sample was diluted prior to analysis
Shaded text indicates exceedance of USEPA LHA
Bold text indicates exceedance of MD Cleanup Standard
*Duplicate sample collected at this location; highest detection is reported

Screening Criteria	LHA (ng/L)	RSL (ng/L)	MD Cleanup Standard
PFBS	--	400,000	--
PFOA	70	--	--
PFOS	70	--	--
TPH-GRO	--	--	47
TPH-DRO	--	--	47

Legend
- Proposed Shallow Monitoring Well Location
- Existing Deep Monitoring Well Location
- Existing Shallow Monitoring Well Location
- PFBS Concentration Contour (dashed where inferred)
- PFOA Concentration Contour (dashed where inferred)
- PFOS Concentration Contour (dashed where inferred)
- Direction of Shallow Groundwater Flow
- Surface Water Centerline
- Fire Testing Area Boundary
- NRL-CBD Base Boundary
- Surface Water

N

0 150 300 Feet

1 inch equals 300 feet

Basemap Data: Esri

Figure 3
2017 PFBS, PFOA, and PFAS Analytical Results and Proposed Monitoring Well Locations
Site 10 Fire Testing Area Site Inspection SAP
NRL-CBD
Chesapeake Beach, Maryland

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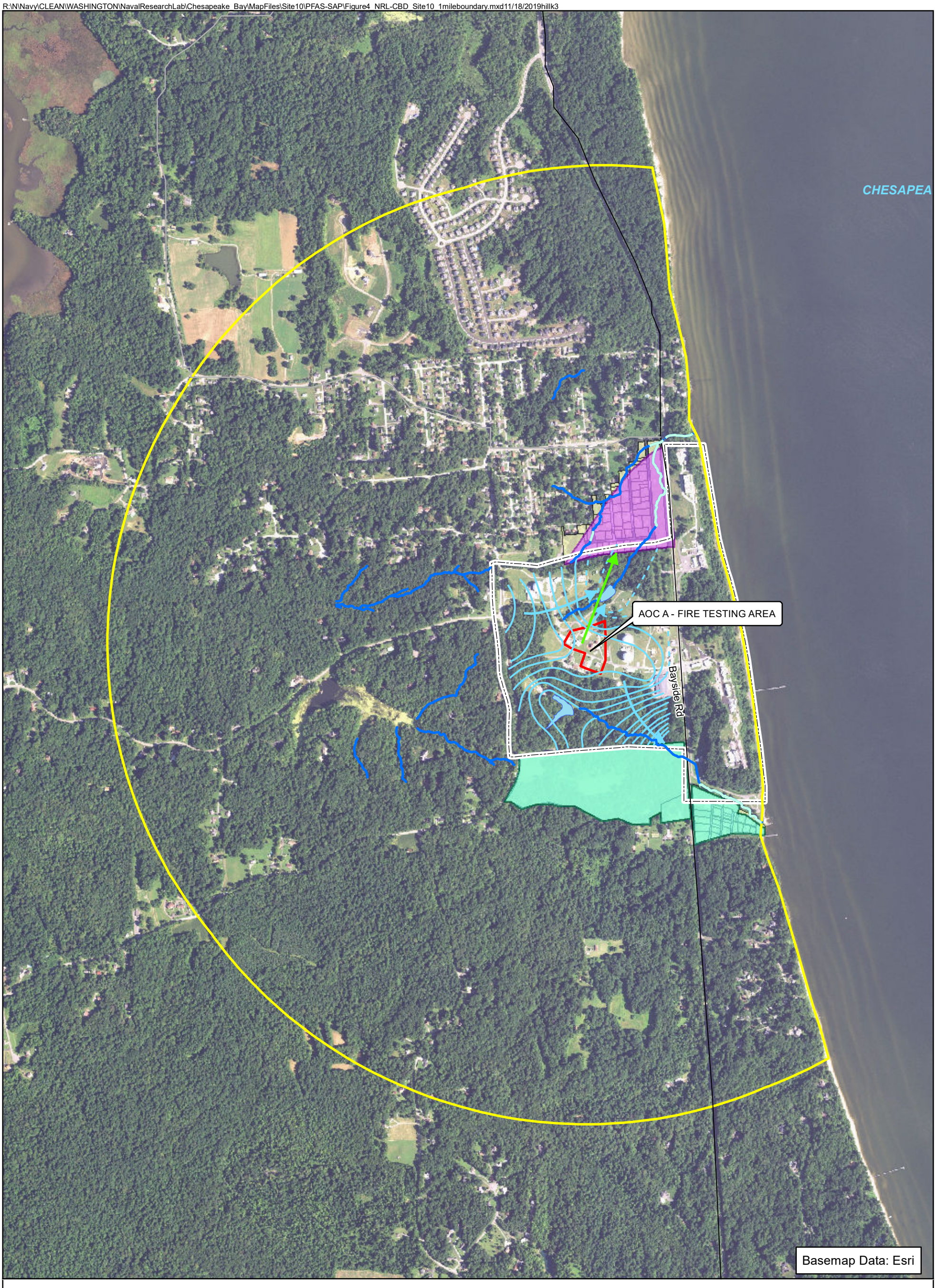

Legend

- Groundwater Flow Direction - Piney Point Aquifer
- Groundwater Flow Direction - Surficial Aquifer
- 0.5-foot surficial aquifer potentiometric contour interval (dashed where inferred); feet amsl
- Assumed Stream Channel
- Stream
- Fire Testing Area Boundary
- Fire Testing Area Boundary - 1-mile zone
- Base Boundary
- Surface Water
- 2018 Off-Base Sampling Area (North of NRL-CBD)
- 2018 Off-Based Sampling Area (South of NRL-CBD)
- Parcels

N

0 0.1 0.2 Miles

1 inch equals 0.2 mile

Figure 4
One-mile Off-Base Boundary
Site 10 Fire Testing Area Site Inspection SAP
NRL-CBD
Chesapeake Beach, Maryland

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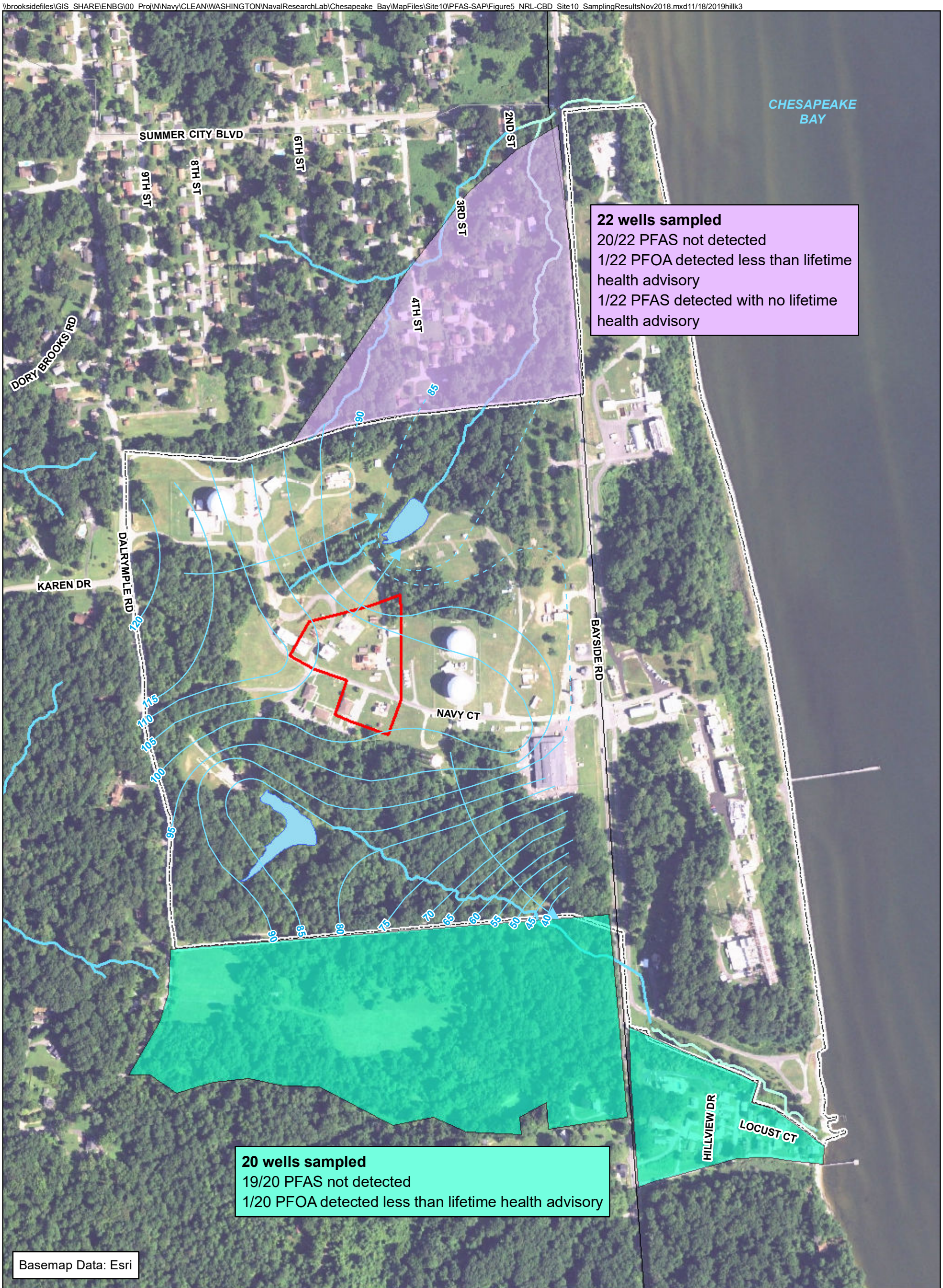


Legend

- Sampling Area
- Sampling Area
- Fire Testing Area Boundary
- Base Boundary
- Surface Water
- 5-foot Contour Interval (dashed where inferred)
- Direction of Shallow Groundwater Flow
- Assumed Stream Channel
- Stream

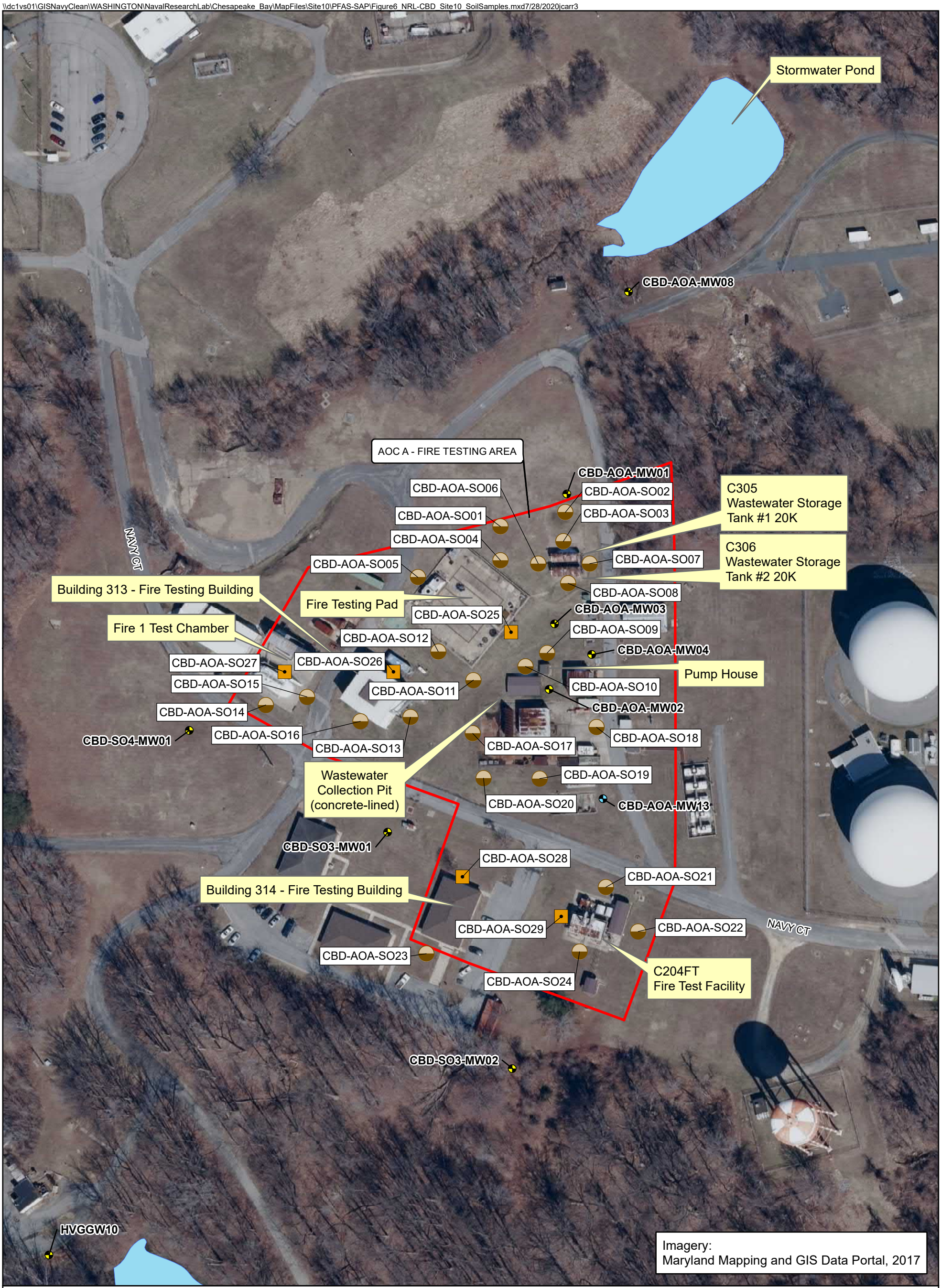
N

0 200 400 Feet

1 inch equals 400 feet

Figure 5
Off-Base Drinking Water Sampling Results through November 2018
Site 10 Fire Testing Area Site Inspection SAP
NRL-CBD
Chesapeake Beach, Maryland

\\dc1vs01\GISNavyClean\WASHINGTON\NavalResearchLab\Chesapeake_Bay\MapFiles\Site10\PFAS-SAP\Figure6_NRL-CBD_Site10_SoilSamples.mxd7/28/2020jcarr3



Legend

- Proposed co-located surface/subsurface soil sample location (3 sample depth intervals)
- Proposed co-located surface/subsurface soil sample location (2 sample depth intervals)
- Existing Deep Monitoring Well Location
- Existing Shallow Monitoring Well Location
- Fire Testing Area Boundary
- Surface Water

N

0 100 200 Feet

1 in = 100 ft

Figure 6
Proposed Soil Sample Locations
Site 10 Fire Testing Area Site Inspection SAP
NRL-CBD
Chesapeake Beach, Maryland

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Legend

- Fire Testing Area Boundary
- Surface Water
- Surface Water Centerline
- Proposed Staff Gauge Location (5 total)
- Proposed Surface Water Sample Location (6 total)
- Proposed Co-located Surface Water/Sediment Sample Location (4 total)
- NRL-CBD Base Boundary

Figure 7
Proposed Staff Gauge, Surface Water, and Sediment Sample Locations
Site 10 Fire Testing Area Site Inspection SAP
NRL-CBD
Chesapeake Beach, Maryland

0 150 300 Feet

1 inch equals 300 feet

N

Appendix A
December 2018 Site 10
SI Scoping Session Presentation

U.S. NAVAL RESEARCH LABORATORY

ch2m

NAVFAC Naval Facilities Engineering Command

Site Inspection Scoping Session
Site 10 - Fire Testing Area
Naval Research Laboratory – Chesapeake Bay Detachment

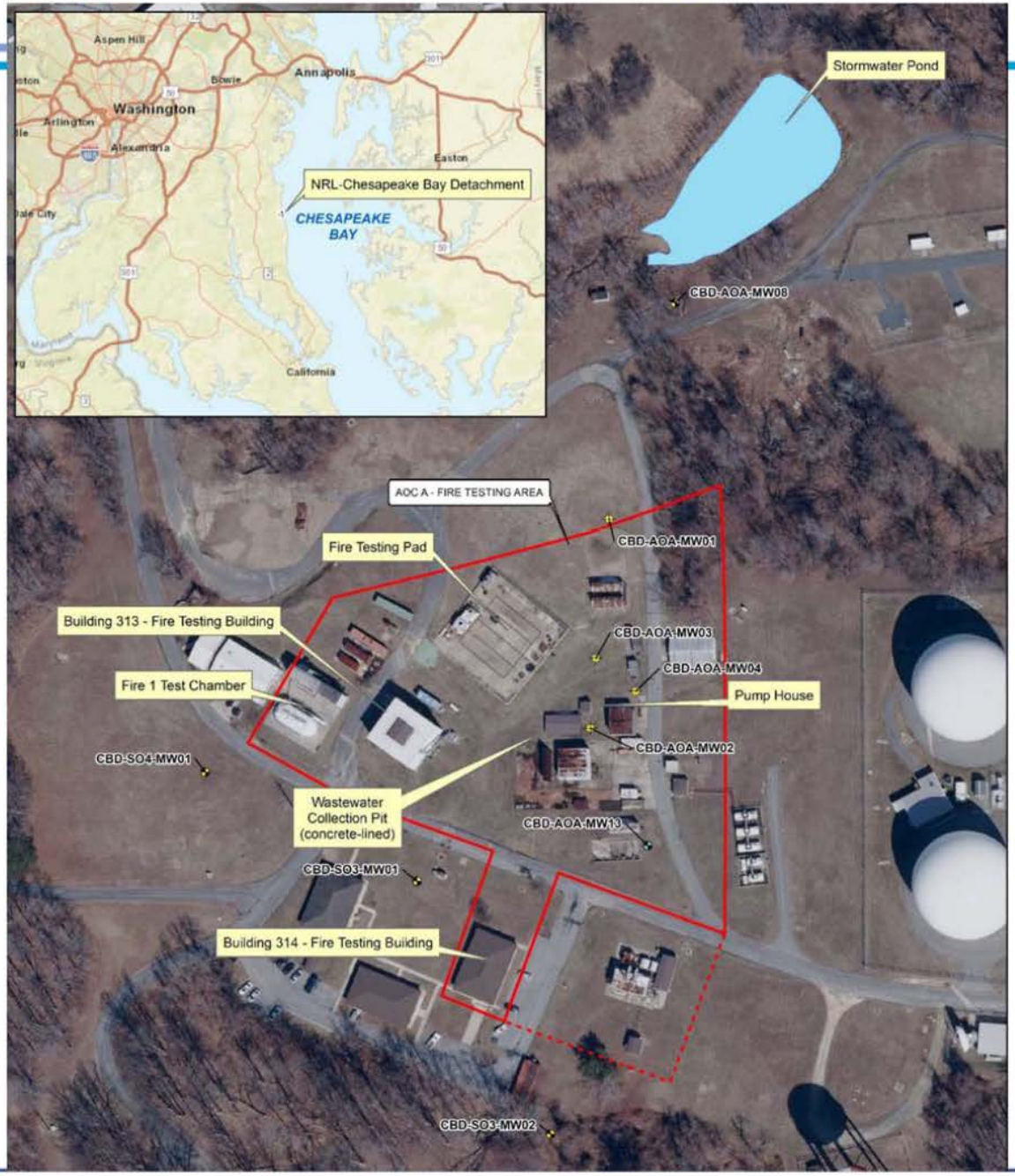
December 2018

Presentation Overview

- Site Summary
  - Location and Description
  - Geology and Hydrogeology
  - Background
  - Previous Investigations/Activities
- Site Inspection Objectives
- Recommended Path Forward

Site 10 (Fire Testing Area [FTA]) Location and Background

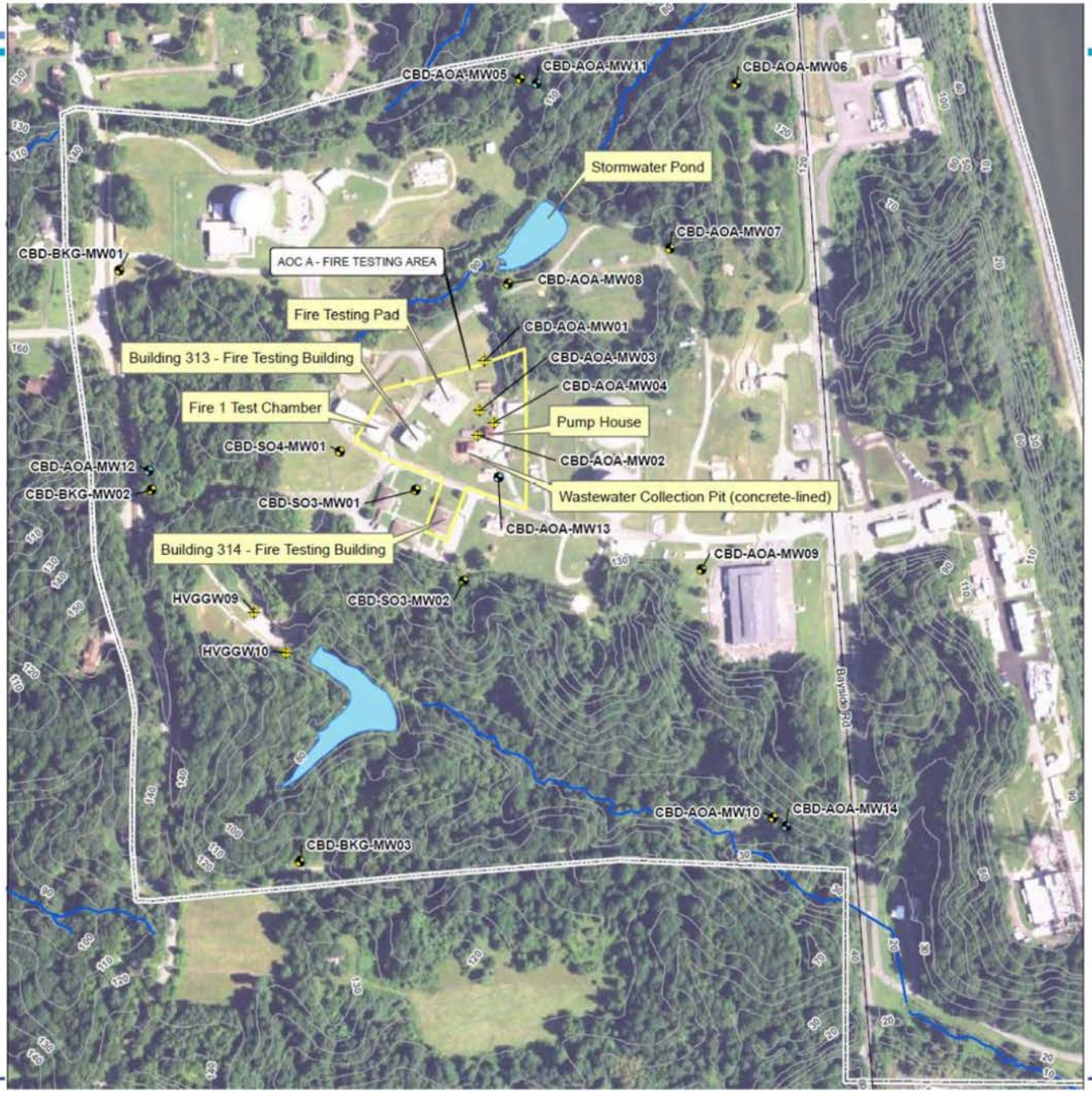
- Site 10 known as the FTA and was previously investigated as AOC A
- FTA is located near the center of NRL-CBD and approximately 3.408 acres
- Fire suppressant testing conducted at the FTA, including use of aqueous film-forming foam (AFFF), has been ongoing since 1968, resulting in a release of PFAS to groundwater and potentially other media



FTA Description and Geology

- The topography of the FTA slopes to the east, with grassy areas separating the Fire Testing Pad, Fire 1 Test Chamber, Bldg. 313 (Fire Testing Building), Pump House, and Wastewater Collection Pit (concrete-lined) in the northern portion of the site, and Bldg. 314 (Fire Testing Building) in the southern portion of the site

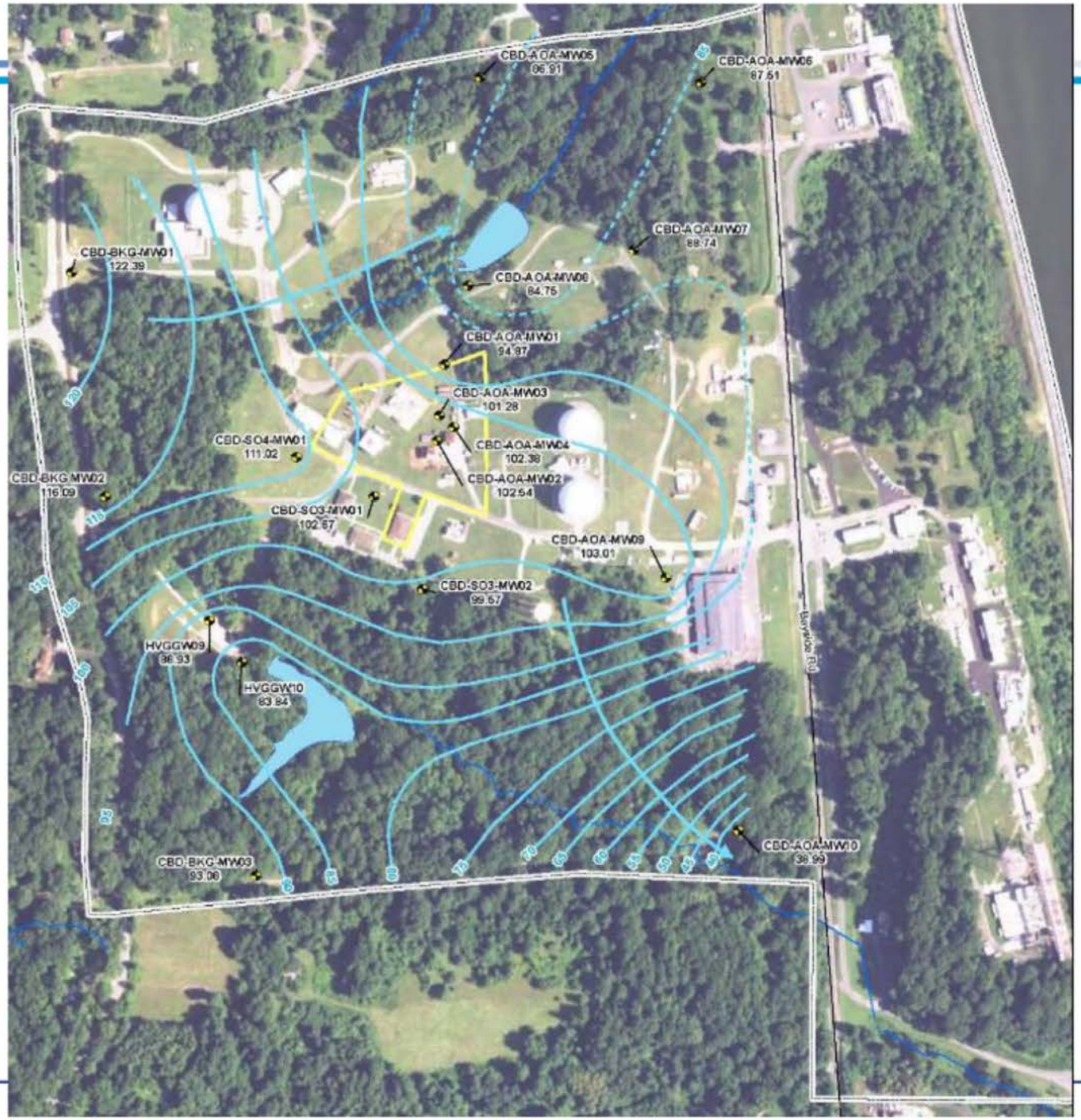
- The surficial geology at the FTA is composed of clayey silt, poorly-graded silty sands, and silty clays underlain by silty lean-to-fat clays



FTA Hydrogeology

- Depth to shallow (surficial aquifer) groundwater ranges from 6-37 ft, with the saturated thickness of the shallow aquifer between 1.7-20 ft
- Groundwater within the surficial aquifer generally flows north-northeast toward the stormwater pond approx. 700 ft. north-northeast of Area A
- A groundwater divide is present to the south of the site, along Navy Court, with groundwater flow north of the road migrating north-northeast, and groundwater flow south of the road migrating south-southeast
- The surficial aquifer transitions into a thick green confining unit (the Calvert confining unit) that consists of lean-to-fat clay, is continuous across the Base, and extends to approx. 200-230 ft bgs. The confining unit varies in thickness from approx. 66-113 ft.

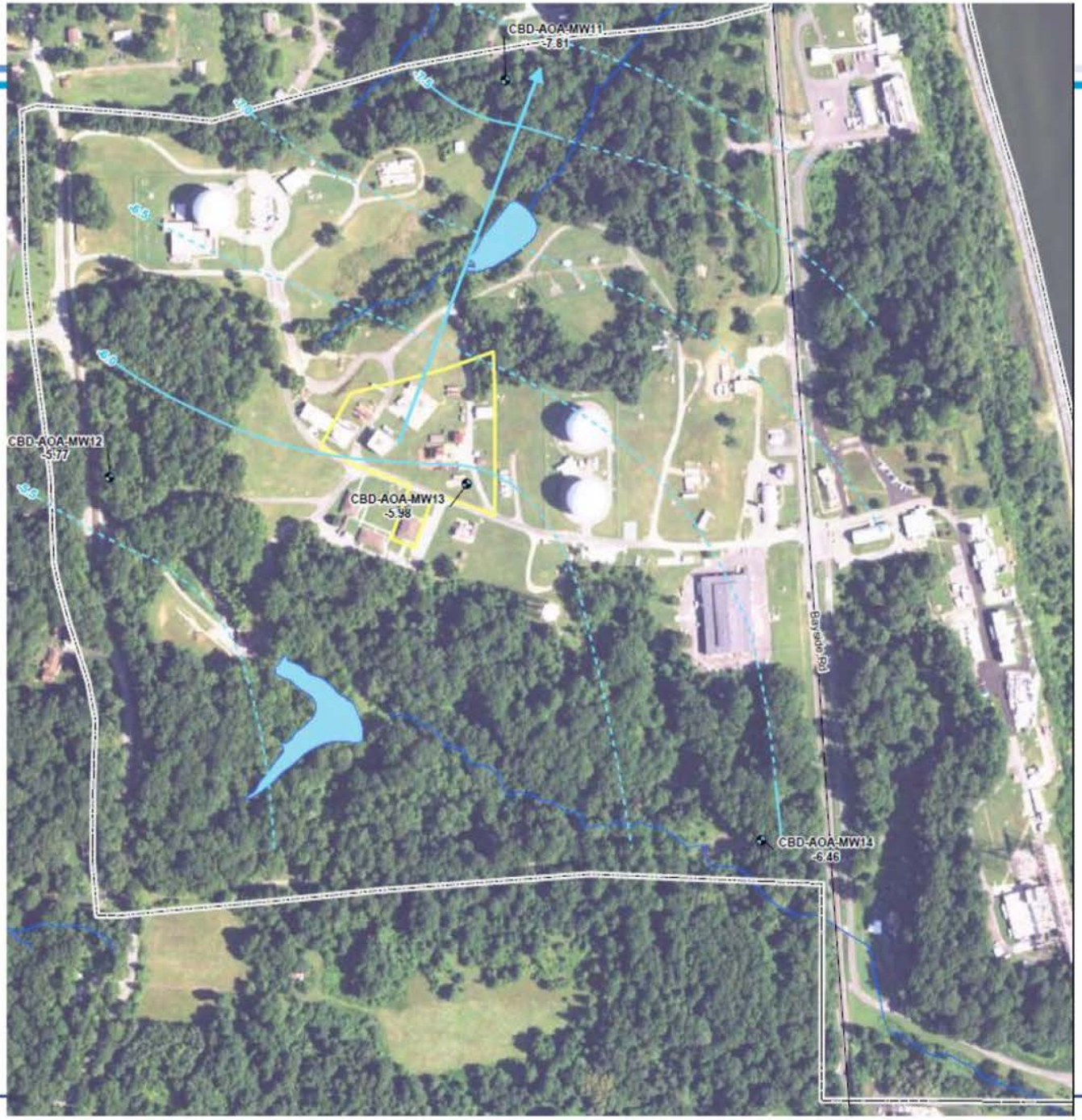
Shallow Aquifer Groundwater Flow – March 2017



FTA Hydrogeology (cont.)

- The Piney Point aquifer underlies the confining unit and consists of poorly graded grey sand
- Based on groundwater elevation data from the 4 existing deep monitoring wells, groundwater within the Piney Point generally flows to the northeast
- The gradient between the shallow and deep aquifers is downward

Piney Point Aquifer Groundwater Flow – March 2017



FTA Background – 1968-1985

- Fire Testing Area (FTA) has been in use since approximately 1968 and is still currently used
- The FTA is used to test extinguishing agents, including aqueous film-forming foam (AFFF), on fires started with various fuel sources (e.g., gasoline, diesel, JP-4, JP-5)
- From 1968-1985, fire testing effluent was drained form the concrete pad (Former Fire Testing Pad) to an open gravel-lined collection pit (Former Collection Pit [gravel-lined]) where the residual fuels were burned off and the remaining effluent infiltrated into the ground

FTA Background – 1986-2009 (modernization)

- In 1986, began construction of two collection pits within the footprint of the Former Collection Pit (gravel-lined). These two pits were lined with plastic "swimming pool liners" and used to collect the fire testing effluent until approximately 1988. During this time the collected effluent was pumped via a vacuum truck and taken to an off-site disposal facility.
- In 1988, the current FTA was constructed consisting of:
  - A new concrete Fire Testing Pad (located to the north/northwest of the Former Fire Testing Pad)
  - A Collection Pit (concrete-lined) constructed on top of one of the Former Collection Pits (plastic-lined) (second Former Collection Pit [plastic-lined] was filled in)
  - 3 FTA-related structures (Bldg. 313, Bldg. 314, and Fire 1 Test Chamber) were connected to the Collection Pit (concrete-lined). The underground effluent piping from these three structures converged into one underground pipe at a manhole approx. 50 feet east of Bldg. 313 before conveying effluent to the Collection Pit (concrete-lined)

FTA Background – 1986-2009 (modernization) (cont.)

- A Pump House was used to transfer effluent from the Collection Pit (concrete-lined) to two above-ground storage tanks (ASTs) located approx. 100 feet north of the Pump House via underground piping. Effluent from the ASTs was then taken to an off-site disposal facility.
- In 2004, the Pump House was taken out of use and the Concrete-lined Collection Pit was cleaned out and repaired

FTA Background – Current Usage

- Since the ASTs became inactive in 2004, the current practice for removing effluent from the Fire Testing Pad is to transfer the effluent into a Baker tank that is staged on the Fire Testing Pad until being shipped off-site for disposal

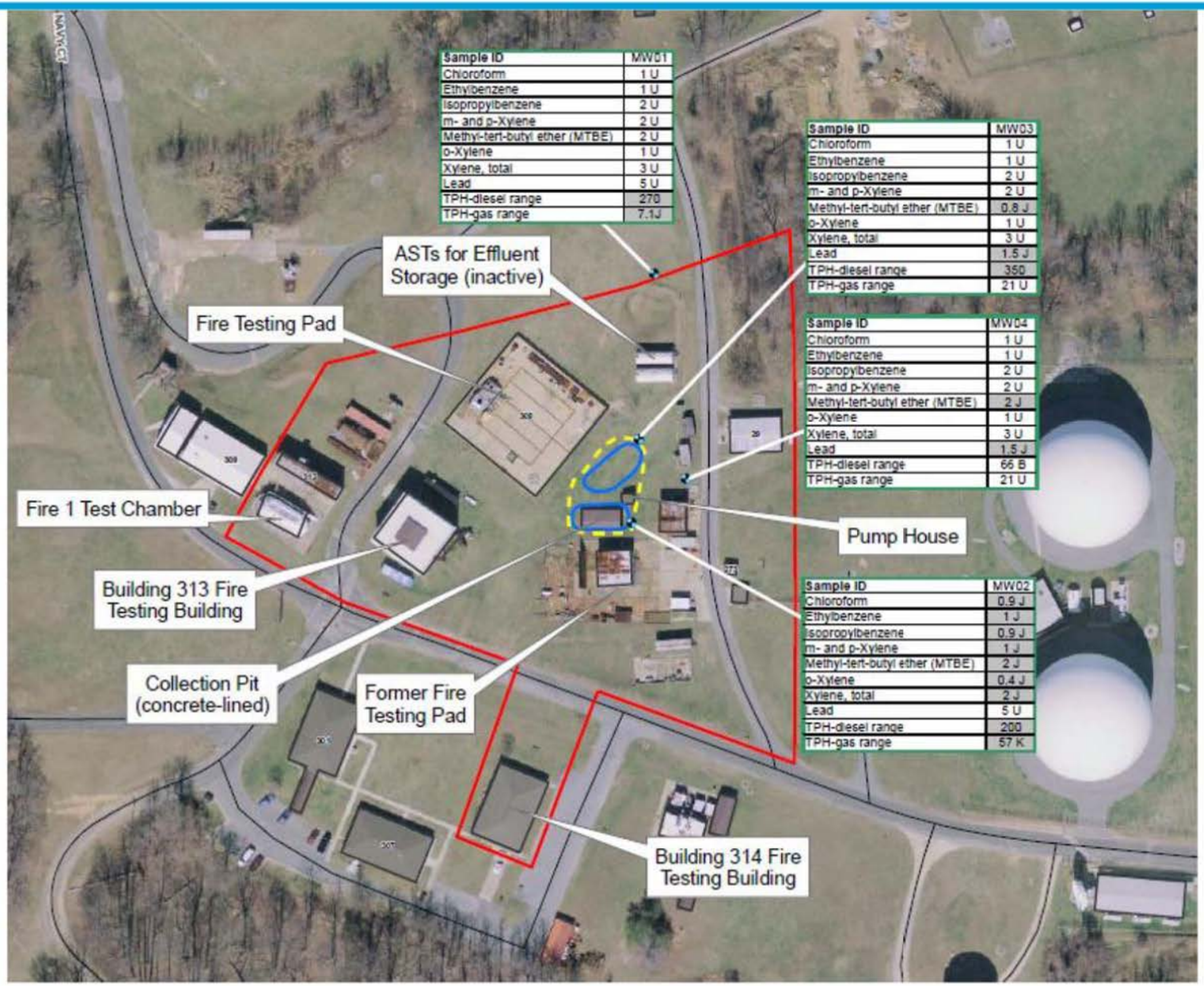
Previous Investigations/Activities

- **1984 Initial Assessment Study**
  - Mentions fire operations are conducted at CBD. Specifically, fire suppressant testing including AFFF. Wastewater is drained to a holding pit and allowed to absorb into the soil.
- **1988 -1989 MDE Correspondence**
  - May 27, 1988: MDE provided a "Report of Observations" to NRL identifying request for a plan to investigate the FTA due to solvent odor in soil samples. Split samples collected - two soil and one groundwater for VOC and toxic metals
  - June 9 – November 23, 1988:
    - NRL provided MDE with analytical results for two soil samples collected in May 1988, indicating no detections of volatile organic compounds (VOCs). MDE acknowledged receipt and asked for more through sampling.
    - Following this, NRL completed four soil borings at the FTA to a depth of 20 feet bgs, collected and submitted 14 soil samples for analysis of VOCs and Extraction Procedure (EP) lead, and reported the results to MDE in a letter dated November 23, 1988. The laboratory analytical results indicated no detections of VOCs or EP lead, with the exception of 2-butanone (from blank contamination)
  - May 4, 1989: MDE provided NRL acknowledgement of soil sampling results provided on November 23, 1988, and stated that no further assessment was required for the FTA.

Previous Investigations/Activities (cont.)

- **2004 Collection Pit Inspection**
  - Minor repairs (hairline cracks re-sealed) conducted on the Collection Pit (concrete-lined). Four soil samples were collected along the perimeter where the hairline cracks were observed for field screening with an organic vapor analyzer. Samples were collected to depth of approx. 8 ft bgs. At 7 ft bgs, the soils were wet and petroleum odors were detected with the organic vapor analyzer; however, no stains, petroleum sheen, or free-phase product was observed.
- **2009 Site Assessment**
  - The Site Assessment was conducted to assess the presence of shallow groundwater contamination at and downgradient of the FTA
  - Based on field screening, no soil contamination was observed
  - Two additional shallow monitoring wells (MW-01 and MW-02) were installed and groundwater from all four monitoring wells (including existing monitoring wells MW-03 and MW-04) was analyzed for VOCs, SVOCs, TPH-DRO, TPH-GRO, and lead
  - GW concentrations were below conservative tap water screening criteria. TPH-DRO and TPH-GRO exceeded MD default clean-up standards (47 µg/L) based on a Hazard Quotient (HQ) of 0.1. However, a second step was conducted to evaluate cumulative HI from all non-carcinogenic constituents, including TPH-DRO and –GRO using risk-ratio approach. The cumulative HI was below 1.

Site 10 (FTA) 2009 Site Assessment Groundwater results



Sample ID	MW01
Chloroform	1 U
Ethylbenzene	1 U
Isopropylbenzene	2 U
m- and p-Xylene	2 U
Methyl-tert-butyl ether (MTBE)	2 U
o-Xylene	1 U
Xylene, total	3 U
Lead	5 U
TPH-diesel range	270
TPH-gas range	7.1J

Sample ID	MW03
Chloroform	1 U
Ethylbenzene	1 U
Isopropylbenzene	2 U
m- and p-Xylene	2 U
Methyl-tert-butyl ether (MTBE)	0.8 J
o-Xylene	1 U
Xylene, total	3 U
Lead	1.5 J
TPH-diesel range	350
TPH-gas range	21 U

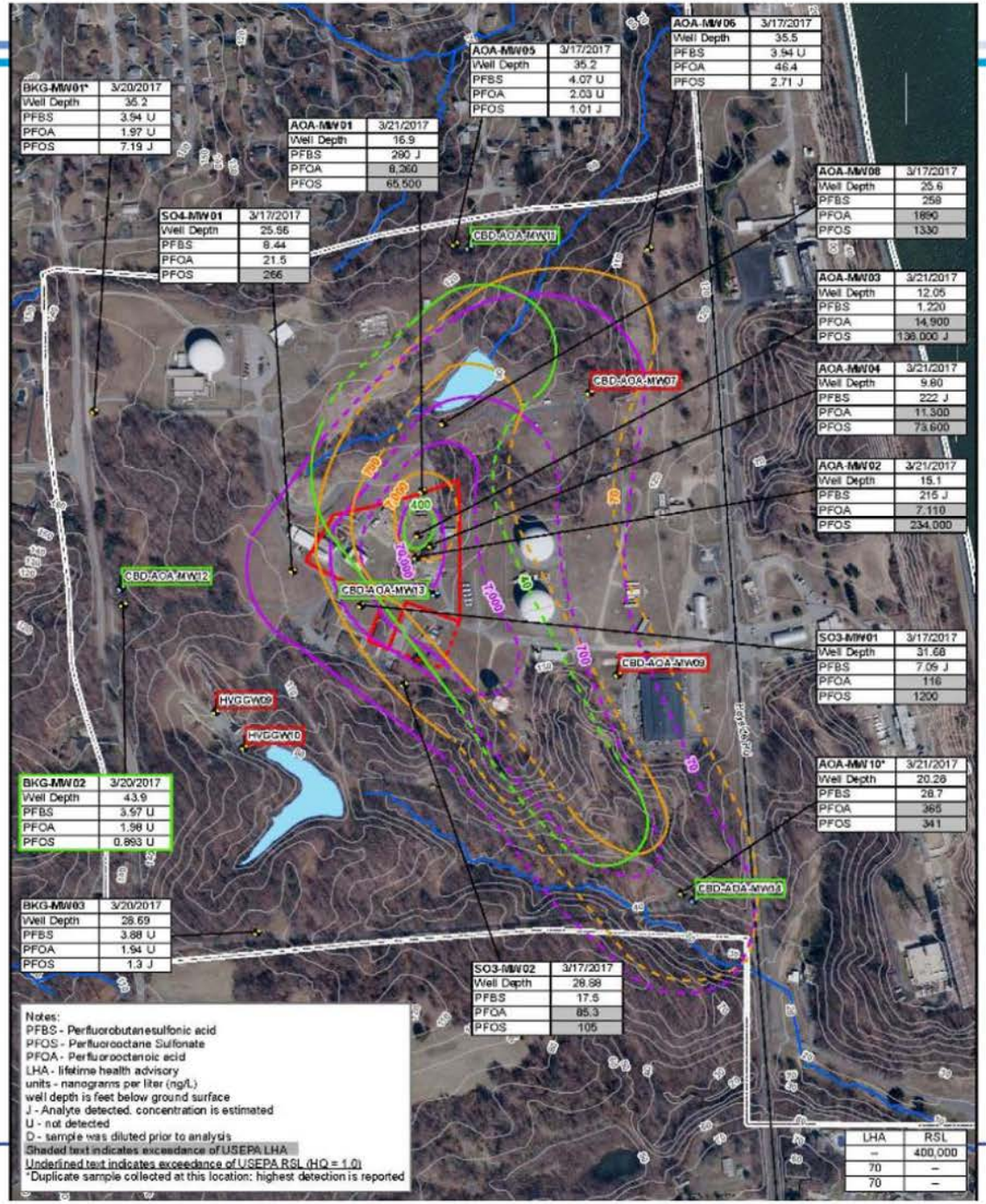
Sample ID	MW04
Chloroform	1 U
Ethylbenzene	1 U
Isopropylbenzene	2 U
m- and p-Xylene	2 U
Methyl-tert-butyl ether (MTBE)	2 J
o-Xylene	1 U
Xylene, total	3 U
Lead	1.5 J
TPH-diesel range	66 B
TPH-gas range	21 U

Sample ID	MW02
Chloroform	0.9 J
Ethylbenzene	1 J
Isopropylbenzene	0.9 J
m- and p-Xylene	1 J
Methyl-tert-butyl ether (MTBE)	2 J
o-Xylene	0.4 J
Xylene, total	2 J
Lead	5 U
TPH-diesel range	200
TPH-gas range	57 K

Previous Investigations/Activities (cont.)

- **2017 Evaluation of PFAS in Groundwater**
  - Nine shallow (20-35.5 ft bgs) and four deep (158-294 ft bgs) monitoring wells were installed
  - Nine new MWs and nine existing MWs were gauged and groundwater samples were analyzed for PFBS, PFOS, and PFOA
  - PFBS detected in nine MWs, ranging from 7.09 to 1,220 ng/L [at CBD-AOA-MW03]; no detections exceeded the RSL of 400,000 ng/L
  - PFOS detected in 13 MWs, ranging from 1.01 ng/L to 234,000 ng/L [at CBD-AOA-MW02]
    - Concentrations at nine MWs exceeded the USEPA LHA of 70 ng/L for PFOS
  - PFOA detected in 10 MWs, ranging from 21.5 ng/L to 14,900 ng/L [at CBD-AOA-MW03]
    - Concentrations at eight MWs exceeded the USEPA LHA of 70 ng/L for PFOA
  - Highest concentrations of PFAS were observed in the surficial aquifer at MWs closest to AOC A (CBD-AOA-MW01 through CBD-AOA MW04)
  - <u>No detections of PFAS in the deep aquifer (Piney Point Aquifer)</u>
  - Recommended additional MW installation and soil and groundwater sampling to: 1) verify that there are no continuing soil sources and 2) define the extent of PFAS contamination in groundwater

Site 10 (FTA) 2017 PFAS Evaluation Groundwater results



SI Objectives

- Update the CSM with regard site hydrogeology
- Determine the presence/absence of PFAS in multiple media (soil, surface water, sediment)
- Define the nature of PFAS contamination in soil, surface water, and sediment
- Refine the extent and nature of PFAS contamination in groundwater

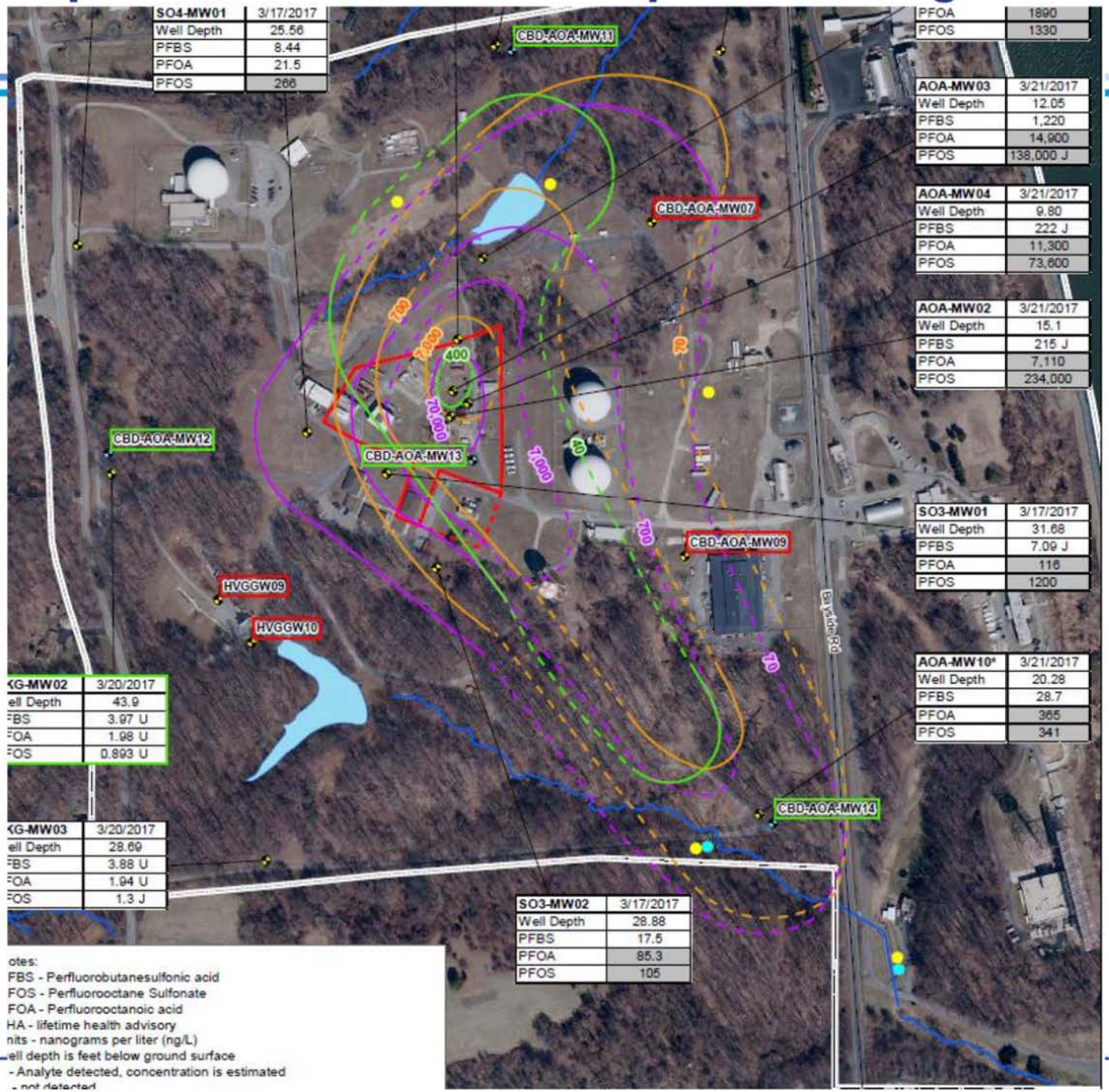
Path Forward

- Collect 29 co-located surface/subsurface soil samples throughout the FTA to evaluate for multiple sources
  - Maximum depth of each soil boring 45 ft bgs
  - Surface soil collected at 0-6 inches bgs; subsurface soil collected from intervals displaying evidence of contamination (soil staining, PID readings, etc.) if no evidence of contamination then collect directly above the water table
  - All soil samples will be analyzed for 14 PFAS compounds
- Install 5 shallow and 2 deep MWs
- Conduct 1 synoptic groundwater gauging event
- Sample groundwater from 29 MWs (23 shallow wells, 6 deep wells)
  - All groundwater samples will be analyzed for 14 PFAS compounds.
  - Subset of 6 shallow MWs will be analyzed for TPH -GRO, -DRO, and -ORO

Proposed Soil Sample Locations

● Proposed co-located surface soil/subsurface soil sample location (29 total)

Proposed Shallow and Deep Monitoring Well Locations



SO4-MW01	3/17/2017
Well Depth	25.56
PFBS	8.44
PFOA	21.5
PFOS	266

PFOA	1890
PFOS	1330

AOA-MW03	3/21/2017
Well Depth	12.05
PFBS	1,220
PFOA	14,900
PFOS	138,000 J

AOA-MW04	3/21/2017
Well Depth	9.80
PFBS	222 J
PFOA	11,300
PFOS	73,600

AOA-MW02	3/21/2017
Well Depth	15.1
PFBS	215 J
PFOA	7,110
PFOS	234,000

SO3-MW01	3/17/2017
Well Depth	31.68
PFBS	7.09 J
PFOA	116
PFOS	1200

AOA-MW10*	3/21/2017
Well Depth	20.28
PFBS	28.7
PFOA	365
PFOS	341

KG-MW02	3/20/2017
ell Depth	43.9
FBS	3.97 U
FOA	1.98 U
FOS	0.893 U

KG-MW03	3/20/2017
ell Depth	28.69
FBS	3.88 U
FOA	1.94 U
FOS	1.3 J

SO3-MW02	3/17/2017
Well Depth	28.88
PFBS	17.5
PFOA	85.3
PFOS	105

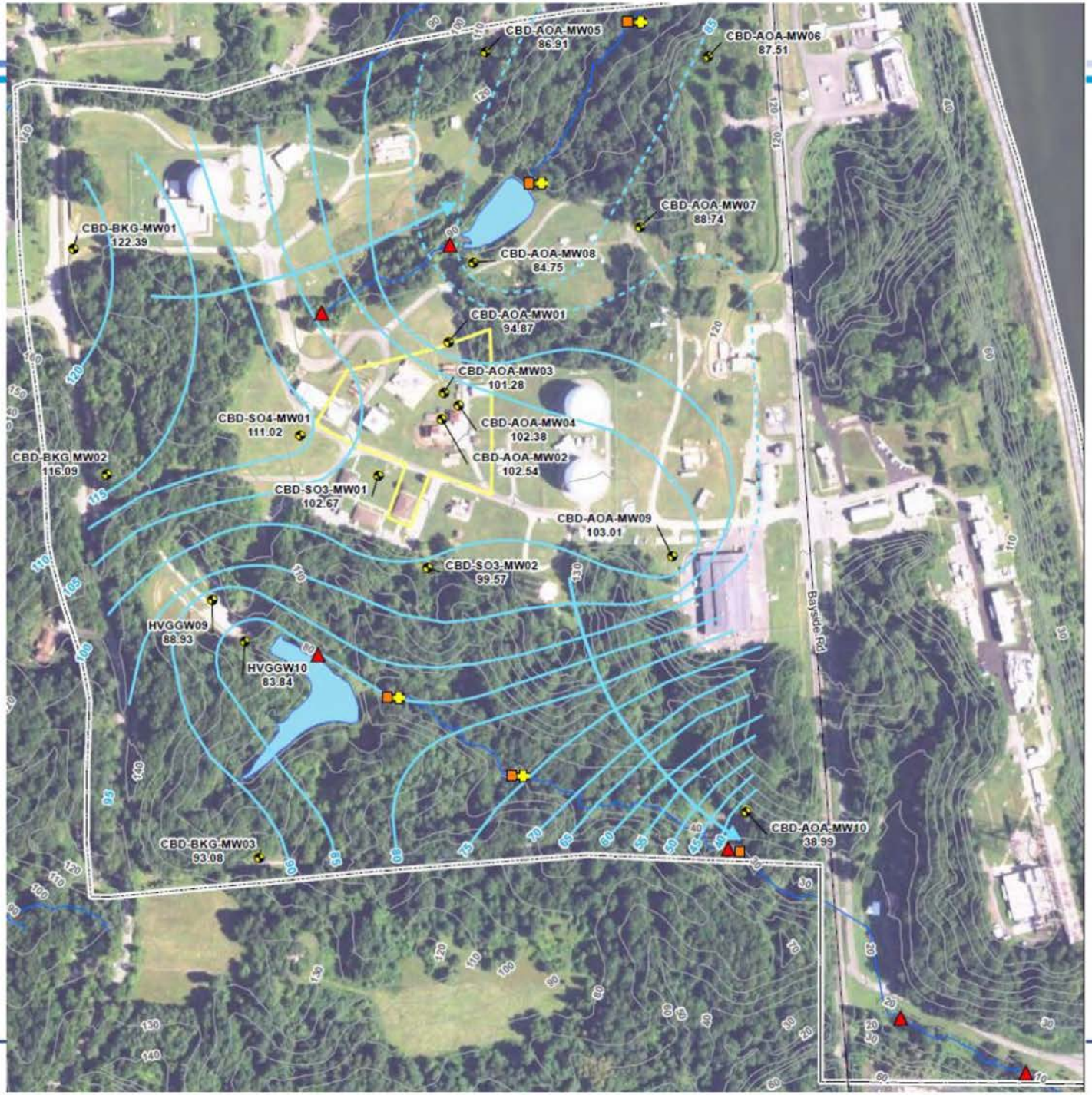
otes:
FBS - Perfluorobutanesulfonic acid
FOS - Perfluorooctane Sulfonate
FOA - Perfluorooctanoic acid
HA - lifetime health advisory
nits - nanograms per liter (ng/L)
ell depth is feet below ground surface
- Analyte detected, concentration is estimated
- not detected

- Proposed deep monitoring well location (2 total)
- Proposed shallow monitoring well location (5 total)

Path Forward (continued)

- Install 5 stream gauges; 2 stream gauges within the north stream, and 3 stream gauges within the south stream
- Collect 4 surface water samples north of the FTA and 6 surface water samples south of the FTA
  - All surface water samples will be analyzed for 14 PFAS compounds
- Collect 2 sediment samples north of the FTA and 2 sediment samples south of the FTA
  - All sediment sample locations will be co-located with surface water sample locations
  - All sediment samples will be analyzed for 14 PFAS compounds

Proposed Stream Gauge and Surface Water Sample Locations



- Proposed staff gauge location (5 total)
- Proposed surface water location (6 total)
- Proposed co-located surface water/sediment location (4 total)

Tentative Schedule

- **February 28, 2019** – Preliminary Draft UFP-SAP for Navy review
- **April 30, 2019** – Draft UFP-SAP for MDE review
- **June 30, 2019** – Final UFP-SAP
- **July 2019** - Fieldwork

Questions?

Appendix B
Ecological Screening Values

Soil Ecological Screening Values (ESVs)
Per- and Polyfluoroalkyl Substances (PFAS)

Chemical	ESV	Units	Type/Receptor	Reference	Comments
Perfluorooctane sulfonic acid (PFOS)	4,600	µg/kg	Plant	Beach et al. 2006	Ryegrass, 21-day NOEC (shoot height); converted to dry weight based on a reported value of 85% solids
	10,000	µg/kg	Invertebrate	NPCA 2008	Earthworm NOEC (note: UF of 100 was applied to this NOEC by NPCA to derive a PNEC value of 100 µg/kg but this was considered very conservative even for use as a screening value and the UF was not applied to derive the ESV)
Perfluorooctanoic acid (PFOA)	16,000	µg/kg	Invertebrate	NPCA 2008	Earthworm NOEC (note: UF of 100 was applied to this NOEC by NPCA to derive a PNEC value of 160 µg/kg but this was considered very conservative even for use as a screening value and the UF was not applied to derive the ESV)

Notes:
Shaded values represent the lowest ESV.
Beach, S.A., J.L. Newsted, K. Coady, and J.P. Giesy. 2006. Ecotoxicological Evaluation of Perfluorooctanesulfonate (PFOS). *Reviews of Environmental Contamination and Toxicology* . 186:133-
Norwegian Pollution Control Authority (NPCA). 2008. Screening of Polyfluorinated Organic Compounds at Four Fire Training Facilities in Norway. TA-2444/2008. December.

Fresh Surface Water Ecological Screening Values (ESVs)
Per- and Polyfluoroalkyl Substances (PFAS)

Chemical	ESV	Units	Type	Reference	Comments
Perfluorooctane sulfonic acid (PFOS)	5.10	µg/L	Final chronic value	Geisy et al. 2010	Acute-to-chronic ratio applied to Final Acute Value (protective of 95% of test species)
Perfluorooctanoic acid (PFOA)	2,900	µg/L	Secondary chronic value	Geisy et al. 2010	
Perfluorobutanesulfonic acid (PFBS)	24,000	µg/L	Secondary chronic value	Geisy et al. 2010	

Notes:
Shaded values represent lowest ESV.
Giesy J.P., J.E. Naile, J.S. Khim, P.D. Jones, and J.L. Newsted. 2010. Aquatic toxicology of perfluorinated chemicals. *Reviews of Environmental Contamination and Toxicology* . 202:1–52.

Freshwater Sediment Ecological Screening Values (ESVs)
Per- and Polyfluoroalkyl Substances (PFAS)

Chemical	ESV	Units	Type/Receptor	Reference	Comments
Perfluorooctane sulfonic acid (PFOS)	220	µg/kg	Chronic No-observed effect concentration (NOEC)	NPCA 2008	Threshold for chronic toxic effects

Notes:
Shaded values represent the lowest ESV.
Norwegian Pollution Control Authority (NPCA). 2008. Screening of Polyfluorinated Organic Compounds at Four Fire Training Facilities in Norway. TA-2444/2008. December.

Appendix C
Field Standard Operating Procedures

Standard Operating Procedure

Locating and Clearing Underground Utilities

I. Purpose

The purpose of this SOP is to provide general guidelines and specific procedures that must be followed on Navy CLEAN projects for locating underground utilities and clearing dig locations in order to maximize our ability to avoid hitting underground utilities and to minimize liabilities to CH2M and its subcontractors and health and safety risks to our project staff.

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

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

II. Scope

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

Scenario 1

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

Scenario 2

The Activity does not get involved in any utility locating processes aside from possibly providing the most recent utility maps, and relies on CH2M to clear the dig locations.

Scenario 1 is preferred because under this scenario the Navy tends to assume the responsibility if the location is improperly cleared, a utility is struck, and property damage results. However, our experience has been that the clearance services provided by the Navy do not meet the standards that we consider to be adequate, in that they often simply rely on available base maps to mark utilities and do not verify locations using field geophysics. And if they do use locating tools, they do not provide adequate documentation or marking to confirm that a location has been cleared. So while the Navy's process may protect us from liability for property damage, it does not

adequately protect our staff and subcontractors from health risks nor does it compensate us for down time, should a utility be hit.

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

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

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

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

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

III. Services and Equipment

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

Services

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

- The local public/private utility-run service such as Miss Utility
- Utility location subcontractors (hired by us)

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

Equipment

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

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

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

IV. Procedures and Guidelines

This section presents specific procedures to be followed for the utility location work to be conducted by CH2M and our subcontractors. In addition, a PM will have to follow the procedures required by the Activity to obtain their approvals, clearances and dig permits where necessary. These "dig permit" requirements vary by Activity and must be added to the project-specific SOP, or project instructions. It is preferable that the Activity perform their clearance processes before we follow up with our clearance work.

Activity Notification and Dig Permit Procedures

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

Activity Specific: To be provided by Activity or Project Manager

CH2M Utility Clearance Procedures

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted by CH2M as a follow-up to the services provided by the Navy. The use of as-built drawings and utility company searches must be supplemented with a geophysical or other survey by a qualified, independent survey contractor (subcontracted to CH2M) to identify additional and undiscovered buried utilities.

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

- **Ground Penetrating Radar (GPR),** which can detect pipes, including gas pipes, tanks, conduits, cables etc, both metallic and non-metallic at depths up to 30 feet depending on equipment. Sensitivity for both minimum object size and maximum depth detectable depends on equipment selected, soil conditions, etc.
- **Radio Frequency (RF),** involves inducing an RF signal in the pipe or cable and using a receiver to trace it. Some electric and telephone lines emit RF naturally and can be detected without an induced signal. This method requires knowing where the conductive utility can be accessed to induce RF field if necessary.
- **Dual RF**, a modified version of RF detection using multiple frequencies to enhance sensitivity but with similar limitations to RF

- **Ferromagnetic Detectors**, are metal detectors that will detect ferrous and non-ferrous utilities. Sensitivity is limited, e.g. a 100 mm iron disk to a depth of about one meter or a 25 mm steel paper clip to a depth of about 20 cm.
- **Electronic markers,** are emerging technologies that impart a unique electronic signature to materials such as polyethylene pipe to facilitate location and tracing after installation. Promising for future installations but not of help for most existing utilities already in place.

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

- Contact utility companies or the state/regional utility protection service (such as Miss Utility) at least two (2) working days prior to intrusive activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation: this is a law. These services will only mark the location of public-utility-owned lines and not Navy-owned utilities. In many cases there will not be any public-utility-owned lines on the Activity. There may also be Base-access issues to overcome.
- Procure and schedule the independent survey.
- The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project site, based on the survey contractor's experience and expertise, types of utilities anticipated to be present and specific site conditions. ***The types of utilities must be provided to the bidding subcontractors in the SOW and procedures to be used must be specified by the bidder in their bid. It is extremely helpful to provide the sub with utility maps, with the caveat that all utilities are not necessarily depicted.***
- The survey subcontractor shall employ the same geophysical techniques used to identify the buried utilities, to survey the proposed path of subsurface investigation/construction work to confirm no buried utilities are present.
- Obtain utility clearances for subsurface work on both public and private property.
- Clearances provided by both the "Miss Utility" service and the CH2M-subcontracted service are to be in writing, signed by the party conducting the clearance. The Miss Utility service will have standard notification forms/letters which typically simply state that they have been to the site and have done their work. The CH2M subcontractor shall be required to fill out the form provided in Attachment D (this can be modified for a particular project) indicating that each dig/drill location has been addressed. ***This documentation requirement (with a copy of the form) needs to be provided in the subcontractor SOW.***
- Marking shall be done using the color coding presented in Attachment E. The type of material used for marking must be approved by the Activity prior to marking. Some base commanders have particular issues with persistent spray paint on their sidewalks and streets. ***Any particular marking requirements need to be provided in the subcontractor SOW.***

- Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.
- Perform a field check prior to drilling/digging (preferably while the utility location sub is still at the site) to see if field utility markings coincide with locations on utility maps. Look for fire hydrants, valves, manholes, light poles, lighted signs, etc to see if they coincide with utilities identified by the subcontractor.
- Underground utility locations must be physically verified (or dig locations must be physically cleared) by hand digging using wood or fiberglass-handled tools, air knifing, or by some other acceptable means approved by CH2M, when the dig location (e.g. mechanical drilling, excavating) is expected to be within 5 feet of a marked underground system. Hand clearance shall be done to a depth of four feet unless a utility cross-section is available that indicates the utility is at a greater depth. In that event, the hand clearance shall proceed until the documented depth of the utility is reached.
- Conduct a site briefing for employees at the start of the intrusive work regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon during drilling or change in color, texture or density during excavation that could indicate the ground has been previously disturbed).

IV. Attachments

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

Attachment A – Example SOW for Subcontracting Underground Utilities Locating Services

CTO-XXX

Scope of Work

Subsurface Utility Locating

Site XX

Navy Activity

City, State

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

Proposed Scope of Work

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

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

Base utility drawings for the Site(s) (CHOOSE 1) can be found at <<insert specific department and address or phone number on the base>> and should be reviewed by the subcontractor and referenced as part of the utility locating. (OR), will be provided to the subcontractor by CH2M HILL upon the award of the subcontract. (OR), are not available. Utility drawings shall not be considered definitive and must be field verified.

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

A CH2M HILL representative shall be present to coordinate utility clearance activities and identify points and features to be cleared.

Field Marking and Documentation

All utilities located within **(CHOOSE 1)** ***a 20-ft radius of the XX proposed soil boring locations*** **(OR)** ***within the boundary of the site(s)*** as identified on the attached figure(s) will be marked using **paint** ***(some Bases such as the WNY may have restrictions on the use of permanent paint)*** and/or pin flags color coded to indicate electricity, gas, water, steam, telephone, TV cable, fiber optic, sewer, etc. The color coding shall match the industry standard as described on the attached form. In addition, the ***Buried Utility Location Tracking Form*** (attached) will be completed by the Subcontractor based upon what is identified in the field during the utility locating and submitted back to CH2M HILL (field staff or project manager) within 24 hours of completing the utility locating activities.

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

Bid Sheet/Payment Units

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

Health and Safety Requirements

The utility locating subcontractor is to provide and assume responsibility for an adequate corporate Health and Safety Plan for onsite personnel. Standard personal safety equipment including: hard hat, safety glasses, steel-toed boots, gloves are recommended for all project activities. Specific health and safety requirements will be established by the Subcontractor for each project. The health and safety requirements will be subject to the review of CH2M HILL.

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

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

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

Security

The work will be performed on US Navy property. CH2M HILL will identify the Subcontractor personnel who will perform the work to the appropriate Navy facility point-of-contact, and will identify the Navy point-of-contact to the Subcontractor crew. The Subcontractor bears final responsibility for coordinating access of his personnel onto Navy property to perform required work. This responsibility includes arranging logistics and providing to CH2M HILL, in advance or at time of entry as specified, any required identification information for the Subcontractor personnel. Specifically, the following information should be submitted with the bid package for all personnel that will perform the work in question (this information is required to obtain a base pass):

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

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

Quality Assurance

The Subcontractor will be licensed and insured to operate in the State of <<state>> and will comply with all applicable federal, state, county and local laws and regulations. The subcontractor will maintain, calibrate, and operate all electronic locating instruments in accordance with the manufacturer's recommendations. Additionally, the Subcontractor shall make all reasonable efforts to review as-built engineering drawings maintained by Base personnel, and shall notify the CH2M HILL Project Manager in writing (email is acceptable) whenever such documentation was not available or could not be reviewed.

Subcontractor Standby Time

At certain periods during the utility locating activities, the Subcontractor's personnel may be asked to stop work and standby when work may normally occur. During such times, the Subcontractor will cease activities until directed by the CH2M HILL representative to resume operations. Subcontractor standby time also will include potential delays caused by the CH2M HILL representative not arriving at the site by the agreed-upon meeting time for start of the work day. Standby will be paid to the

Subcontractor at the hourly rate specified in the Subcontractor's Bid Form attached to these specifications.

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

During periods for which standby time is paid, the surveying equipment will not be demobilized and the team will remain at the site. At the conclusion of each day, the daily logs for the Subcontractor and CH2M HILL representative will indicate the amount of standby time incurred by the Subcontractor, if any. Payment will be made only for standby time recorded on CH2M HILL's daily logs.

Down Time

Should equipment furnished by the Subcontractor malfunction, preventing the effective and efficient prosecution of the work, or inclement weather conditions prevent safe and effective work from occurring, down time will be indicated in the Subcontractor's and CH2M Hill representative's daily logs. No payment will be made for down time.

Schedule

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

Attachment B - Services Available for Identifying and Marking Underground Utilities

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

- The Activity's PWC (or similar organization)
- The local public/private utility -run service such as Miss Utility
- Utility location subcontractors (hired by CH2M HILL)

Each are discussed below.

Navy Public Works Department

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

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

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

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

Miss Utility or "One Call" service centers are information exchange centers for excavators, contractors and property owners planning any kind of excavation or digging. The "One Call" center notifies participating public utilities of the upcoming excavation work so they can locate and mark their underground utilities in advance to prevent possible damage to underground utility lines, injury, property damage and service outages. In some instances, such with southeastern Virginia bases, the Navy has entered into agreement with Ms. Utilities and is part of the response process for Miss

Utilities. Generally, a minimum of 48 hours is required for the public utility mark-outs to be performed. The "One Call" services are free to the public. Note that the "One Call" centers only coordinate with participating public utilities. There may be some public utilities that do NOT participate in the "One Call" center which may need to be contacted separately. For example, in Washington, DC, the Miss Utility "One Call" center does not locate and mark public sewer and water lines. Therefore, the municipal water and sewer authority must be contacted separately to have the sewer and water lines marked out. The AM should contact the appropriate one-call center to determine their scope of services.

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

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

Private Subcontractors

1. Utility-locating support is required at some level for most all CH2M HILL field projects in "clearing" proposed subsurface boring locations on the project site. Utility location and sample clearance can include a comprehensive effort of GIS map interpretation, professional land surveying, field locating, and geophysical surveying. Since we can usually provide our own GIS-related services for projects and our professional land surveying services are normally procured separately, utility-locating subcontractors will normally only be required for some level of geophysical surveying support in the field. This level of geophysical surveying support can range widely from a simple electromagnetic (EM) survey over a known utility line, to a blind geophysical effort, including a ground-penetrating radar (GPR) survey and/or a comprehensive EM survey to delineate and characterize all unknown subsurface anomalies.

   The level of service required from the subcontractor will vary depending on the nature of the site. At sites where utility locations are well defined on the maps and recent construction is limited, CH2M HILL may be confident with a limited effort from a traditional utility-locating subcontractor providing a simple EM survey. At

sites where utility locations are not well defined, where recent constructions may have altered utility locations, or the nature of the site makes utility location difficult, CH2M HILL will require the services of a comprehensive geophysical surveying subcontractor, with a wide range of GPR and EM services available for use on an "as-needed" basis. Typical costs for geophysical surveying subcontractors will range from approximately $200 per day for a simple EM effort (usually one crew member and one instrument) to approximately $1,500 per day for a comprehensive geophysical surveying effort (usually a two-person crew and multiple instruments). Comprehensive geophysical surveying efforts may also include field data interpretation (and subsequent report preparation) and non-destructive excavation to field-verify utility depths and locations.

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

Company Name and Address	Contact Name and Phone Number	Equipment[1]					Other Services[2]		
		1	2	3	4	5	A	B	C
US Radar, Inc.* PO Box 319 Matawan, NJ 07747	Ron LaBarca 732-566-2035			4					
Utilities Search, Inc.*	Jim Davis 703-369-5758	4				4	4	4	4
So Deep, Inc.* 8397 Euclid Avenue Manassas Park, VA 20111	703-361-6005	4					4	4	4
Accurate Locating, Inc. 1327 Ashton Rd., Suite 101 Hanover, MD 21076	Ken Shipley 410-850-0280	4	4						
NAEVA Geophysics, Inc. P.O. Box 7325 Charlottesville, VA 22906	Alan Mazurowski 434-978-3187	4	4	4	4	4	4	4	4
Earth Resources Technology. Inc. 8106 Stayton Rd. Jessup, MD 20794	Peter Li 240-554-0161	4	4	4	4	4	4	4	
Geophex, Ltd 605 Mercury Street Raleigh, NC 27603	I. J. Won 919-839-8515	4	4	4	4	4	4	4	4

Notes:

*Companies denoted with an asterisk have demonstrated reluctance to assume responsibility for damage to underground utilities or an inability to accommodate the insurance requirements that CH2M HILL requests for this type of work at many Navy sites.

[1]Equipment types are:

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

[2]Other services include:

A. Data interpretation and/or report preparation to provide a permanent record of the geophysical survey results and a professional interpretation of the findings, including expected accuracy and precision.

B. Non-destructive excavation to field-verify the depths, locations, and types of subsurface utilities.

C. Concrete/asphalt coring and pavement/surface restoration.

Attachment C – Equipment Used for Identifying Underground Utilities

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

CH2M HILL In-house Utility Location Experts

Steve Saville/KNV

Home Office Phone – 720-261-5367

Electromagnetic Induction (EMI) Methods

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

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

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

receiver. Whether hunting for unknown, or confirming known, utilities, this method will only detect continuous lengths of metallic conductors.

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

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

Ground Penetrating Radar (GPR)

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

Magnetic Field Methods

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

ferrous metal, primarily iron and steel for utility location applications. Some utility detector combine magnetic and EMI methods into a single hand-held unit.

Optical Methods

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

Attachment D – Utility Clearance Documentation Form

Attachment E – Utility Marking Color Codes

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

White – Proposed excavations and borings

Pink – Temporary survey markings

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

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

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

Blue – Potable water

Purple – Reclaimed water, irrigation and slurry lines

Green – Sewer and storm drain lines

Buried Utility Location Tracking Form

(Submit to CH2M HILL PM within 24 hrs of location activities)

Project Location:
CH2M HILL Project No.:
CH2M HILL Project Manager: Name/Phone:
Fax:
Email:
CH2M HILL Field Team Leader: Name/Phone:

CH2M HILL Purchase Order:

Utility Location Subcontractor:
Subcontractor POC:

Dates of location activities:

Check each box using an "X" if a buried utility is present within 5 feet of a marked Station ID. If color of the flag or paint differs from listed color, note change in color on the form.

Station ID	Gas (Yellow)	Electric (Red)	Fiber optic (Orange)	Cable (Orange)	Water (Blue)	San. Sewer (Green)	Storm Sewer (Green)	Steam (Yellow)	Petroleum (Yellow)	Compressed air (Yellow)	Other ____	Other ____	Other ____	Other ____	Date completed	Technician initials	Notes (methods/tools used

The findings of the buried utility location activities summarized herein were conducted in strict accordance with the CH2M HILL scope of work.

Subcontractor's Signature

Date

0715 ARRIVE ON SITE AT XYZ SITE.
CH2M HILL STAFF:
JOHN SMITH: FIELD TEAM LEADER
BOB BUILDER: SITE SAFETY COORD.
WEATHER: OVERCAST + COOL, 45°F
CHANCE OF LATE SHOWERS
SCOPE: • COLLECT GROUNDWATER SAMPLES FOR LTM WORK AT SITE 14
• SUPERVISE SURVEY CREW AT SITE 17
0725 BB ~~CAL~~ ~~JS~~ (JS) CALIBRATES PID: 101 ppm/100 ppm OK
PID MODEL #, SERIAL #
0730 BB CALIBRATES HORIBA METER MODEL #, SERIAL #
→ LIST CALIBRATION RESULTS
0738 SURVEY CREW ARRIVES ON SITE
→ LIST NAMES
0745 BB HOLDS H+S TALK ON SLIPS, TRIPS, FALLS, TICKS + AIR MONITORING
JS + SURVEY CREW ATTEND
NO H+S ISSUES IDENTIFIED AS CONCERNS. ALL WORK IS IN "LEVEL D."
0755 JS CONDUCTS SITE-WIDE AIR MONITORING
ALL READINGS = 0.0 ppm IN

JS 5-12-03

SITE 14 LTM
BREATHING ZONE (BZ)
0805 MOBILIZE TO WELL MW-22 TO SAMPLE, SURVEYORS SETTING UP AT SITE 17
0815 PM (PAUL PAPER PUSHER) CALLS AND INFORMS JS TO COLLECT GW SAMPLE AT WELL MW-44 TODAY FOR 24 hour TAT ANALYSIS OF VOCS
0820 PURGING MW-22
→ RECORD WATER QUALITY DATA
JS 5-12-03
0843 COLLECT SAMPLE AT MW-22 FOR total TAL METALS AND VOC'S. NO Dissolved METALS NEEDED PER PM.
0905 JS + BB MOBILIZE TO SITE 17 TO SHOW SURVEYORS WELLS TO SURVEY.
0942 MOBILIZE TO WELL MW-22 TO COLLECT SAMPLE
0950 CAN NOT ACCESS WELL MW-22 DUE TO BASE OPERATIONS; CONTACT PAUL PAPERPUSHER AND HE STATED HE WILL CHECK ON GAINING ACCESS WITH BASE CONTACT.
0955 MOBILIZE TO WELL MW-19

JS 5-12-03

PMS 219

PMS 1795*

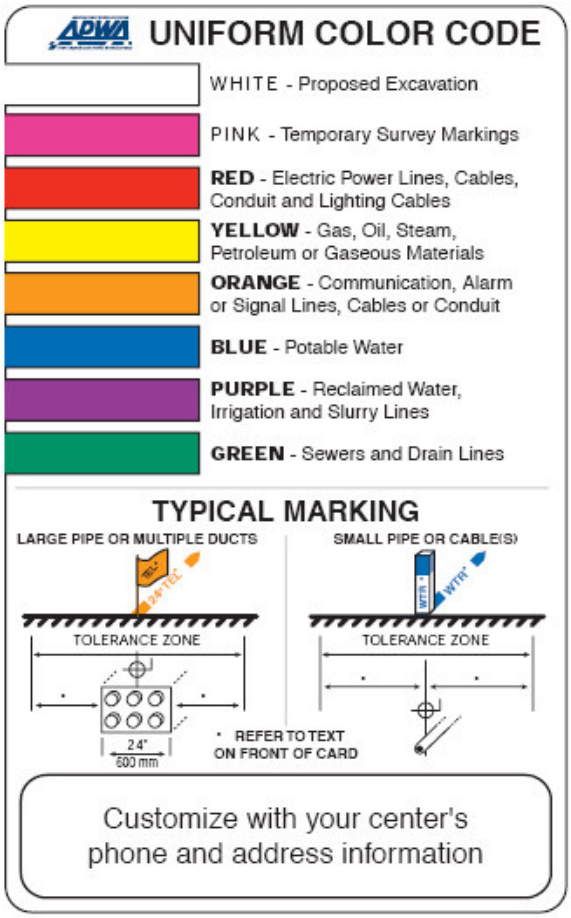
PMS 108

PMS 144*

13.5 parts process
2.5 parts reflex

PMS 253

PMS 3415



GUIDELINES FOR UNIFORM TEMPORARY MARKING OF UNDERGROUND FACILITIES

This marking guide provides for universal use and understanding of the temporary marking of subsurface facilities to prevent accidents and damage or service interruption by contractors, excavators, utility companies, municipalities or any others working on or near underground facilities.

ONE-CALL SYSTEMS
The One-Call damage prevention system shall be contacted prior to excavation.

PROPOSED EXCAVATION
Use white marks to show the location, route or boundary of proposed excavation. Surface marks on roadways do not exceed 1.5" by 18" (40 mm by 450 mm). The facility color and facility owner identity may be added to white flags or stakes.

USE OF TEMPORARY MARKING
Use color-coded surface marks (i.e., paint or chalk) to indicate the location or route of active and out-of-service buried lines. To increase visibility, color coded vertical markers (i.e., stakes or flags) should supplement surface marks. Marks and markers indicate the name, initials or logo of the company that owns or operates the line, and width of the facility if it is greater than 2" (50 mm). Marks placed by other than line owner/operator or its agent indicate the identity of the designating firm. Multiple lines in joint trench are marked in tandem. If the surface over the buried line is to be removed, supplementary offset markings are used. Offset markings are on a uniform alignment and clearly indicate the actual facility is a specific distance away.

TOLERANCE ZONE
Any excavation within the tolerance zone is performed with non-powered hand tools or non-invasive method until the marked facility is exposed. The width of the tolerance zone may be specified in law or code. If not, a tolerance zone including the width of the facility plus 18" (450 mm) measured horizontally from each side of the facility is recommended.

ADOPT UNIFORM COLOR CODE
The American Public Works Association encourages public agencies, utilities, contractors, other associations, manufacturers and all others involved in excavation to adopt the APWA Uniform Color Code, using ANSI standard Z535.1 Safety Colors for temporary marking and facility identification.

Rev. 4/99

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

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

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

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

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

2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.

4. Remove respirator (if worn).

5. Remove inner gloves and discard.

6. At the end of the work day, shower entire body, including hair, either at the work site or at home.

7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Spread plastic on the ground to keep equipment from touching the ground

3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.

4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.

5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)

6. Rinse with 1 gallon of tap water. (deionized water may be substituted for tap water)

7. Rinse with 1 gallon of deionized water.

8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

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

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.

2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

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

1. Set up a decontamination pad in area designated by the Facility

2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, Liquinox® solution (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

Disposal of Waste Fluids and Solids

I. Purpose and Scope

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

II. Equipment and Materials

A. Fluids

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

B. Solids

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

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or roll-offs or frac tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. The drums will be filled with the drilling and well installation wastes, capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will be labeled as they are filled in the field and labels indicating that the contents are pending analysis affixed.

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

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

B. Labels

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

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

C. Fluids

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

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

D. Solids

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

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

E. Storage and Disposal

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

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

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

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

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

STANDARD OPERATING PROCEDURE

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

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

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Liquinox®
- Buckets
- Brushes
- Isopropanol, pesticide grade
- Personal Protective Equipment as specified by the Health and Safety Plan
- ASTM–Type II grade water or Lab Grade DI Water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

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

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

B. Downhole Drilling Tools

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

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

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

C. Field Analytical Equipment

1. Water Level Indicators

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

   a. Rinse with tap water
   b. Rinse with de-ionized water
   c. Solvent rinse with isopropanol (Optional)
   d. Rinse with de-ionized water

2. Probes

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

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

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

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

I. Purpose and Scope

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

II. Equipment and Materials

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

III. Procedures and Guidelines

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

A. Instructions for Completing Soil Boring Logs

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

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

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

B. Heading Information

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

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

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

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

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

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

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

Logger. Enter the first and last name.

C. Technical Data

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

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

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

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

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

partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

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

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

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

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

Specific information might include the following:

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

D. Field Classification of Soil

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

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual

procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

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

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

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

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

E. Soil Name

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

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

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

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

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

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

F. Group Symbol

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

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

G. Color

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

H. Moisture Content

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

I. Relative Density or Consistency

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

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

J. Soil Structure, Mineralogy, and Other Descriptors

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

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

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

K. Equipment and Calibration

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

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

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

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

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

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

V. Key Checks and Preventive Maintenance

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

JACOBS

PROJECT NUMBER	BORING NUMBER

SOIL BORING LOG

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

ATD WATER LEVEL : START : END : LOGGER :

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

CH2M HILL

PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT _____ LOCATION _____

ELEVATION _____ DRILLING CONTRACTOR _____

DRILLING METHOD AND EQUIPMENT _____

WATER LEVELS _____ START _____ FINISH _____ LOGGER _____

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

Figure 1
SOIL BORING LOG,
FORM D1586

CH2M HILL

PROJECT NUMBER	BORING NUMBER	SHEET 1 OF 3
DEN22371.G5	BL-3	

SOIL BORING LOG

PROJECT Howard Ave. Landslide LOCATION Howard & 24th Ave, Centennial, CO

ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colorado

DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drill rig

WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A. Michner

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

Figure 2
EXAMPLE OF COMPLETED LOG FORM

Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Feb. 10, 2000. Published May 2000. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 93ϵ1.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**

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limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula*.

6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens*.

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water

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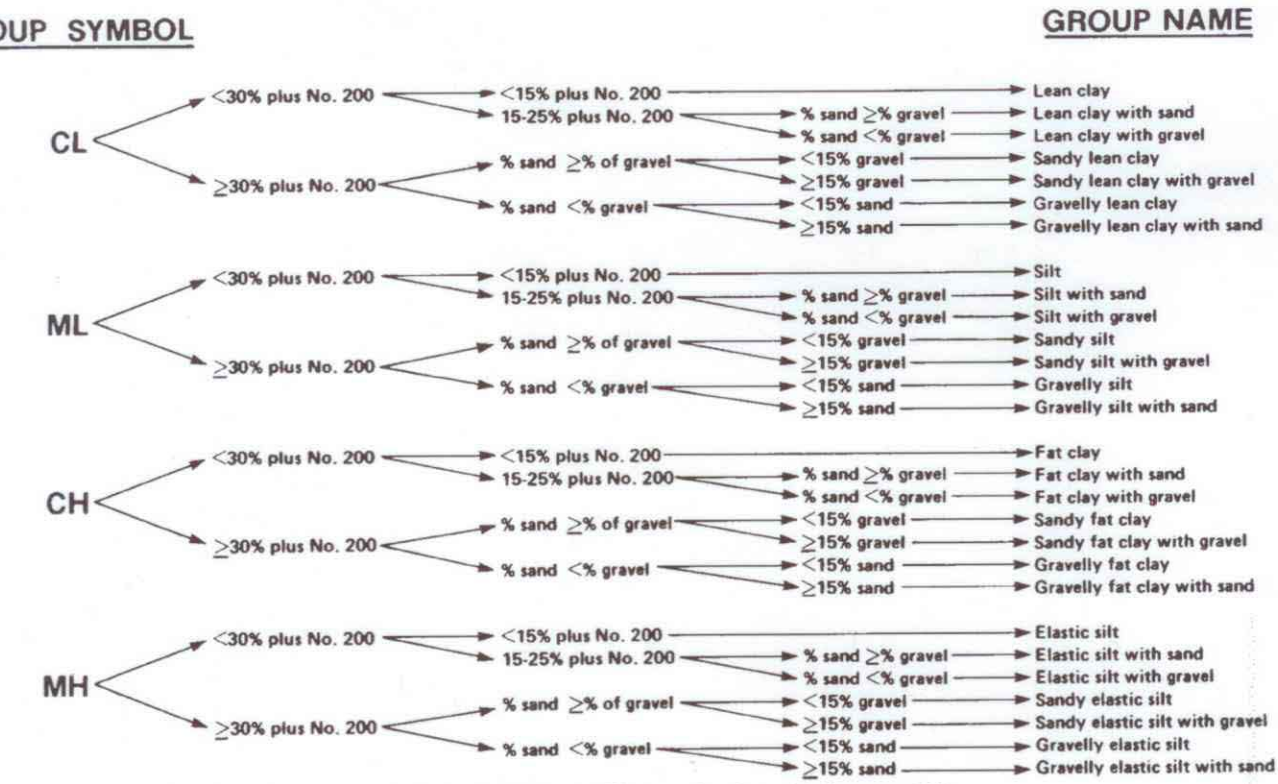
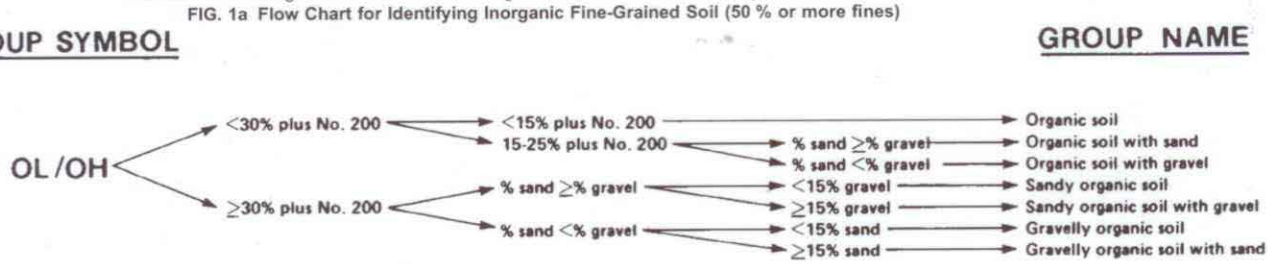


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

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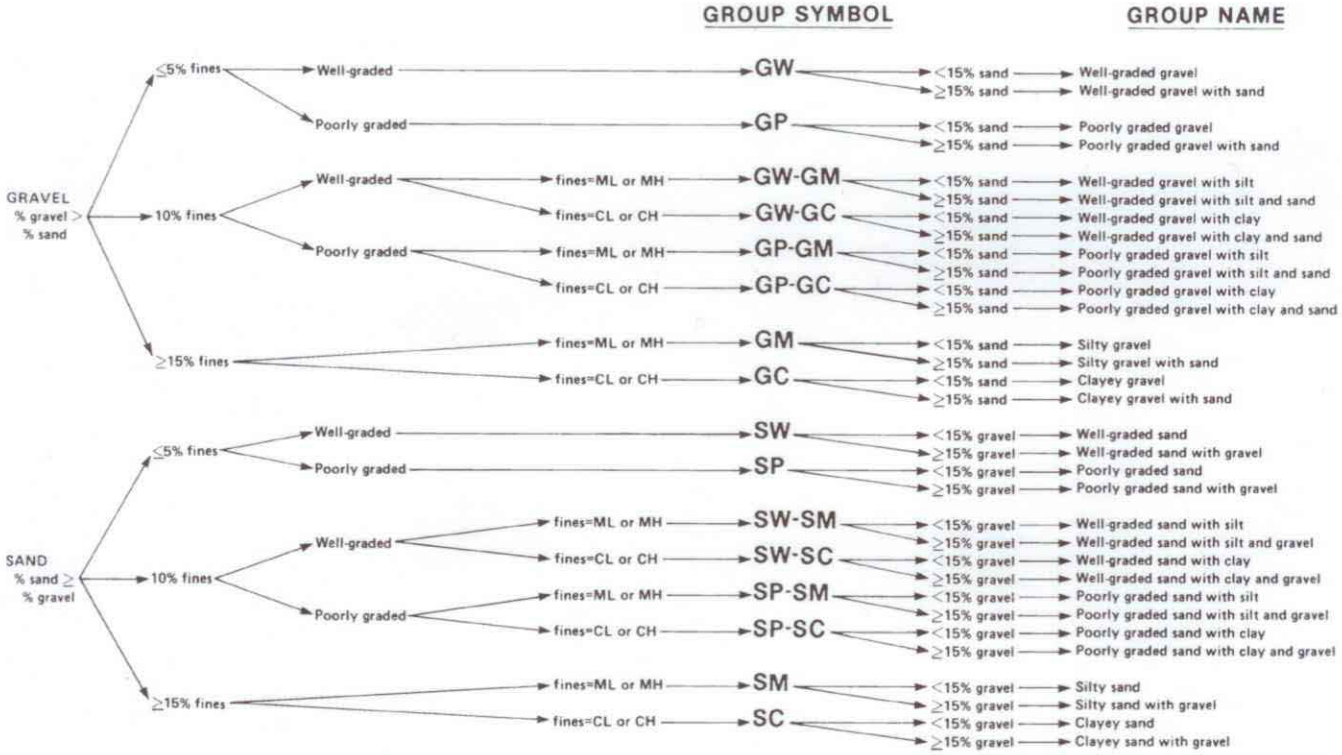

NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description 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

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

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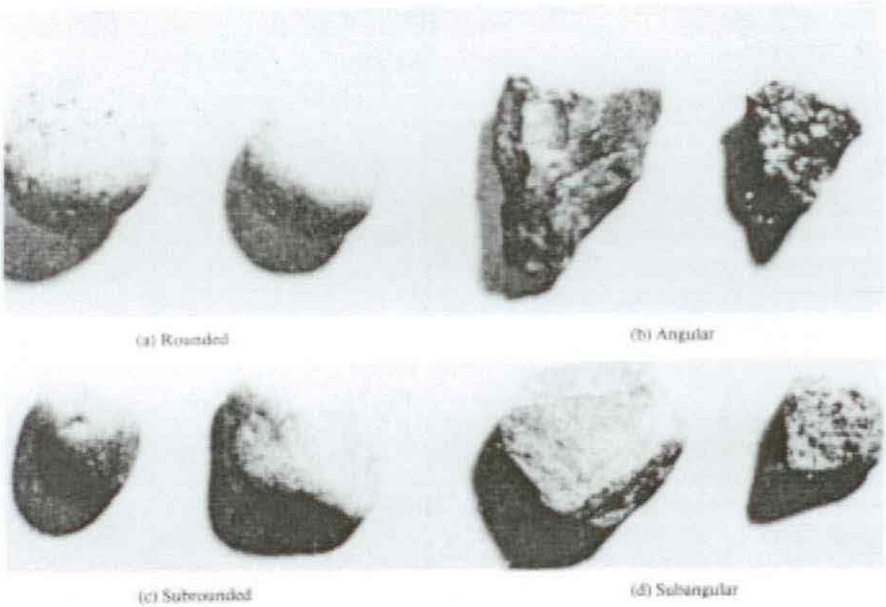

FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

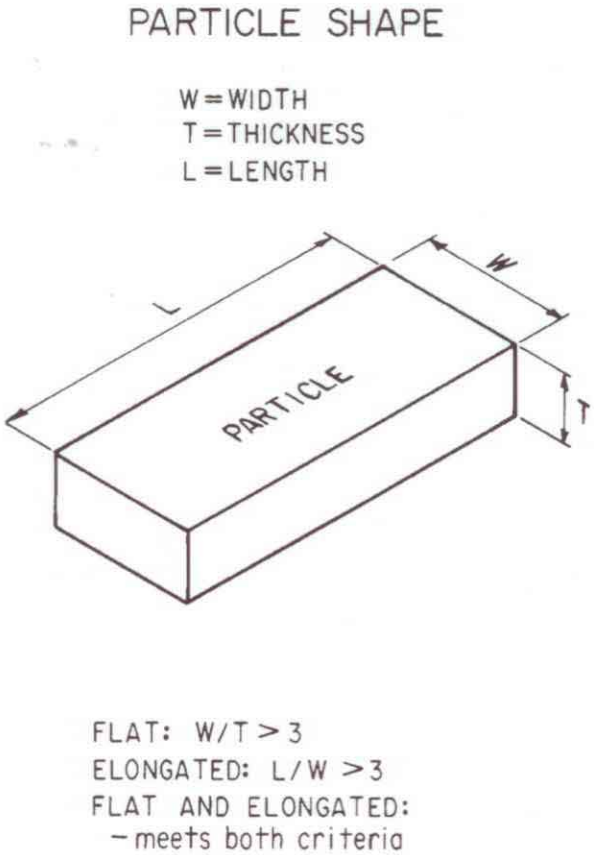

FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

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TABLE 3 Criteria for Describing Moisture Condition

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

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Dilatancy

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low,

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medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 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 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 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 ⅛ in. (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 reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. 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.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing Toughness

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 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

TABLE 10 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

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (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 drier 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 reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

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14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 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, black to brown, when exposed to the 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.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %
Few—5 to 10 %
Little—15 to 25 %
Some—30 to 45 %
Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

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16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard,

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angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix: Suffix:

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s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993$^{\epsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

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Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

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(Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 4633 Test Method for Energy Measurement for Dynamic Penetrometers

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

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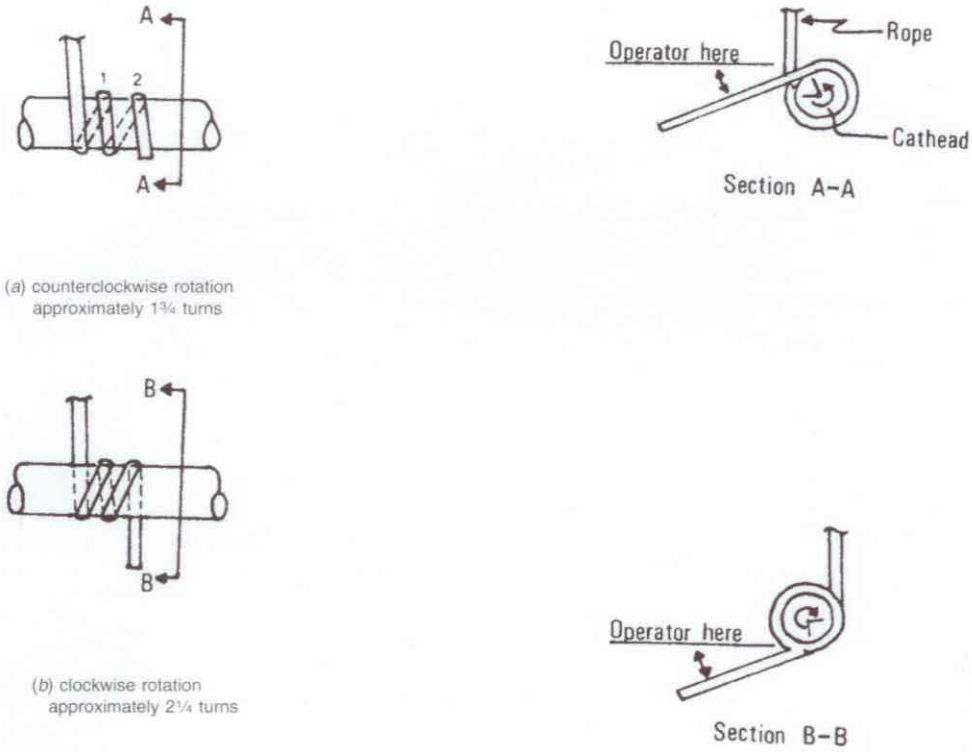

(*a*) counterclockwise rotation approximately 1¾ turns

(*b*) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1

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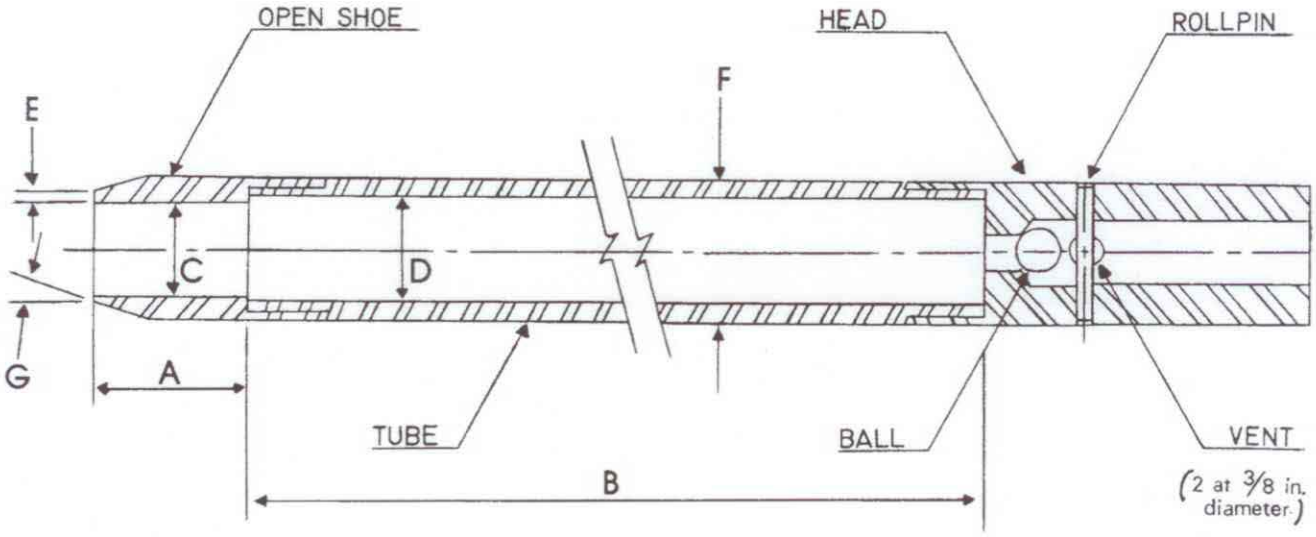

A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

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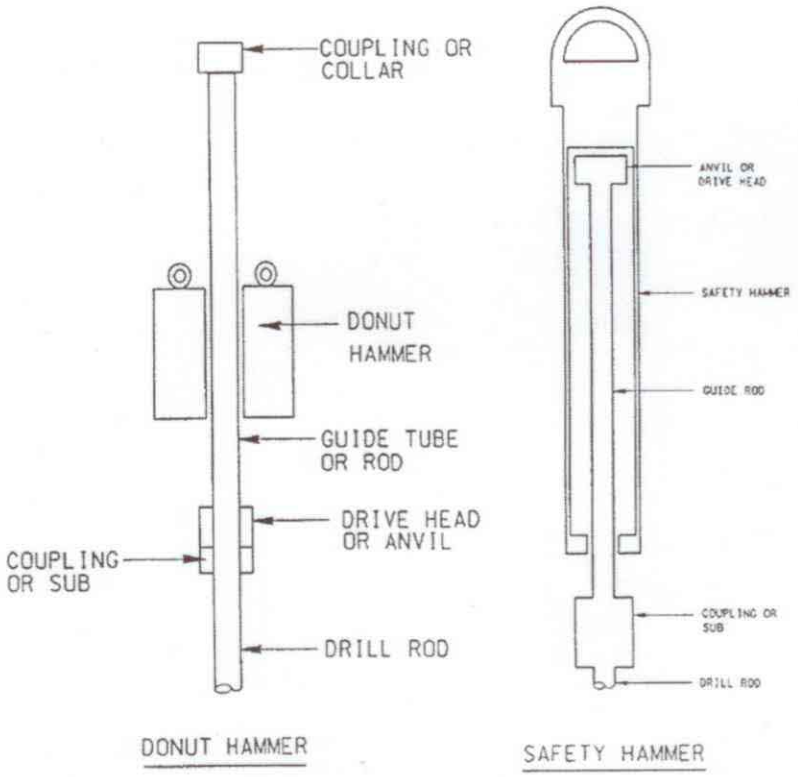

FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

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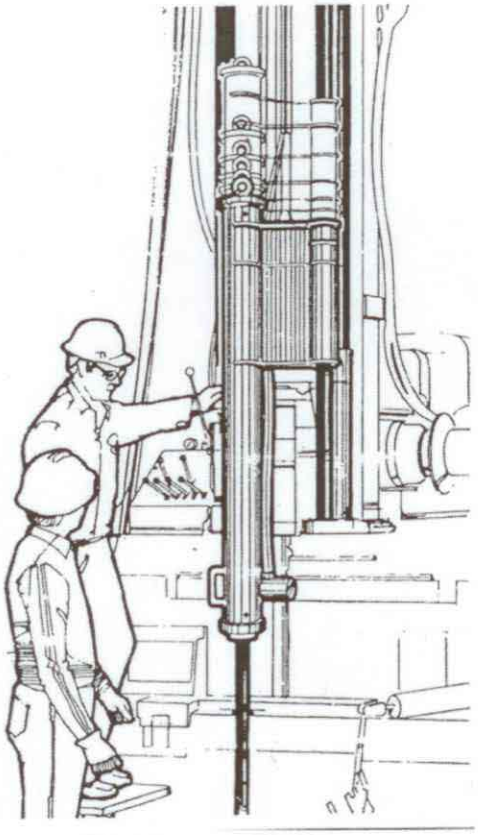

FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

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heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

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APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

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DRILLERS BORING LOG

Project: _____ Project No. _____ Boring No. _____

Location: _____ Sheet _____ of _____

Date Started: _____ Date Completed: _____

Drill Crew:

Boring Location
Station _____ Offset _____

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type _____

Method Of Drilling:

Auger _____ Size _____

Wash _____ Water _____ Mud _____

Hammer Type

Auto _____ Manual _____

Spilt-Spoon Type

Length _____ Liner Used _____

Boring Size _____ Bit Used _____

Casing Size _____ Length _____

Weather _____

Non-Drilling Time (Hrs.)

Boring Layout _____ Moving _____

Hauling Water _____ Standby _____

Water Level @ _____ Date _____ Time _____

@ _____ Date _____ Time _____

@ _____ Date _____ Time _____

Cave-in Depth

@ _____ Date _____ Time _____

FIG. 5 Example Data Sheet

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SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(*1*) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.

(*2*) Scope was completely revised.

(*3*) Referenced Documents updated to include new standards.

(*4*) Terminology: added section on Definitions.

(*5*) Significance and Use: clarified use of the SPT test.

(*6*) Apparatus: general editorial changes.

(*7*) Sampling and Testing Procedure: general editorial changes.

(*8*) Data Sheets/Forms: general editorial changes.

(*9*) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

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Table 1
EXAMPLE SOIL DESCRIPTIONS

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

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

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

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

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

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

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

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

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

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

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

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

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

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

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

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

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

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

STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

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

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Rite in the Rain® or Sanford Sharpie® permanent markers. **Note:** for sites where PFC is being analyzed for, Rite-in-the-Rain®, Sanford Sharpie®, or anything water-resistant or with Teflon® cannot be used in the field. All field book materials must be "fluorine free". Acceptable substitutes would be a sewn notebook without a plastic cover, or loose-leaf notebook paper.

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

   - Company name and address

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

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

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

5. Daily entries will be made chronologically.

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

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

8. The final page of each day's notes will include the note-takers signature as well as the date.

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

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

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

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

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

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

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

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

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

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

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

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

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

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

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

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

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

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

Manager prior to beginning the field work.

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

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

    - Description of the general sampling area – site name, buildings and streets in the area, etc.
    - Station/Location identifier
    - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
    - Sample matrix and type
    - Sample date and time
    - Sample identifier
    - Draw a box around the sample ID so that it stands out in the field notes
    - Information on how the sample was collected – distinguish between "grab," "composite," and "discrete" samples
    - Number and type of sample containers collected
    - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
    - Parameters to be analyzed for, if appropriate
    - Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).

2. Use tables to record sampling information and field data from multiple samples.

3. Sketch sampling locations and other pertinent information.

4. Sketch well construction diagrams.

V. Attachments

Example field notes.

STANDARD OPERATING PROCEDURE

Chain-of-Custody

I Purpose

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

II Scope

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

III Definitions

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

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

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

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

IV. Procedures

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

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

Sample Identification

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

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

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

Measurements and observations shall be recorded using waterproof ink.

Sample Label

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

- Project – Name of project site.
- Sample Identification - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 05/21/17).

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

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

Chain-of-Custody Procedures

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

Field Custody Procedures

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

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

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

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

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a

pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

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

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

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

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

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

V Quality Assurance Records

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

VI Attachments

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

VII References

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

Attachment A

Example Sample Label

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

Client _____
Sample No. _____
Location _____
_____
Analysis _____
_____
Preservative HCL
Date _____ By _____

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

SITE NAME	DATE
ANALYSIS	TIME
	PRESERVATIVE

SAMPLE TYPE

☐ Grab ☐ Composite ☐ Other _____

COLLECTED BY:

Attachment B

Example Chain-of-Custody Record

CH2M HILL
APPLIED SCIENCES LABORATORY

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M Hill Project #: ☐☐☐☐☐☐☐☐.☐☐.☐☐

Purchase Order #:

Project Name:

Company Name CH2M HILL Office:

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

Report Copy to:

Requested Completion Date:

Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

Sample Disposal: Dispose ☐ Return ☐

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

LAB TEST CODES

SHADED AREA– FOR LAB USE ONLY

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

Sampled By & Title (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Shipped Via: UPS BUS Fed-Ex Hand Other ____	Shipping #
Work Authorized By (Please sign and print name)	Remarks		

QC Level: 1 2 3 Other: ____

COC Rec	ICE
Ana Req	TEMP
Cust Seal	Ph

Instructions and Agreement Provisions on Reverse Side

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

REV 3/94 FORM 340

Attachment C

Example Custody Seal

CH2M HILL

CUSTODY SEAL

Date

Signature

STANDARD OPERATING PROCEDURE

Equipment Blank and Field Blank Preparation

I. Purpose

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

II. Scope

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

III. Equipment and Materials

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

IV. Procedures and Guidelines

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

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

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

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

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

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

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

F. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

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

STANDARD OPERATING PROCEDURE

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Horiba or YSI Water Quality Parameter Meter with Flow-through Cell

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using a water quality parameter meter (e.g., Horiba® or YSI) for field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of aqueous samples. The YSI instrument does not measure turbidity. A separate turbidity meter (i.e., Hanna Turbidity Meter) will need to be used in conjunction with the YSI meter. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Water Quality Parameter Meter such as a Horiba® Water Quality Monitoring System or YSI with flow-though cell
- Calibration Standard Solutions (provided by rental company)
- Deionized water in spray bottle

III. Procedures and Guidelines

A. Parameters and Specifications:

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

B. Calibration:

Prior to each day's use, clean the probe and flow-through cell using deionized water and calibrate using the Standard Solution.

Horiba Calibration procedure:

1. Fill a calibration beaker with standard solution to the recommended fill line.
2. Insert the probe into the beaker. All the parameter sensors will now be immersed in the standard solution except the D.O. sensor; the D.O. calibration is done using atmospheric air.
3. Turn power on and allow some time for the machine to warm-up prior to starting the calibration. When the initial readings appear to stabilize the instrument is ready to calibrate.
4. Press CAL key to put the unit in the calibration mode.
5. Press the ENT key to start automatic calibration. Wait a moment, and the upper cursor will gradually move across the four auto-calibration parameters one by one: pH, COND, TURB, and DO. When the calibration is complete, the readout will briefly show END. The instrument is now calibrated.
6. If the unit is calibrated properly the instrument readings, while immersed in the standard solution, will match the standard solution values provided on the solution container. The typical standard solution values are: pH = 4.0 +/- 3%, conductivity 4.49 mS/cm +/- 3%, and turbidity = 0 NTU +/- 3%.
7. Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

YSI Calibration procedure:

1. Press the **On/off** key to display the run screen
2. Press the **Escape** key to display the main menu screen
3. Use the arrow keys to highlight the **Calibrate**
4. Press the **Enter** key. The Calibrate screen is displayed
5. Choose the parameter to calibrate

A. Conductivity Calibration:

This procedure calibrates specific conductance (recommended), conductivity and salinity. Calibrating any one option automatically calibrates the other two.

1) Use the arrow keys to highlight the **Conductivity** selection
2) Press **Enter.** The Conductivity Calibration Selection Screen is displayed.
3) Use the arrow keys to highlight the Specific Conductance selection.
4) Press **Enter.** The Conductivity Calibration Entry Screen is displayed.
5) Place the correct amount of conductivity standard (see Instrument Manual) into a clean, dry or pre-rinsed transport/calibration cup.
6) Carefully immerse the sensor end of the probe module into the solution.

7) Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.

   NOTE: The sensor must be completely immersed past its vent hole. Using the recommended volumes from the Instrument Manual Calibration Volumes should ensure that the vent hole is covered.

8) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not over tighten as this could cause damage to the threaded portions.

9) Use the keypad to enter the calibration value of the standard you are using.

   NOTE: Be sure to enter the value in **mS/cm at 25°C**.

10) Press **Enter**. The Conductivity Calibration Screen is displayed.
11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
12) Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
13) Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen
14) Press **Escape** to return to the calibrate menu.
15) Rinse the probe module and sensors in tap or purified water and dry.

B. Dissolved Oxygen Calibration:

This procedure calibrates dissolved oxygen. Calibrating any one option (% or mg/L) automatically calibrates the other.

1) Go to the calibrate screen as described in Section

   NOTE: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.

2) Use the arrow keys to highlight the **Dissolved Oxygen** selection.
3) Press **Enter**. The dissolved oxygen calibration screen is displayed.
4) DO calibration in mg/L is carried out in a water sample which has a known concentration of dissolved oxygen (usually determined by a Winkler titration).
5) Use the arrow keys to highlight the **DO mg/L** selection.
6) Press **Enter**. The DO mg/L Entry Screen is displayed.
7) Place the probe module in water with a known DO concentration.

   NOTE: Be sure to completely immerse all the sensors.

8) Use the keypad to enter the known DO concentration of the water.
9) Press **Enter**. The Dissolved Oxygen mg/L Calibration Screen is displayed.
10) Stir the water with a stir bar, or by rapidly moving the probe module, to provide fresh sample to the DO sensor.
11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
12) Observe the DO mg/L reading, when the reading is stable (shows no significant change for approximately 30 seconds), press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
13) Press **Enter**. This returns you to the DO calibration screen.
14) Press **Escape** to return to the calibrate menu.

15) Rinse the probe module and sensors in tap or purified water and dry.

C. pH Calibration:

1) Go to the calibrate screen.
2) Use the arrow keys to highlight the **pH** selection.
3) Press **Enter**. The pH calibration screen is displayed.
   - Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a one point calibration. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select only one pH buffer.
   - Select the **2-point** option to calibrate the pH sensor using only two calibration standards. Use this option if the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is sufficient. A three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.
   - Select the **3-point** option to calibrate the pH sensor using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer.
4) Use the arrow keys to highlight the **2-point** selection.
5) Press **Enter**. The pH Entry Screen is displayed.
6) Place the correct amount of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.

   NOTE: For maximum accuracy, the pH buffers you choose should be within the same pH range as the water you are preparing to sample.

   NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.
7) Carefully immerse the sensor end of the probe module into the solution.
8) Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.

   NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the sensor is covered.
9) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not over tighten as this could cause damage to the threaded portions.
10) Use the keypad to enter the calibration value of the buffer you are using **at the current temperature**.

    NOTE: pH vs. temperature values are printed on the labels of all YSI pH buffers.
11) Press **Enter**. The pH calibration screen is displayed.

12) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
13) Observe the reading under pH, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
14) Press **Enter**. This returns you to the Specified pH Calibration Screen.
15) Rinse the probe module, transport/calibration cup and sensors in tap or purified water and dry.
16) Repeat steps 6 through 13 above using a second pH buffer.
17) Press **Enter**. This returns you to the pH Calibration Screen.
18) Press **Escape** to return to the calibrate menu.
19) Rinse the probe module and sensors in tap or purified water and dry.

D. ORP Calibration:

1) Go to the calibrate screen.
2) Use the arrow keys to highlight the **ORP** selection.
3) Press **Enter**. The ORP calibration screen is displayed.
4) Place the correct amount of a known ORP solution into a clean, dry or pre-rinsed transport/calibration cup.

   NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the ORP sensor with a small amount of solution that can be discarded. Be certain that you avoid cross-contamination with other solutions.
5) Carefully immerse the sensor end of the probe module into the solution.
6) Gently rotate and/or move the probe module up and down to remove any bubbles from the ORP sensor.

   NOTE: The sensor must be completely immersed.
7) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.
8) Use the keypad to enter the correct value of the calibration solution you are using at the current temperature.
9) Press **Enter**. The ORP calibration screen is displayed.
10) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
11) Observe the reading under ORP, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
12) Press **Enter**. This returns you to the Calibrate Screen.
13) Rinse the probe module and sensors in tap or purified water and dry.
    Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

C. Sample Measurement:

<u>Horiba measurement procedure:</u>

As water passes through the flow-through the flow cell, press MEAS to obtain reading;

record data in a field notebook.

YSI measurement procedure:

As water passes through the flow-through the flow cell, the readings are displayed for each parameter. Record the water quality parameter data in a field notebook. In addition, the data is recorded in the YSI and can be downloaded to a computer following completion of the sampling event.

IV. Key Checks and Preventive Maintenance

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

V. References

YSI 556 Multi Probe System Operator Manual

YSI **Environmental**

Pure Data for a Healthy Planet.™

YSI 556 MPS

Multi Probe System

Operations Manual

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1. Safety

1.1 General Safety Information

Read all safety information in this manual carefully before using the YSI 556 Multi-Probe System (MPS). Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review *Appendix D Health and Safety*.

⚠ **WARNING**

Warnings are used in this manual when misuse of the instrument could result in death or serious injury to a person.

⚠ **CAUTION**

Cautions are used in this manual when misuse of the instrument could result in mild or serious injury to a person and/or damage to equipment.

⚠ **IMPORTANT SAFETY INSTRUCTIONS!**

⚠ **SAVE THESE INSTRUCTIONS!**

⚠ In essence, the most important safety rule for use of the YSI 556 MPS is to utilize the instrument ONLY for purposes documented in this manual. This is particularly true of the YSI 6117 rechargeable battery pack that contains nickel metal hydride (NiMH) batteries. The user should be certain to read all of the safety precautions outlined below before using the instrument.

⚠ YSI 6117 Rechargeable Battery Pack Safety Information

⚠ **Restrictions on Usage**

1. Never dispose of the battery pack in a fire.
2. Do not attempt to disassemble the YSI 6117 battery pack.
3. Do not tamper with any of the electronic components or the batteries within the battery pack. Tampering with either the electronic circuitry or the batteries will result in the voiding of the warranty and the compromising of the system performance, but, more importantly, can cause safety

hazards which result from overcharging such as overheating, venting of gas, and loss of corrosive electrolyte.

4. Do not charge the battery pack outside the 0–40°C temperature range.
5. Do not use or store the battery at high temperature, such as in strong direct sunlight, in cars during hot weather, or directly in front of heaters.
6. Do not expose the battery pack to water or allow the terminals to become damp.
7. Avoid striking or dropping the battery pack. If the pack appears to have sustained damage from these actions or malfunctions after an impact or drop, the user should not attempt to repair the unit. Instead, contact YSI Customer Service. Refer to *Appendix E Customer Service*.
8. If the battery pack is removed from the YSI 556 MPS, do not store it in pockets or packaging where metallic objects such as keys can short between the positive and negative terminals.

⚠ Precautions for Users with Small Children

Keep the battery pack out of reach of babies and small children.

⚠ Danger Notifications – Misuse creates a STRONG possibility of death or serious injury.

FAILURE TO CAREFULLY OBSERVE THE FOLLOWING PROCEDURES AND PRECAUTIONS CAN RESULT IN LEAKAGE OF BATTERY FLUID, HEAT GENERATION, BURSTING, AND SERIOUS PERSONAL INJURY.

1. Never dispose of the battery pack in a fire or heat it.
2. Never allow the positive and negative terminals of the battery pack to become shorted or connected with electrically conductive materials. When the battery pack has been removed from the YSI 556 MPS, store it in a heavy plastic bag to prevent accidental shorting of the terminals.

3. Never disassemble the battery pack and do not tamper with any of the electronic components or the batteries within the battery pack. The battery pack is equipped with a variety of safety features. Accidental deactivation of any of these safety features can cause a serious hazard to the user.
4. The NiMH batteries in the battery pack contain a strong alkaline solution (electrolyte). The alkaline solution is extremely corrosive and will cause damage to skin or other tissues. If any fluid from the battery pack comes in contact with a user's eyes, immediately flush with clean water and consult a physician immediately. The alkaline solution can damage eyes and lead to permanent loss of eyesight.

⚠ Warning Notifications – Misuse creates a possibility of death or serious injury

1. Do not allow the battery pack to contact freshwater, seawater, or other oxidizing reagents that might cause rust and result in heat generation. If a battery becomes rusted, the gas release vent may no longer operate and this failure can result in bursting.
2. If electrolyte from the battery pack contacts the skin or clothing, thoroughly wash the area immediately with clean water. The battery fluid can irritate the skin.

⚠ Caution Notifications – Misuse creates a possibility of mild or serious injury or damage to the equipment.

1. Do not strike or drop the battery pack. If any impact damage to the battery pack is suspected, contact YSI Customer Service. Refer to *Appendix E Customer Service*.
2. Store the battery pack out of reach of babies and small children.
3. Store the battery pack between the temperatures of -20 and 30°C.
4. Before using the battery pack, be sure to read the operation manual and all precautions carefully. Then store this information carefully to use as a reference when the need arises.

⚠ YSI 616 Cigarette Lighter Charger Safety Information

1. This section contains important safety and operating instructions for the YSI 556 MPS cigarette lighter battery charger (YSI 616; RadioShack Number 270-1533E). BE SURE TO SAVE THESE INSTRUCTIONS.
2. Before using the YSI 616 cigarette lighter charger, read all instructions and cautionary markings on battery charger, battery pack, and YSI 556 MPS.
3. Charge the YSI 6117 battery pack with the YSI 616 cigarette lighter charger ONLY when the YSI 6117 is installed in the YSI 556 MPS.
4. Do not expose charger to rain, moisture, or snow.
5. Use of an attachment not recommended or sold by the battery charger manufacturer may result in a risk of fire, electric shock, or injury to persons.
6. To reduce risk of damage to cigarette lighter and cord, pull by cigarette lighter rather than cord when disconnecting charger.
7. Make sure that the cord is located so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.
8. Do not operate charger with damaged cord or cigarette lighter connector – replace it immediately.
9. Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; contact YSI Customer Service. Refer to *Appendix E Customer Service*.
10. Do not disassemble charger other than to change the fuse as instructed. Replace the part or send it to YSI Product Service if repair is required (refer to *Appendix E Customer Service*). Incorrect reassembly may result in a risk of electric shock or fire.
11. To reduce risk of electric shock, unplug charger before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

⚠ YSI 556 MPS Water Leakage Safety Information

The YSI 556 MPS has been tested and shown to comply with IP67 criterion, i.e. submersion in 1 meter of water for 30 minutes with no leakage into either the battery compartment or the main case. However, if the instrument is submersed for periods of time in excess of 30 minutes, leakage may occur with subsequent damage to the batteries, the rechargeable battery pack circuitry, and/or the electronics in the main case.

If leakage into the battery compartment is observed when using alkaline C cells, remove batteries, dispose of batteries properly, and dry the battery compartment completely, ideally using compressed air. If corrosion is present on the battery terminals, contact YSI Customer Service for instructions. Refer to *Appendix E Customer Service*.

If leakage into the battery compartment is observed when using the YSI 6117 rechargeable battery pack, remove the battery assembly and set aside to dry. Return the battery pack to YSI Product Service for evaluation of possible damage. Finally dry the battery compartment completely, ideally using compressed air. If corrosion is present on the battery terminals, contact YSI Customer Service for instructions. Refer to *Appendix E Customer Service*.

⚠ **CAUTION:** If water has contacted the rechargeable battery pack, do not attempt to reuse it until it has been evaluated by YSI Product Service (refer to *Appendix E Customer Service*). Failure to follow this precaution can result in serious injury to the user.

If it is suspected that leakage into the main cavity of the case has occurred, remove the batteries immediately and return the instrument to YSI Product Service for damage assessment. Refer to *Appendix E Customer Service*.

⚠ **CAUTION:** Under no circumstances should the user attempt to open the main case.

2. General Information

2.1 Description

The rugged and reliable YSI 556 MPS (Multi-Probe System) combines the versatility of an easy-to-use, easy-to-read handheld unit with all the functionality of a multi-parameter system. Featuring a waterproof, impact-resistant case, the YSI 556 MPS simultaneously measures dissolved oxygen, conductivity, temperature, and optional pH and ORP. A simple cellular phone style keypad and large display make the instrument easy to use. The YSI 556 MPS is compatible with YSI EcoWatch™ for Windows™ software.

The YSI 556 MPS assists the user in conforming to Good Laboratory Practice (GLP) standards which help ensure that quality control/quality assurance methods are followed. Battery life is displayed with a fuel gauge, and the user can choose standard alkaline batteries or an optional rechargeable battery pack.

The 1.5 MB memory can store more than 49,000 data sets. Other options include a flow cell and barometer. The internal barometer can be user-calibrated and displayed along with other data, used in dissolved oxygen calibrations, and logged to memory for tracking changes in barometric pressure.

Features

- Waterproof - meets IP67 specifications
- Field-replaceable DO electrode module; pH and pH/ORP sensors
- Compatible with Ecowatch™ for Windows™ data analysis software
- Assists with Good Laboratory Practice Standards (GLP)
- Choice of DO membrane material for different applications
- Easy-to-use, screw-on cap DO membranes
- User-upgradable software from YSI website
- Three-year warranty on the instrument; one-year on the probe modules
- Available with 4,10, and 20 m cable lengths
- Stores over 49,000 data sets, time and date stamped

- Auto temperature compensating display contrast
- Optional barometer
- Optional rechargeable battery pack or standard alkaline batteries

2.2 Unpacking the Instrument

1. Remove the instrument from the shipping box. Note that the probe module and sensors are shipped in a separate box and will be unpacked later in Section *3.2 Unpacking the Probe Module*.

   NOTE: Do not discard any parts or supplies.

2. Use the packing list to ensure all items are present.

3. Visually inspect all components for damage.

   NOTE: If any parts are missing or damaged, contact your YSI Service Center immediately. Refer to *Appendix E Customer Service* or www.ysi.com.

2.3 Features of the YSI 556 Multi-Probe System

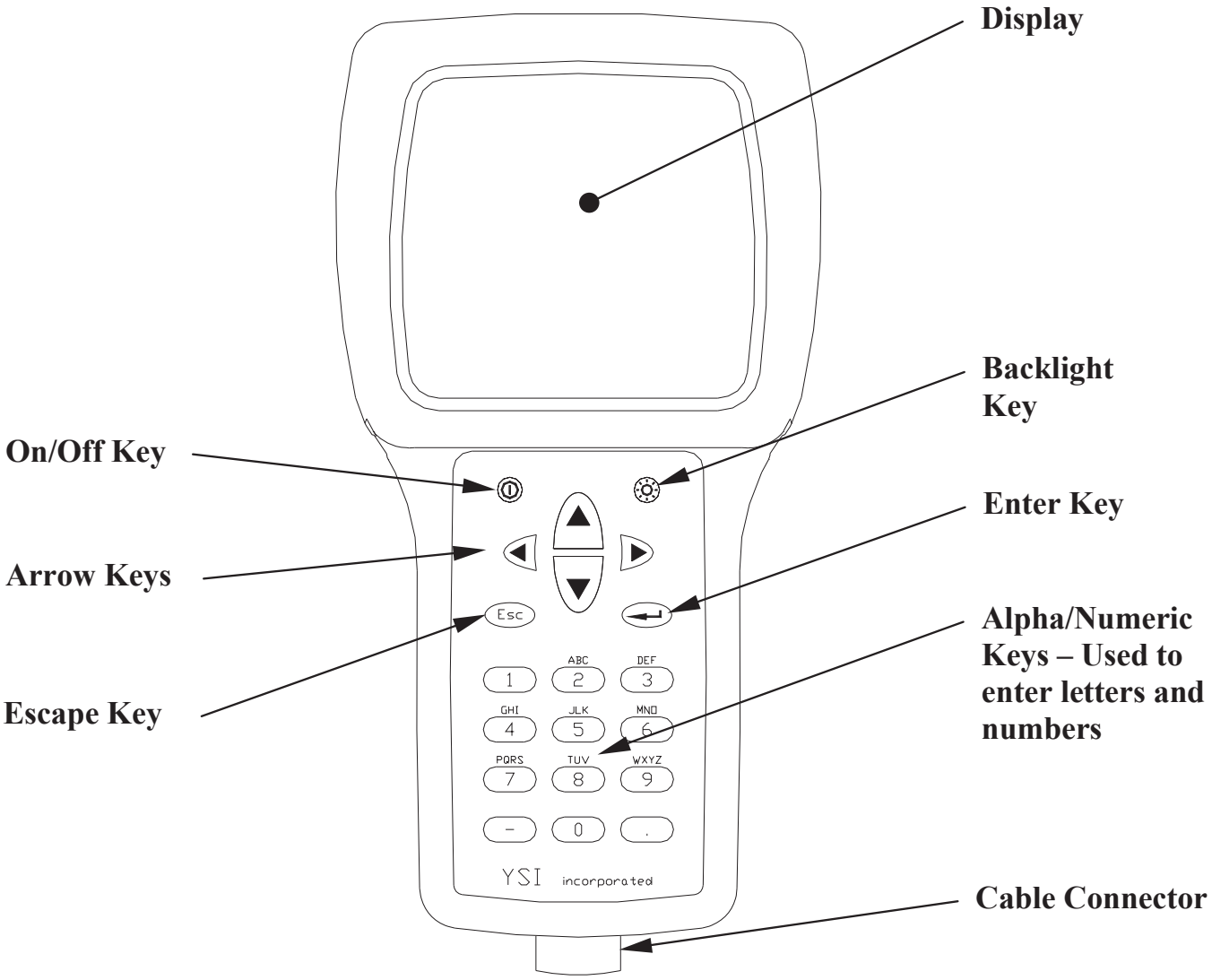


Figure 2.1 Front View of YSI 556 MPS

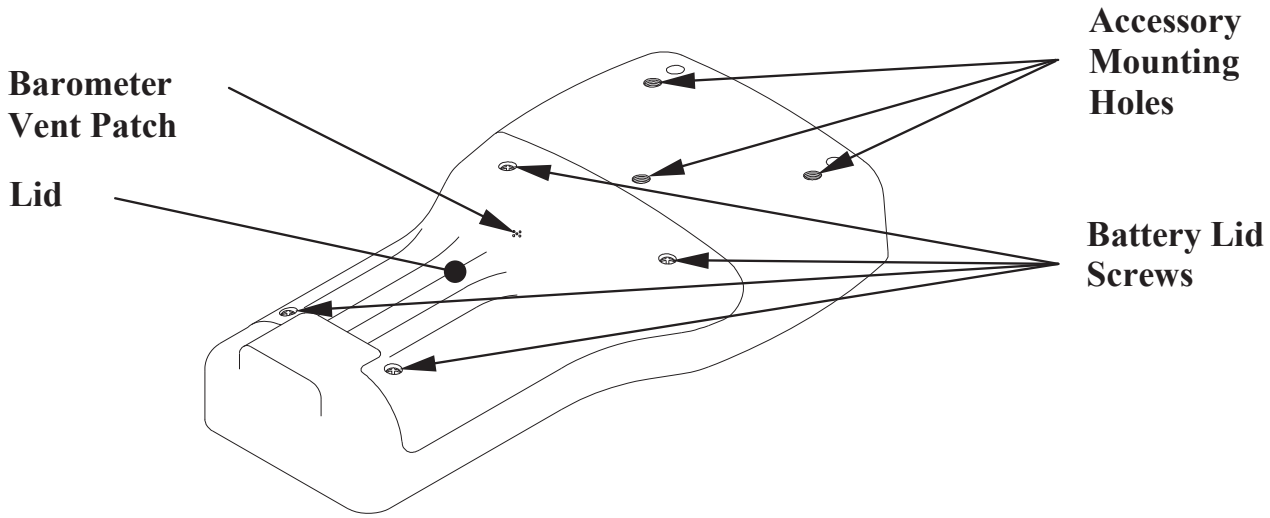


Figure 2.2 Back View of YSI 556 MPS

2.4 Batteries

2.4.1 Battery Life

Standard Alkaline Batteries

With the standard battery configuration of 4 alkaline C cells, the YSI 556 MPS will operate continuously for approximately 180 hours. Assuming a standard usage pattern when sampling of 3 hours of "on time" in a typical day, the alkaline cells will last approximately 60 days.

Optional Rechargeable Battery Pack

When fully charged, the optional rechargeable battery pack will provide approximately 50 hours of battery life.

2.4.2 Inserting 4 C Batteries

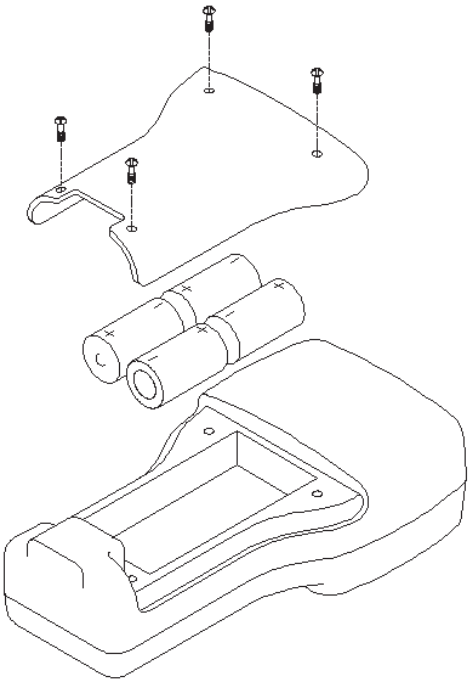


Figure 2.3 Inserting C Cells

⚠ **CAUTION: Install batteries properly to avoid damage to the instrument.**

1. Loosen the four screws in the battery lid on the back of the instrument using any screwdriver.

2. Remove the battery lid.

3. Insert four C batteries between the clips following the polarity (+ and -) labels on the bottom of the battery compartment.

4. Check gasket for proper placement on the battery lid.

5. Replace the battery lid and tighten the 4 screws securely and evenly.

   NOTE: Do not over-tighten the screws.

2.4.3 Inserting Optional Rechargeable Battery Pack

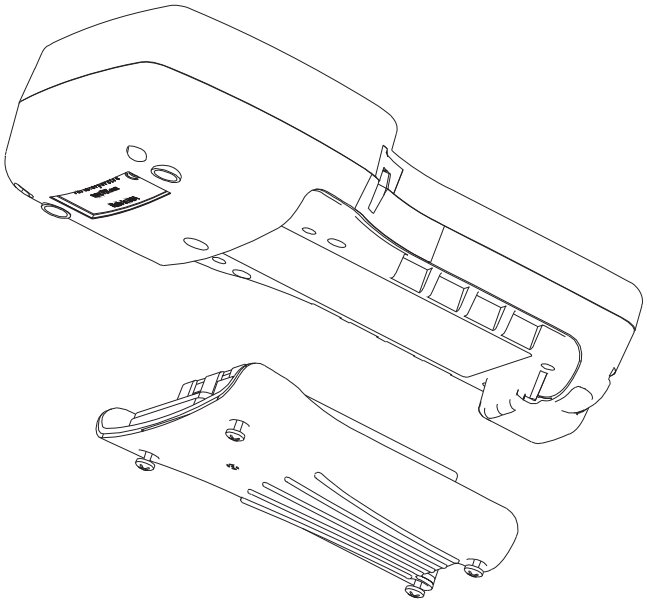


Figure 2.4 Inserting Battery Pack

⚠ **CAUTION: Read all cautions and warnings that come with the battery pack *before* using the battery pack.**

1. Loosen the four screws in the battery lid on the back of the instrument using any screwdriver.

2. Remove the C battery lid and store for future use. Remove C batteries, if installed.

3. Check for proper placement of gasket on the rechargeable battery pack and lid.

4. Install the rechargeable battery pack and lid and tighten the 4 screws securely and evenly.

   NOTE: Do not over tighten the screws.

2.4.4 Charging the Optional Rechargeable Battery Pack

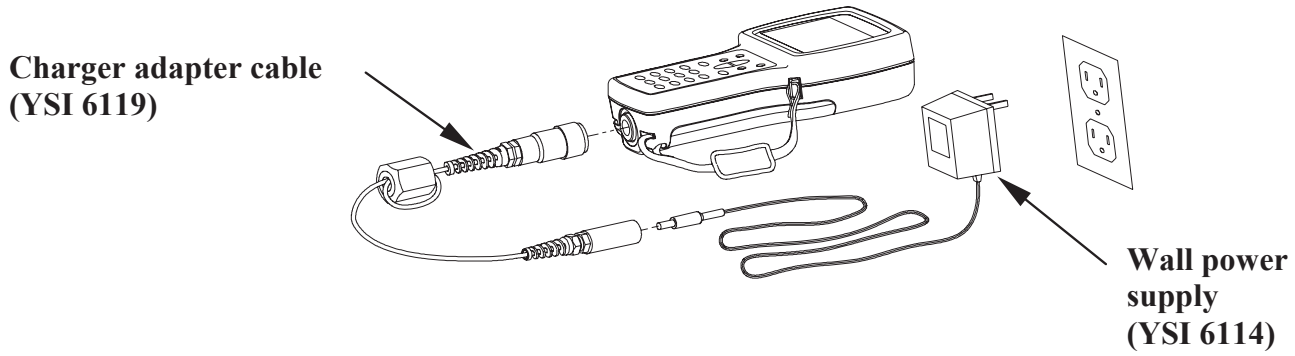


Figure 2.5 Charging the Battery Pack

⚠ **CAUTION: Do not use or store the battery pack at extreme temperatures such as in strong direct sunlight, in cars during hot weather or close to heaters.**

1. Install the rechargeable battery pack into the instrument as described in Section *2.4.3 Inserting Optional Rechargeable Battery Pack*.

2. Attach the charger adapter cable (YSI 6119) to the instrument.

   NOTE: Wall power supplies for use in countries outside the US and Canada can be found in *Appendix B Instrument Accessories*.

3. Insert the barrel connector of the wall power supply into the barrel of the adapter cable.

⚠ **CAUTION: Do not charge the battery pack continuously for more than 48 hours.**

⚠ **CAUTION: Do not drop or expose to water.**

⚠ **CAUTION: Do not charge the battery pack at temperatures below 0°C or above 40°C.**

4. Plug the wall power supply into an AC power outlet for approximately 2 hours to obtain an 80% to 90% charge and for 6 hours to get a full charge.

   NOTE: The battery pack can be recharged whether the instrument is on or off.

2.4.5 Storing the Battery Pack

Remove the battery pack from the instrument when the instrument will not be used for extended periods of time to prevent over discharge of the battery pack.

Store the battery pack in a heavy plastic bag to prevent accidental shorting of the terminals. Store between –20 and 30°C.

2.4.6 Optional Cigarette Lighter Charger

⚠ **CAUTION: Read all warnings and cautions that come with the charger before using the charger.**

⚠ **CAUTION: Only use cigarette lighter charger when *rechargeable* battery pack is inserted into instrument.**

⚠ **CAUTION: Do not mishandle cigarette lighter charger. Do not expose to moisture.**

1. Plug the barrel connector of the cigarette lighter charger into the mating end of the YSI 6119 Charger Adapter Cable.

2. Attach the MS-19 end of the YSI 6119 Charger Adapter Cable to the instrument.

3. Make one of the following modifications to the other end of the charger:

   Slide the adapter ring off the plug to use the device with an American or Japanese vehicle.

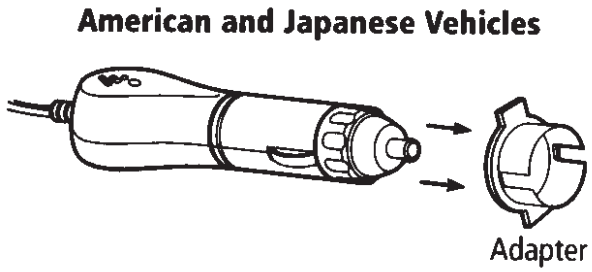


Figure 2.6 Charger Plug Adapter Use

Leave the adapter ring on the plug and position it so that the slots on the adapter ring line up with the plug's spring clips to use the device on a European vehicle.

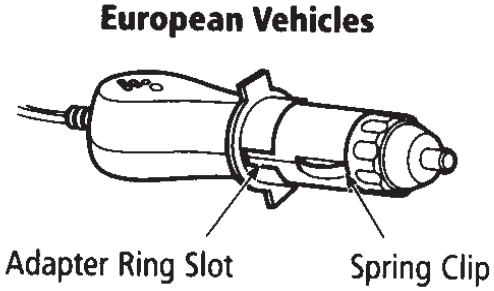


Figure 2.7 European Charger Plug Adapter Use

NOTE: If the charger stops working properly, refer to Section *13 Troubleshooting*.

2.5 Power On

Press and release the on/off button in the upper left corner of the instrument keypad to turn the instrument on or off. See Figure 2.1 Front View of YSI 556 MPS.

2.6 Setting Display Contrast

The display contrast automatically compensates for temperature changes. However, under extreme temperature conditions you may wish to optimize the display by manual adjustment as follows:

1. Press and *hold down* the backlight key in the upper right corner of the keypad and press the “up” arrow to increase (darken) the contrast.

2. Press and *hold down* the backlight key in the upper right corner of the keypad and press the “down” arrow to decrease (lighten) the contrast.

2.7 Backlight

Press and *release* the backlight key in the upper right corner of the keypad to turn the backlight on or off. See Figure 2.1 Front View of YSI 556 MPS.

NOTE: The backlight turns off automatically after two minutes of non-use.

2.8 General Screen Features

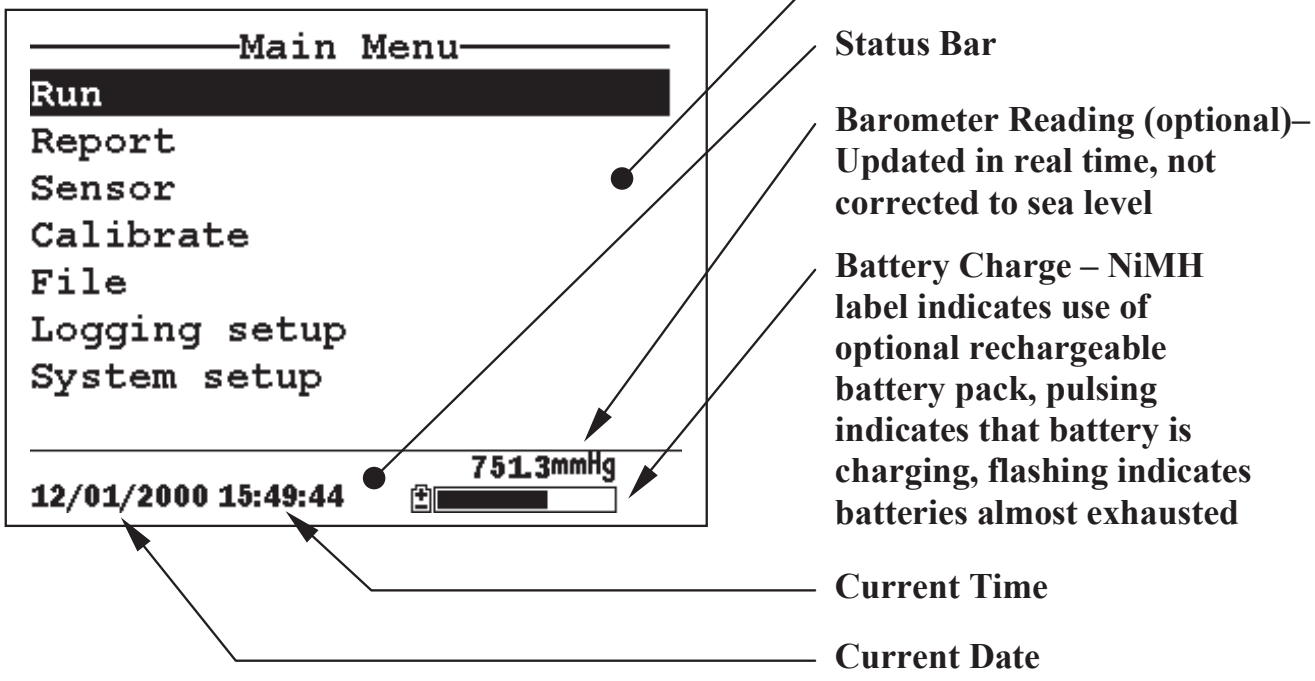


Figure 2.8 Main Menu Screen

2.9 Keypad Use

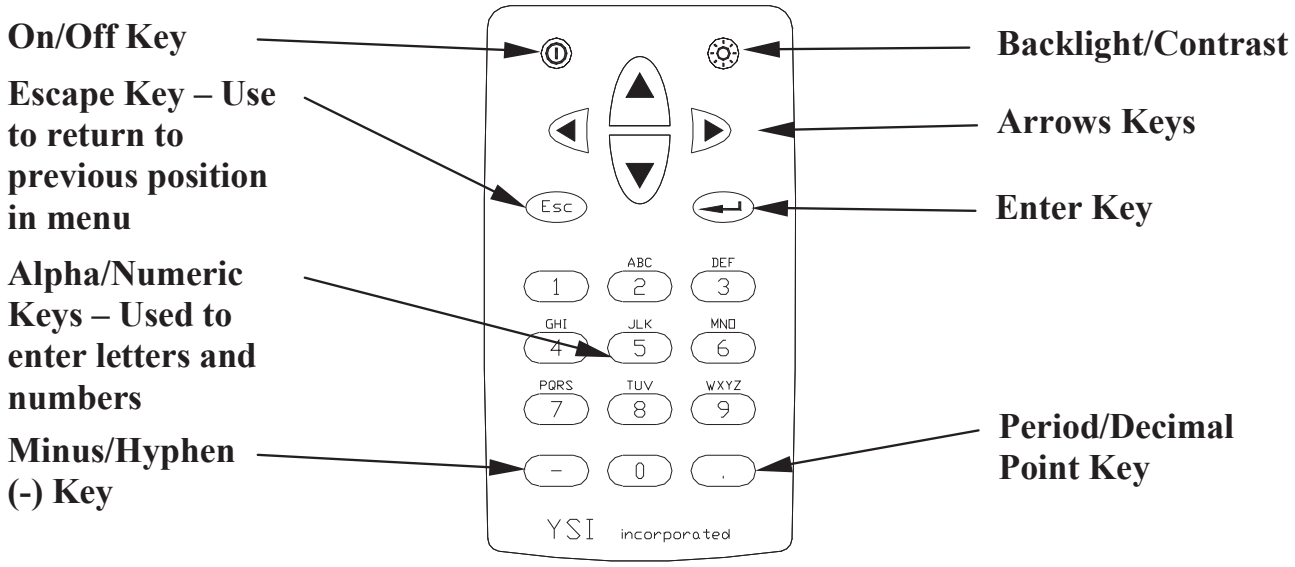


Figure 2.9 Keypad Features

KEY	LETTER/ NUMBER
1	1
2	ABC2abc3
3	DEF3def3
4	GHI4ghi4
5	JKL5jkl5
6	MNO6mno6
7	PQRS7pqrs7
8	TUV8tuv8
9	WXYZ9wxyz9
0	0

Figure 2.10 Keypad Letters & Numbers

1. See Figure 2.10 Keypad Letters & Numbers and press the appropriate key repeatedly until letter or number desired appears in display.

   NOTE: Press the key repeatedly in rapid succession to get to the desired letter or number. If you pause for more than a

second, the cursor automatically scrolls to the right to prepare for the next input.

EXAMPLE 1: Press the **6** key *once* and *release* to display an uppercase "M."

EXAMPLE 2: Press the **6** key *four times* and *release* to display the number "6."

EXAMPLE 3: Press the **6** key *five times* and *stop* to display a lowercase "m."

2. Press the left arrow key to go back and reenter a number or letter that needs to be changed.

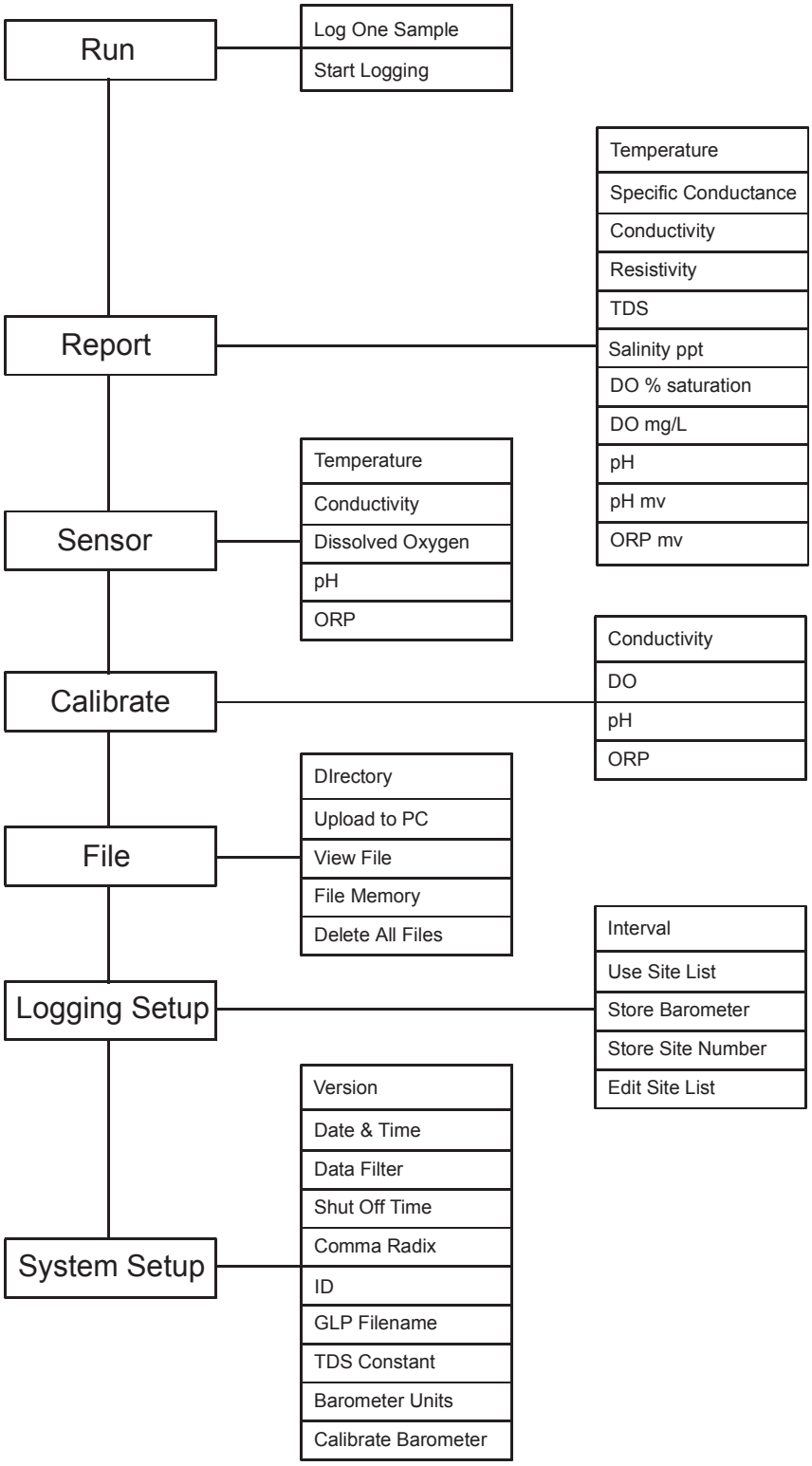
3. Press the **Enter** key when your entry is complete.

   NOTE: The instrument software permits only numeric entries in many instances, such as when setting the clock or entering calibration parameters.

2.10 Instrument Reset

The YSI 556 MPS is characterized by sophisticated software that should provided trouble-free operation. However as with all high-capability software packages, it is always possible that the user will encounter circumstances in which the instrument does not respond to keypad entry. If this occurs, the instrument function can easily be restored by removing and then reapplying battery power. Simply remove either your C-cells or rechargeable battery pack from the battery compartment, wait 30 seconds and then replace the batteries. See Section *2.4 Batteries* for battery removal/reinstallation instructions.

2.11 Menu Flowchart



3. Probe Module

3.1 Introduction

The YSI 5563 Probe module is used for measuring dissolved oxygen, temperature, conductivity, and optional pH and ORP. The probe module is rugged, with the sensors enclosed in a heavy duty probe sensor guard with attached sinking weight. A 4, 10 or 20 meter cable is directly connected to the probe module body making it waterproof. An MS-19 connector at the end of the cable makes the YSI 5563 fully compatible with the YSI 556 Multi-Probe System.

3.2 Unpacking the Probe Module

1. Remove the YSI 5563 Probe module from the shipping boxes.

   NOTE: Do not discard any parts or supplies.

2. Use the packing list to ensure all items are present.

3. Visually inspect all components for damage.

   NOTE: If any parts are missing or damaged, contact your YSI Service Center immediately. Refer to *Appendix E Customer Service* or www.ysi.com.

3.3 Features of the YSI 5563 Probe Module

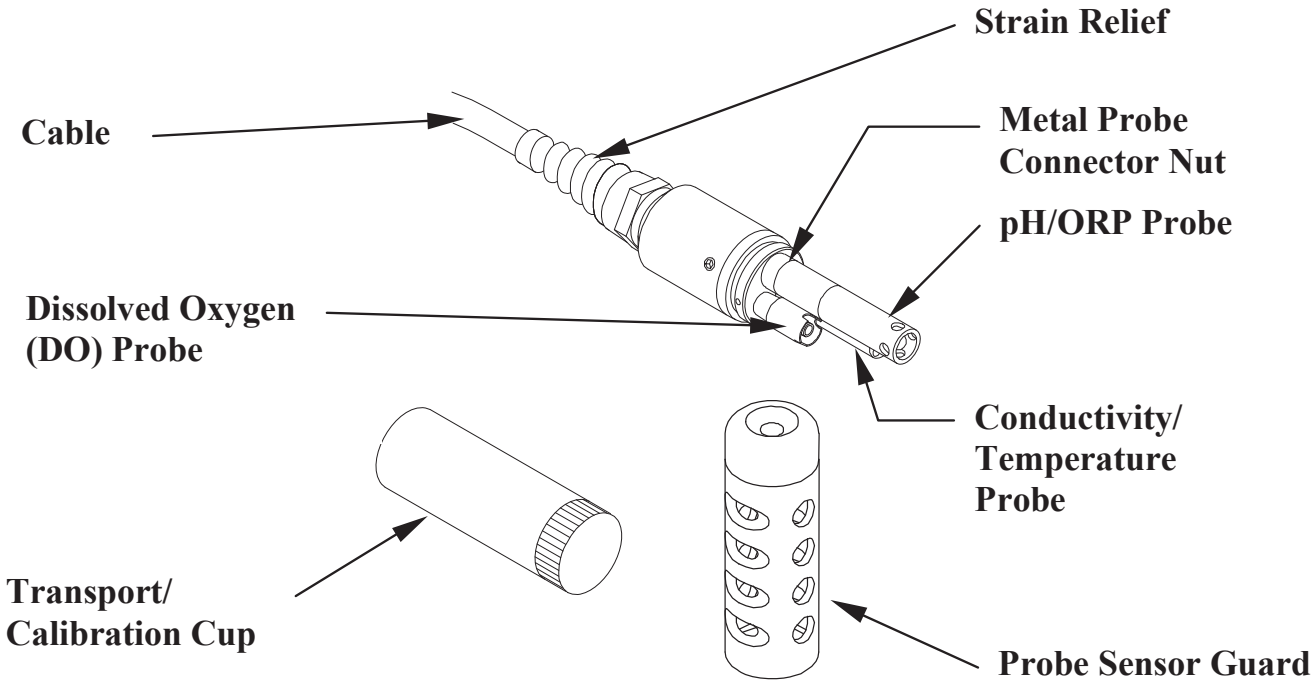


Figure 3.1 Probe Module

3.4 Preparing the Probe Module

To prepare the probe module for calibration and operation, you need to install the sensors into the connectors on the probe module bulkhead. In addition to sensor installation, you need to install a new DO membrane cap.

3.4.1 Sensor Installation

Whenever you install, remove or replace a sensor, it is extremely important that the entire probe module and all sensors be thoroughly dried prior to the removal of a sensor or a sensor port plug. This will prevent water from entering the port. Once you remove a sensor or plug, examine the connector inside the probe module sensor port. If any moisture is present, use compressed air to completely dry the connector. If the connector is corroded, return the probe module to your dealer or directly to YSI Customer Service. Refer to *Appendix E Customer Service*.

Conductivity/Temperature and pH, pH/ORP Sensor Installation

1. Unscrew and remove the probe sensor guard.

2. Using the sensor installation tool supplied in the YSI 5511 maintenance kit, unscrew and remove the sensor port plugs.

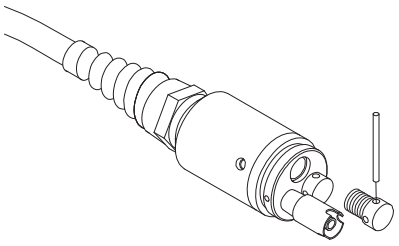


Figure 3.2 Port Plug Removal

3. Locate the port with the connector that corresponds to the sensor that is to be installed.

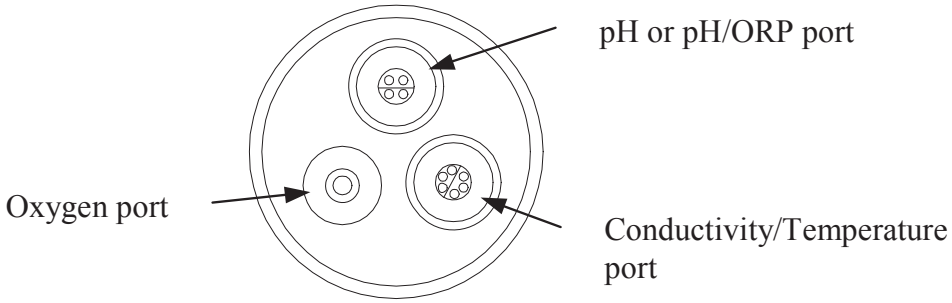


Figure 3.3 Sensor Port Identification

4. Apply a thin coat of o-ring lubricant (supplied in the YSI 5511 maintenance kit) to the o-rings on the connector side of the sensor (see Figure 3.4 O-Ring Lubrication).

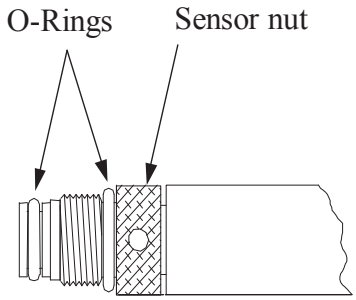


Figure 3.4 O-Ring Lubrication

⚠ **CAUTION:** Make sure that there are NO contaminants between the O-ring and the sensor. Contaminants that are present under the O-ring may cause the O-ring to leak.

5. Be sure the probe module sensor port is free of moisture and then insert the sensor into the correct port. Gently rotate the sensor until the two connectors align.

6. With connectors aligned, screw down the sensor nut using the sensor installation tool.

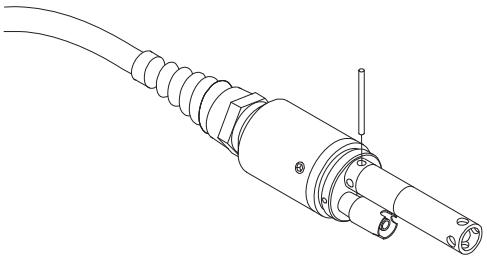


Figure 3.5 Sensor Installation

⚠ **CAUTION:** Do not cross thread the sensor nut. Tighten the nut until it is flush with the face of the probe module bulkhead. Do not over tighten.

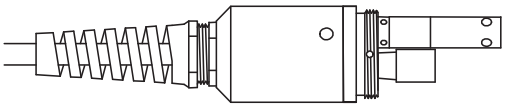


Figure 3.6 Bulkhead Seating

7. Repeat steps 3-6 for any other sensors.

8. Replace the probe sensor guard.

Dissolved Oxygen Sensor Installation

The YSI 5563 comes with the DO sensor already installed. Refer to Section *11.1.2 DO Sensor Replacement* for instructions on installing the YSI 558 Replaceable DO Module Kit.

3.4.2 Membrane Cap Selection

The YSI 5563 is shipped with a YSI 5909 kit that contains membrane caps made with 2 mil polyethylene (PE), a material which should be ideal for most field applications of the 556. However, YSI also offers membrane caps made with two other materials (1 mil polyethylene and 1 mil Teflon) which some users may also prefer. All membranes available for the 556/5563 system provide comparable accuracy if used properly. The difference between the two thicknesses of PE is found in the trade-off of flow dependence and response time as described below. Teflon is offered because some users may prefer to continue using the traditional membrane material used by YSI. To avoid confusion, the membrane caps are color coded as described below and can be ordered in kits as noted:

1 mil Teflon – Black Caps (Kit = YSI 5906)
1 mil Polyethylene (PE) – Yellow Caps (Kit = YSI 5908)
2 mil Polyethylene (PE) – Blue Caps (Kit = YSI 5909)

The 1 mil Teflon caps will offer traditional, reliable performance for most dissolved oxygen applications. The 1 mil PE caps will provide a significantly faster dissolved oxygen response (as long as your 556 Data Filter is set correctly as described below in Sections 10.2 and 10.3.1)) while also giving readings which are significantly less flow dependent than the 1 mil Teflon caps. Finally, 2 mil PE caps will show a large reduction in flow dependence over 1 mil Teflon while not significantly increasing the response time. Generally, one of the PE caps is likely to provide better performance for your application.

IMPORTANT: No matter which type of membrane cap you select, you will also have to confirm your selection in the 556

software from the Sensor menu as described in Section *4 Sensors*.

3.4.3 Membrane Cap Installation

NOTE: The YSI 5563 DO sensor (already installed in the probe module) was shipped dry. A shipping membrane was installed to protect the electrode. **A new membrane cap must be installed before the first use**.

1. Unscrew and remove the probe sensor guard.
2. Unscrew, remove, and discard the old membrane cap.
3. Thoroughly rinse the sensor tip with distilled water.
4. Prepare the electrolyte according to the directions on the electrolyte solution bottle.
5. Hold the new membrane cap and fill it at least 1/2 full with the electrolyte solution.
6. Screw the membrane cap onto the sensor moderately tight. A small amount of electrolyte should overflow.

⚠ **CAUTION:** Do not touch the membrane surface.

7. Screw the probe sensor guard on moderately tight.

3.5 Transport/Calibration Cup

The YSI 5563 Probe module has been supplied with a convenient transport/calibration cup. This cup is an ideal container for calibration of the different sensors, minimizing the amount of solution needed. Refer to Section *6 Calibrate*.

3.5.1 Transport/Calibration Cup Installation

1. Remove probe sensor guard, if already installed.

2. Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body.

3. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

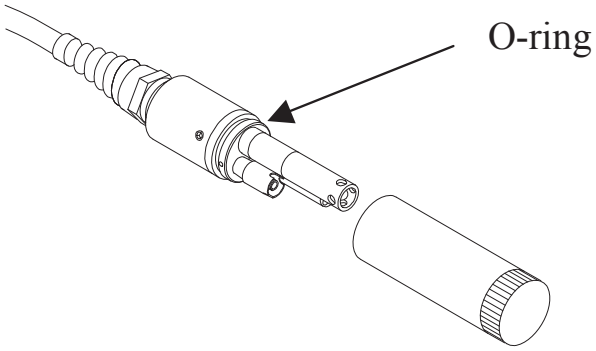


Figure 3.7 Transport/Calibration Cup Installation

3.6 Instrument/Cable Connection

Attach the cable to the instrument as follows:

1. Line up the pins and guides on the cable with the holes and indentations on the cable connector at the bottom of the YSI 556 instrument. See Figure 2.1 Front View of YSI 556 MPS.

2. Holding the cable firmly against the cable connector, turn the locking mechanism clockwise until it snaps into place.

Remove the cable from the instrument by turning the cable connector counterclockwise until the cable disengages from the instrument.

The Sensors Enabled screen allows the user to enable or disable each of the sensors and select which membrane material will be used for the dissolved oxygen sensor. Disabled sensors will not be displayed on the screen in real time or logged to files.

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.

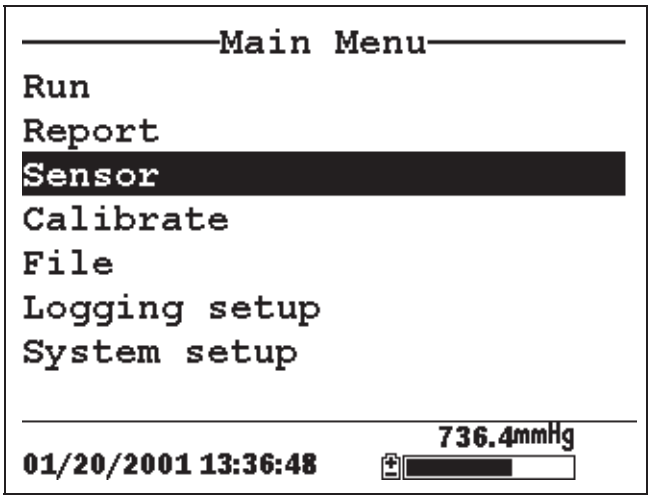


Figure 4.1 Main Menu Screen

3. Use the arrow keys to highlight the **Sensor** selection.

4. Press the **Enter** key to display the sensors enabled screen.

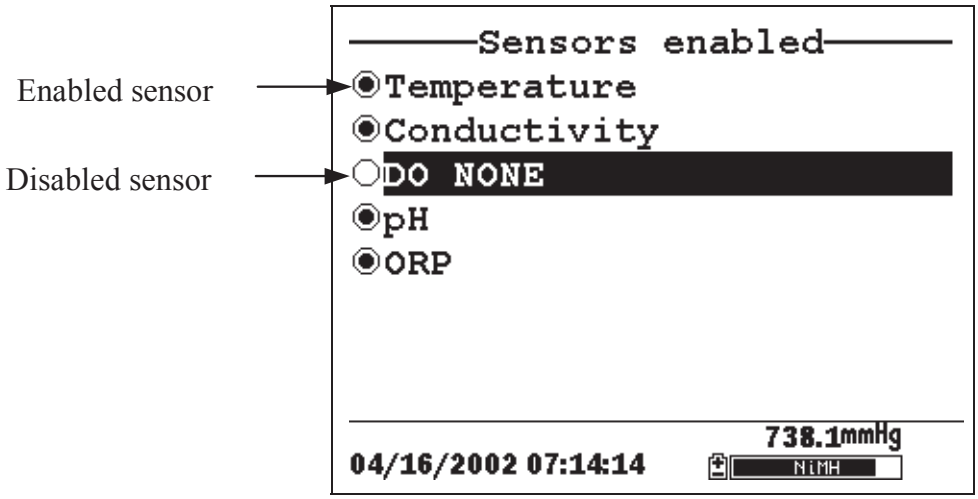


Figure 4.2 Sensors Enabled Screen Before DO Membrane Selection

A black dot to the left of a sensor indicates that sensor is enabled. Sensors with an empty circle are disabled.

Highlight the “DO None” entry as shown above and press **Enter** to display the membrane choice screen. Consult Section *3.4.2 Membrane Cap Selection* for information on the advantages of each type of membrane material. Blue membrane caps using 2 mil polyethylene (PE) were shipped with your YSI 5563 and are likely to be the best choice for most 556 field applications.

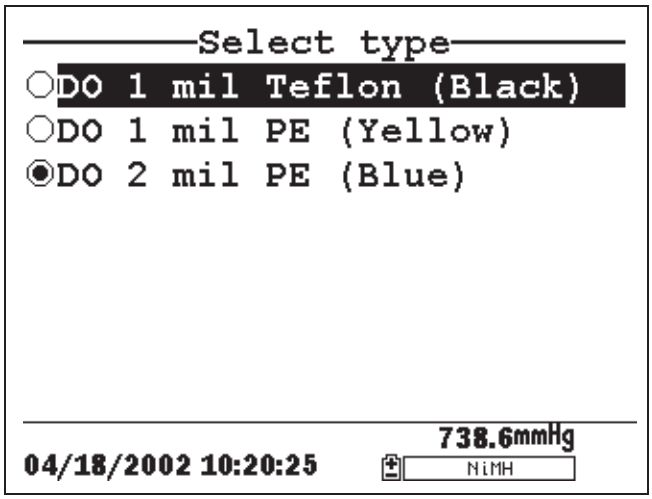


Figure 4.3 Membrane Selection Screen

Highlight the desired membrane choice – in this case, 2 mil PE -- and press Enter to activate your selection with a dot to the left of the screen. Then press **Escape** to return to the Sensor menu that now shows your DO membrane selection.

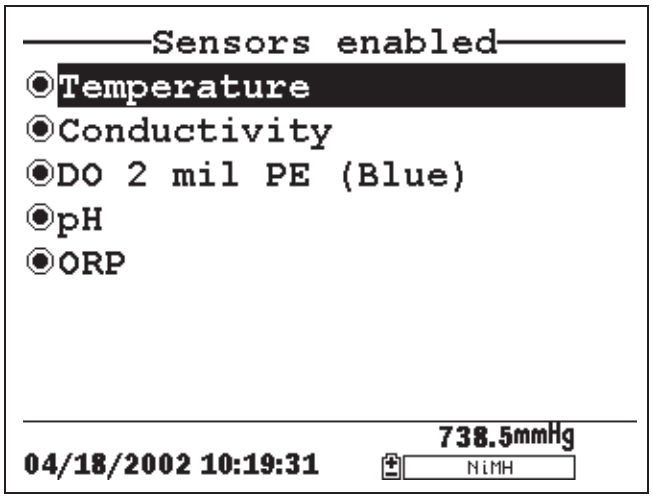


Figure 4.4 Sensors Enabled Screen After DO Membrane Selection

NOTE: The Temperature sensor cannot be disabled. Most other sensors require temperature compensation for accurate readings. In addition, the conductivity sensor must be activated in order to obtain accurate dissolved oxygen mg/L readings.

5. Use the arrow keys to highlight the sensor you want to change, then press the **Enter** key to enable or disable it.

6. Repeat step 5 for each sensor you want to change.

7. Press the **Escape** key to return to the main menu screen.

5. Report

The Report Setup screen allows the user to select which sample parameters and units the YSI 556 MPS will display on the screen. It does NOT determine which parameters are logged to memory. Refer to Section *4 Sensors*.

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.

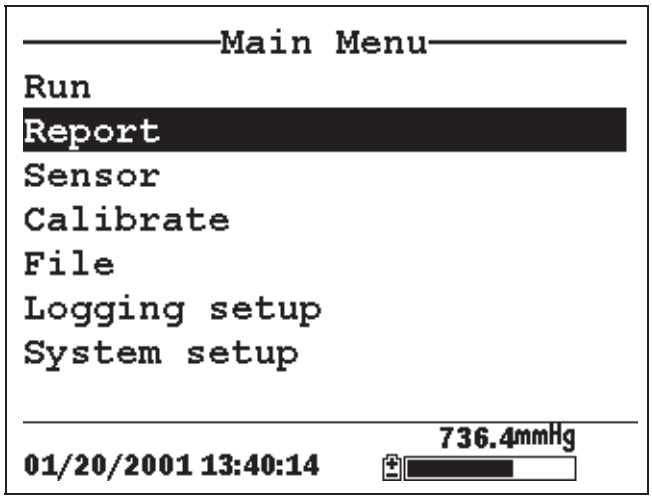


Figure 5.1 Main Menu

3. Use the arrow keys to highlight the **Report** selection.

4. Press the **Enter** key to display the report setup screen.

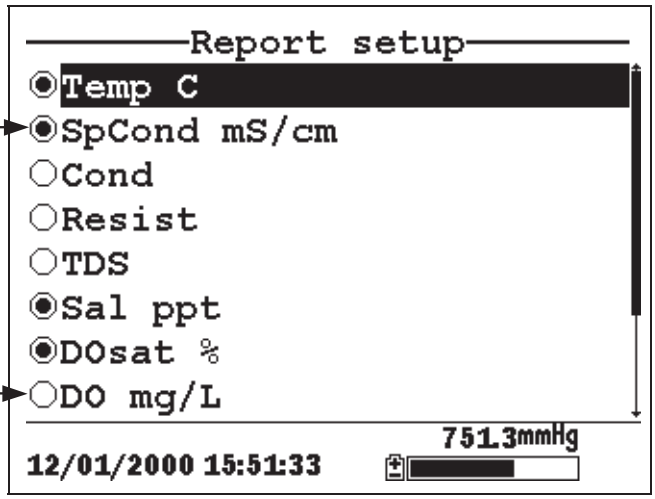


Figure 5.2 Report Setup Screen

NOTE: A black dot to the left of a parameter indicates that parameter is selected for display. Parameters with an empty circle will not be displayed.

NOTE: You may have to scroll down past the bottom of the screen to see all the parameters.

5. Use the arrow keys to highlight the parameter you want to change, then press the **Enter** key. If you can't find the parameter you want, even after scrolling down past the bottom of the screen, the sensor used for that parameter is disabled. Refer to Section *4 Sensors*.

6. If you selected Temperature, Specific Conductivity, Conductivity, Resistance or Total Dissolved Solids, the Units screen will appear.

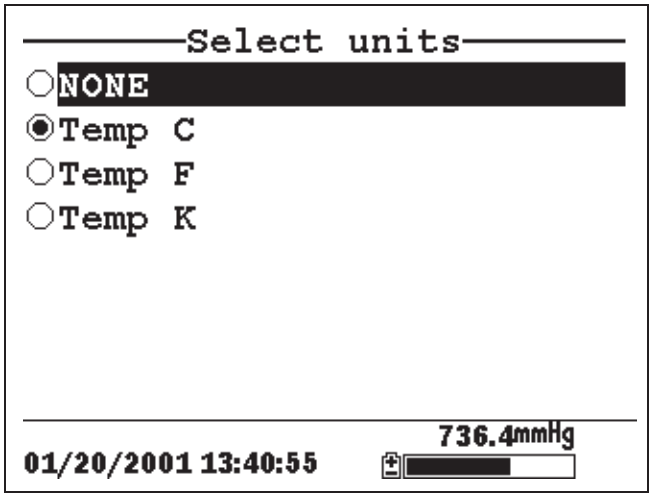


Figure 5.3 Units Screen

7. Use the arrow keys to select the units desired, then press the **Enter** key to return to the report setup screen.

   If you selected Salinity, Dissolved Oxygen %, Dissolved Oxygen mg/L, pH, pH mv or ORP mv, the selection dot will simply toggle on or off.

8. Repeat steps 5 and 6 for each parameter you want to change.

NOTE: All parameters may be enabled at the same time.

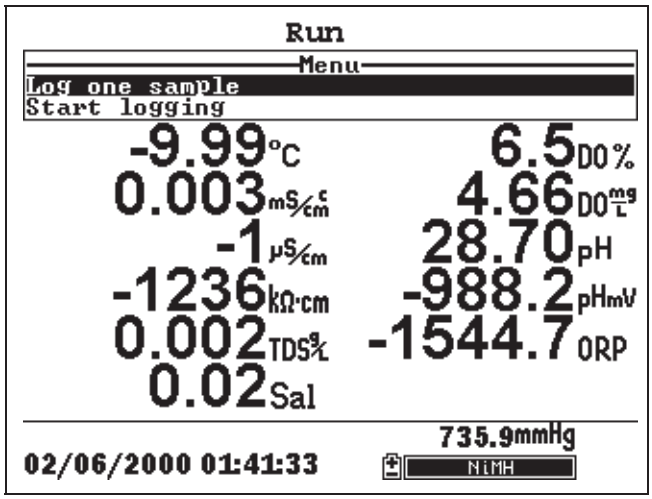


Figure 5.4 All Parameters Displayed

9. Press the **Escape** key to return to the Main menu screen.

6. Calibrate

All of the sensors, except temperature, require periodic calibration to assure high performance. You will find specific calibration procedures for all sensors that require calibration in the following sections. If a sensor listed is not installed in your probe module, skip that section and proceed to the next sensor until the calibration is complete.

⚠ **CAUTION:** Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review *Appendix D Health and Safety*. Some calibration standard solutions may require special handling.

6.1 Getting Ready to Calibrate

6.1.1 Containers Needed to Calibrate the Probe Module

The transport/calibration cup that comes with your probe module serves as a calibration chamber for all calibrations and minimizes the volume of calibration reagents required.

Instead of the transport/calibration cup, you may use laboratory glassware to perform calibrations. If you do not use the transport/calibration cup that is designed for the probe module, you are cautioned to do the following:

- ✓ Perform all calibrations with the Probe Sensor Guard installed. This protects the sensors from possible physical damage.
- ✓ Use a ring stand and clamp to secure the probe module body to prevent the module from falling over. Most laboratory glassware has convex bottoms.
- ✓ Ensure that all sensors are immersed in calibration solutions. Many of the calibrations factor in readings from other sensors (e.g., temperature sensor). The top vent hole of the conductivity sensor must also be immersed during some calibrations.

6.1.2 Calibration Tips

1. If you use the Transport/Calibration Cup for dissolved oxygen (DO) calibration, make certain to loosen the seal to allow pressure equilibration before calibration. The DO calibration is a water-saturated air calibration.
2. The key to successful calibration is to ensure that the sensors are completely submersed when calibration values are entered. Use recommended volumes when performing calibrations.
3. For maximum accuracy, use a small amount of previously used calibration solution to pre-rinse the probe module. You may wish to save old calibration standards for this purpose.
4. Fill a bucket with ambient temperature water to rinse the probe module between calibration solutions.
5. Have several clean, absorbent paper towels or cotton cloths available to dry the probe module between rinses and calibration solutions. Shake the excess rinse water off of the probe module, especially when the probe sensor guard is installed. Dry off the outside of the probe module and probe sensor guard. Making sure that the probe module is dry reduces carry-over contamination of calibrator solutions and increases the accuracy of the calibration.
6. If you are using laboratory glassware for calibration, you do not need to remove the probe sensor guard to rinse and dry the sensors between calibration solutions. The inaccuracy resulting from simply rinsing the sensor compartment and drying the outside of the guard is minimal.
7. If you are using laboratory glassware, remove the stainless steel weight from the bottom of the probe sensor guard by turning the weight counterclockwise. When the weight is removed, the calibration solutions have access to the sensors without displacing a lot of fluid. This also reduces the amount of liquid that is carried between calibrations.
8. Make certain that port plugs are installed in all ports where sensors are not installed. It is extremely important to keep these electrical connectors dry.

6.1.3 Recommended Volumes

Follow these instructions to use the transport/calibration cup for calibration procedures.

- ✓ Ensure that an o-ring is installed in the o-ring groove of the transport/calibration cup bottom cap, and that the bottom cap is securely tightened.

  NOTE: Do not over-tighten as this could cause damage to the threaded portions.
- ✓ Remove the probe sensor guard, if it is installed.
- ✓ Remove the o-ring, if installed, from the probe module and inspect the installed o-ring on the probe module for obvious defects and, if necessary, replace it with the extra o-ring supplied.
- ✓ Some calibrations can be accomplished with the probe module upright or upside down. A separate clamp and stand, such as a ring stand, is required to support the probe module in the inverted position.
- ✓ To calibrate, follow the procedures in the next section, Calibration Procedures. The approximate volumes of the reagents are specified below for both the upright and upside down orientations.
- ✓ When using the Transport/Calibration Cup for dissolved oxygen % saturation calibration, make certain that the vessel is vented to the atmosphere by loosening the bottom cap or cup assembly and that approximately 1/8” of water is present in the cup.

Sensor to Calibrate	Upright	Upside Down
Conductivity	55ml	55ml
pH/ORP	30ml	60ml

Table 6.1 Calibration Volumes

6.2 Calibration Procedures

6.2.1 Accessing the Calibrate Screen

1. Press the **On/off** key to display the run screen.
2. Press the **Escape** key to display the main menu screen.
3. Use the arrow keys to highlight the **Calibrate** selection.

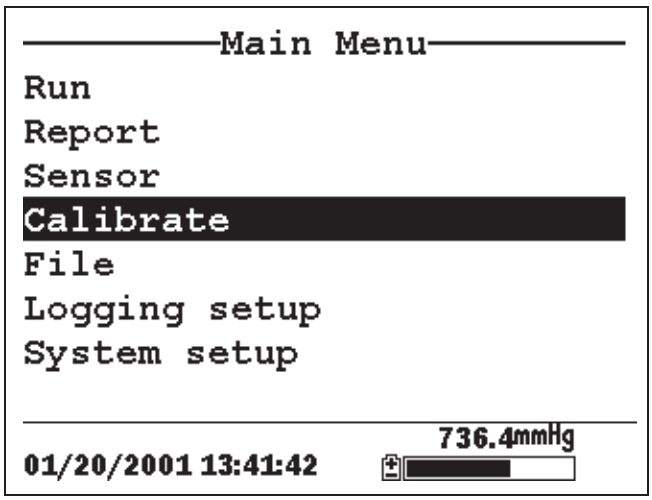


Figure 6.1 Main Menu

4. Press the **Enter** key. The Calibrate screen is displayed.

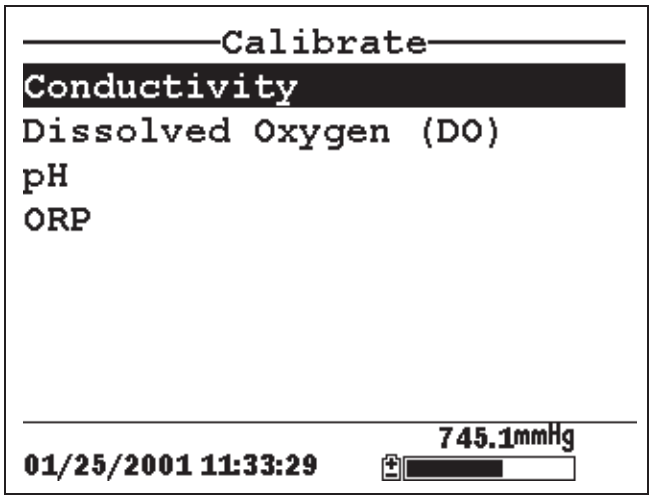


Figure 6.2 Calibrate Screen

6.2.2 Conductivity Calibration

This procedure calibrates specific conductance (recommended), conductivity and salinity. Calibrating any one option automatically calibrates the other two.

1. Go to the calibrate screen as described in Section 6.2.1 Accessing the Calibrate Screen.

2. Use the arrow keys to highlight the **Conductivity** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter.** The Conductivity Calibration Selection Screen is displayed.

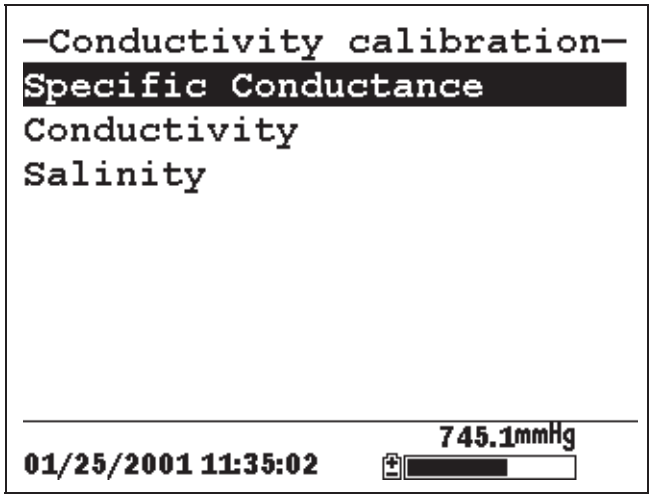


Figure 6.3 Conductivity Calibration Selection Screen

4. Use the arrow keys to highlight the Specific Conductance selection.

5. Press **Enter.** The Conductivity Calibration Entry Screen is displayed.

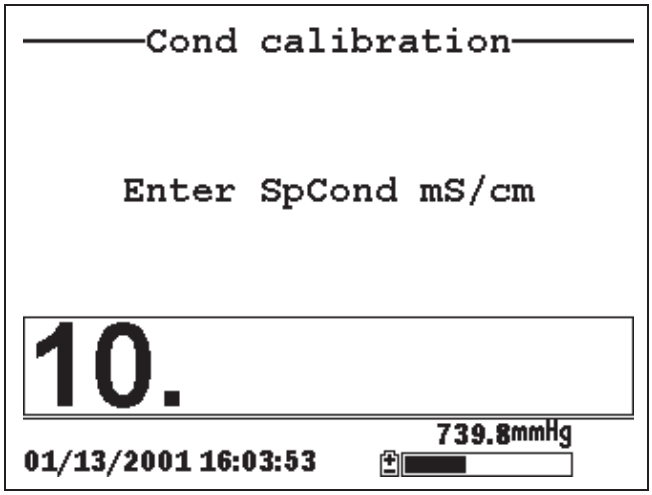


Figure 6.4 Conductivity Calibration Entry Screen

6. Place the correct amount of conductivity standard (see Table 6.1 Calibration Volumes) into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: For maximum accuracy, the conductivity standard you choose should be within the same conductivity range as the samples you are preparing to measure. However, we do not recommend using standards less than 1 mS/cm. For example:

- ✓ For fresh water use a 1 mS/cm conductivity standard.
- ✓ For brackish water use a 10 mS/cm conductivity standard.
- ✓ For seawater use a 50 mS/cm conductivity standard.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the conductivity sensor with a small amount of standard that can be discarded. Be certain that you avoid cross-contamination of solutions. Make certain that there are no salt deposits around the oxygen and pH/ORP sensors, particularly if you are employing standards of low conductivity.

7. Carefully immerse the sensor end of the probe module into the solution.

8. Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.

   NOTE: The sensor must be completely immersed past its vent hole. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the vent hole is covered.

9. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

10. Use the keypad to enter the calibration value of the standard you are using.

    NOTE: Be sure to enter the value in **mS/cm at 25°C**.

11. Press **Enter**. The Conductivity Calibration Screen is displayed.

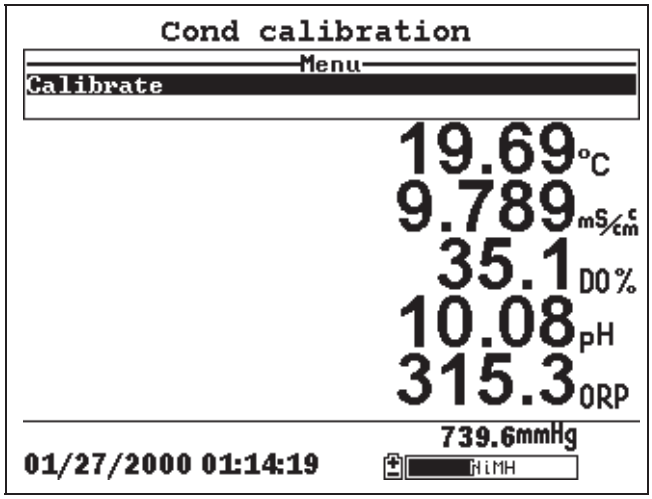


Figure 6.5 Conductivity Calibration Screen

12. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors

will appear on the screen and will change with time as they stabilize.

13. Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

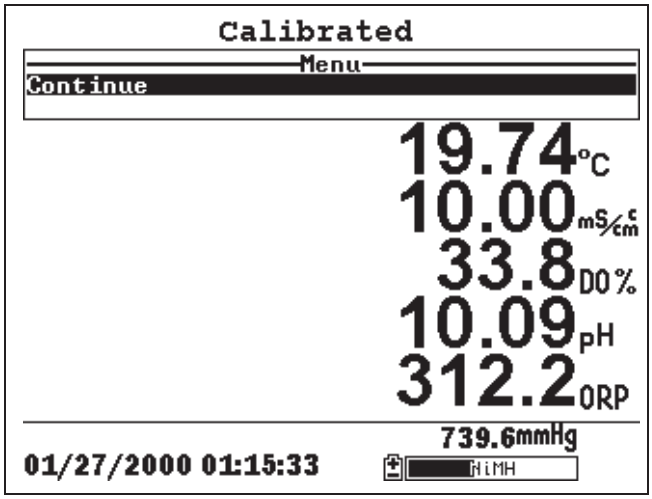


Figure 6.6 Calibrated

14. Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen, See Figure 6.3 Conductivity Calibration Selection Screen.

15. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

16. Rinse the probe module and sensors in tap or purified water and dry.

6.2.3 Dissolved Oxygen Calibration

This procedure calibrates dissolved oxygen. Calibrating any one option (% or mg/L) automatically calibrates the other.

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen*.

NOTE: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.

2. Use the arrow keys to highlight the **Dissolved Oxygen** selection. See Figure 6.2 Calibrate Screen.
3. Press **Enter**. The dissolved oxygen calibration screen is displayed.

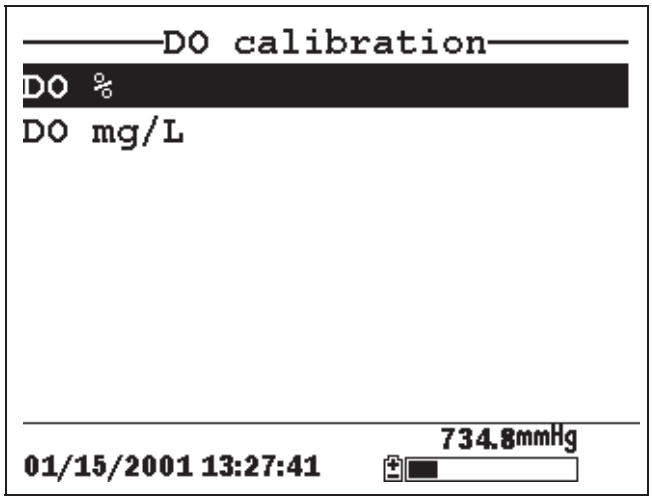


Figure 6.7 DO Calibration Screen

DO Calibration in % Saturation

1. Use the arrow keys to highlight the DO% selection.
2. Press **Enter**. The DO Barometric Pressure Entry Screen is displayed.

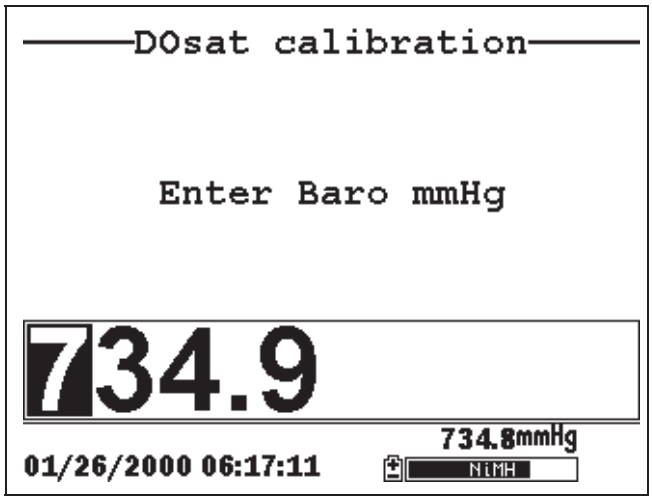


Figure 6.8 DO Barometric Pressure Entry Screen

3. Place approximately 3 mm (1/8 inch) of water in the bottom of the transport/calibration cup.

4. Place the probe module into the transport/calibration cup.

   NOTE: Make sure that the DO and temperature sensors are **not** immersed in the water.

5. Engage only 1 or 2 threads of the transport/calibration cup to ensure the DO sensor is vented to the atmosphere.

6. Use the keypad to enter the current local barometric pressure.

   NOTE: If the unit has the optional barometer, no entry is required.

   NOTE: Barometer readings that appear in meteorological reports are generally corrected to sea level and must be uncorrected before use (refer to Section *10.10 Calibrate Barometer, Step 2*).

7. Press **Enter**. The DO% saturation calibration screen is displayed.

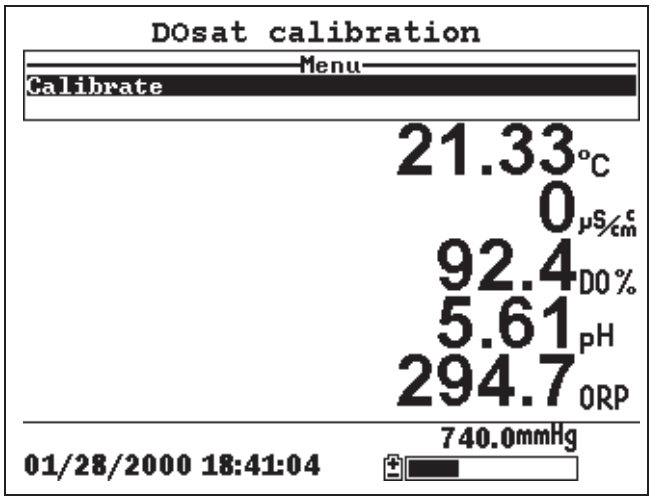


Figure 6.9 DO Sat Calibration Screen

8. Allow approximately ten minutes for the air in the transport/calibration cup to become water saturated and for

the temperature to equilibrate before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

9. Observe the reading under DO %. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue. See Figure 6.6 Calibrated.

10. Press **Enter**. This returns you to the DO calibration screen, See Figure 6.7 DO Calibration Screen.

11. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

12. Rinse the probe module and sensors in tap or purified water and dry.

DO Calibration in mg/L

DO calibration in mg/L is carried out in a water sample which has a known concentration of dissolved oxygen (usually determined by a Winkler titration).

1. Go to the DO calibrate screen as described in Section *6.2.3 Dissolved Oxygen Calibration*, steps 1 through 3.

2. Use the arrow keys to highlight the **DO mg/L** selection.

3. Press **Enter**. The DO mg/L Entry Screen is displayed.

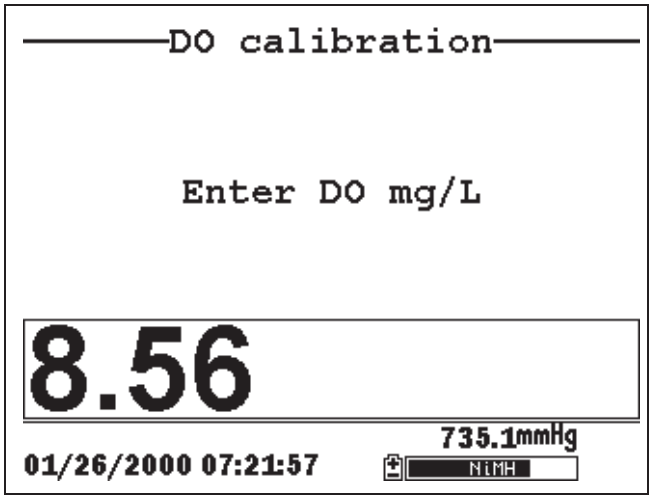


Figure 6.10 DO mg/L Entry Screen

4. Place the probe module in water with a known DO concentration.

   NOTE: Be sure to completely immerse all the sensors.

5. Use the keypad to enter the known DO concentration of the water.

6. Press **Enter**. The Dissolved Oxygen mg/L Calibration Screen is displayed.

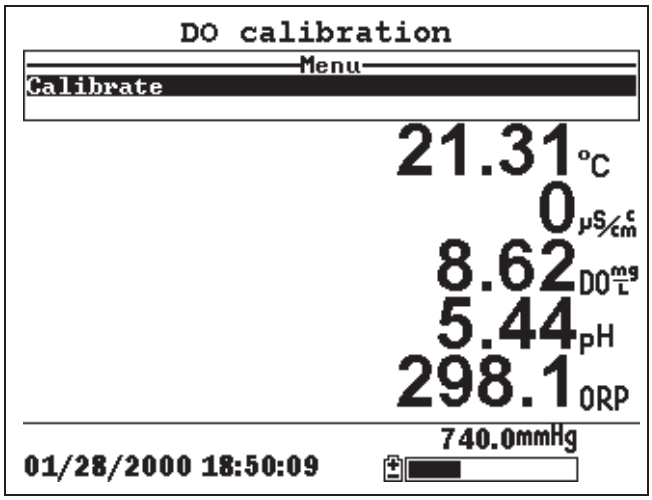


Figure 6.11 DO mg/L Calibration Screen

7. Stir the water with a stir bar, or by rapidly moving the probe module, to provide fresh sample to the DO sensor.

8. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

9. Observe the DO mg/L reading, when the reading is stable (shows no significant change for approximately 30 seconds), press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

10. Press **Enter**. This returns you to the DO calibration screen. See Figure 6.7 DO Calibration Screen.

11. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

12. Rinse the probe module and sensors in tap or purified water and dry.

6.2.4 pH Calibration

1. Go to the calibrate screen as described in *Section 6.2.1 Accessing the Calibrate Screen*.

2. Use the arrow keys to highlight the **pH** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter**. The pH calibration screen is displayed.

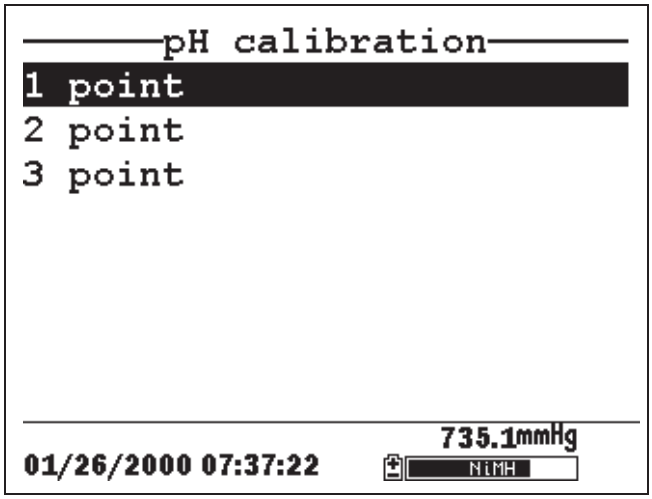


Figure 6.12 pH Calibration Screen

- Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a one point calibration. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select only one pH buffer.
- Select the **2-point** option to calibrate the pH sensor using only two calibration standards. Use this option if the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is sufficient. A three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.
- Select the **3-point** option to calibrate the pH sensor using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer.

4. Use the arrow keys to highlight the **2-point** selection.

5. Press **Enter**. The pH Entry Screen is displayed.

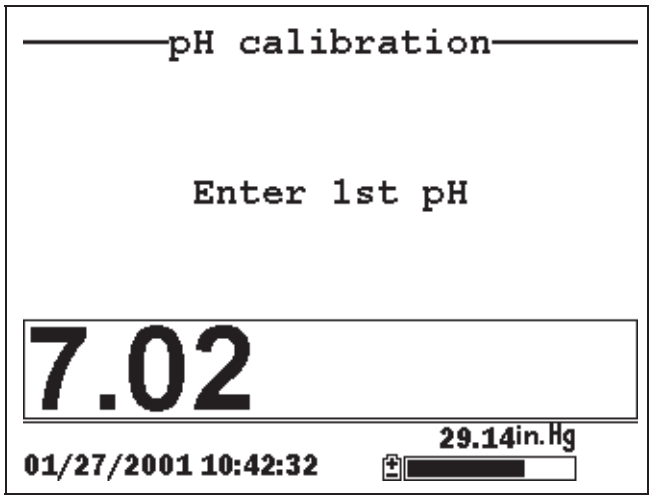


Figure 6.13 pH Entry Screen

6. Place the correct amount (see Table 6.1 Calibration Volumes) of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: For maximum accuracy, the pH buffers you choose should be within the same pH range as the water you are preparing to sample.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.

7. Carefully immerse the sensor end of the probe module into the solution.

8. Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.

NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the sensor is covered.

9. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

10. Use the keypad to enter the calibration value of the buffer you are using **at the current temperature**.

    NOTE: pH vs. temperature values are printed on the labels of all YSI pH buffers.

11. Press **Enter**. The pH calibration screen is displayed.

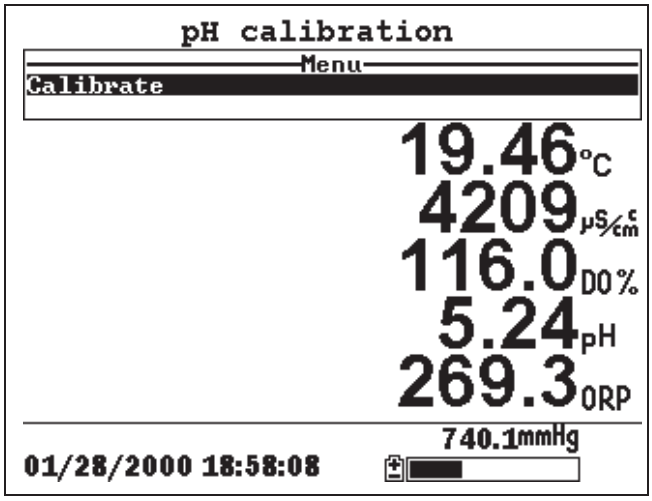


Figure 6.14 pH Calibration Screen

12. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

13. Observe the reading under pH, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

14. Press **Enter**. This returns you to the Specified pH Calibration Screen, See Figure 6.13 pH Entry Screen.

15. Rinse the probe module, transport/calibration cup and sensors in tap or purified water and dry.

16. Repeat steps 6 through 13 above using a second pH buffer.

17. Press **Enter**. This returns you to the pH Calibration Screen, See Figure 6.12 pH Calibration Screen.

18. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

19. Rinse the probe module and sensors in tap or purified water and dry.

6.2.5 ORP Calibration

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen*.

2. Use the arrow keys to highlight the **ORP** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter**. The ORP calibration screen is displayed.

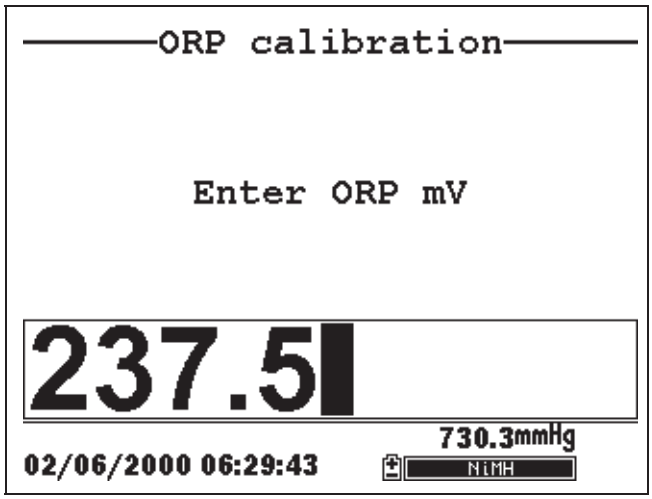


Figure 6.15 Specified ORP Calibration Screen

4. Place the correct amount (see Table 6.1 Calibration Volumes) of a known ORP solution (we recommend Zobell solution) into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the ORP sensor with a small amount of solution that can be discarded. Be certain that you avoid cross-contamination with other solutions.

5. Carefully immerse the sensor end of the probe module into the solution.

6. Gently rotate and/or move the probe module up and down to remove any bubbles from the ORP sensor.

   NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes should ensure that the sensor is covered.

7. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

8. Use the keypad to enter the correct value of the calibration solution you are using at the current temperature. Refer to Table 6.2 Zobel Solution Values.

Temperature °C	Zobell Solution Value, mV
-5	270.0
0	263.5
5	257.0
10	250.5
15	244.0
20	237.5
25	231.0
30	224.5
35	218.0
40	211.5
45	205.0
50	198.5

Table 6.2 Zobel Solution Values

9. Press **Enter**. The ORP calibration screen is displayed.

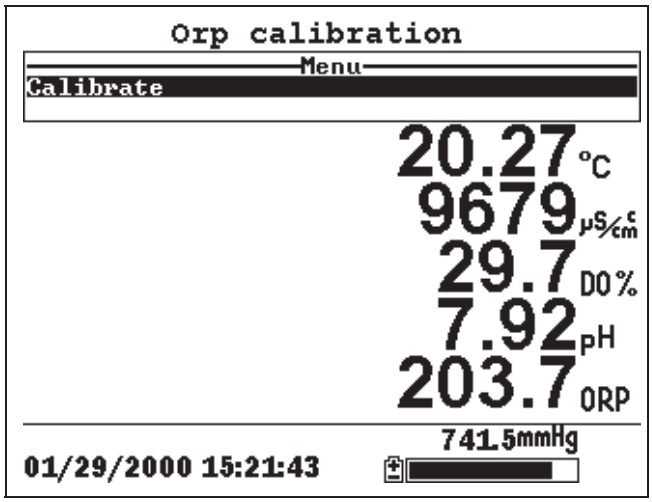


Figure 6.16 ORP Calibration Screen

10. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

NOTE: Verify that the temperature reading matches the value you used in Table 6.2 Zobel Solution Values.

11. Observe the reading under ORP, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

12. Press **Enter**. This returns you to the Calibrate Screen. See Figure 6.2 Calibrate Screen.

13. Rinse the probe module and sensors in tap or purified water and dry.

6.3 Return to Factory Settings

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen*.

2. Use the arrow keys to highlight the **Conductivity** selection. See Figure 6.2 Calibrate Screen.

   NOTE: We will use the Conductivity sensor as an example; however, this process will work for any sensor.

3. Press **Enter.** The Conductivity Calibration Selection Screen is displayed. See Figure 6.3 Conductivity Calibration Selection Screen.

4. Use the arrow keys to highlight the **Specific Conductance** selection.

5. Press **Enter.** The Conductivity Calibration Entry Screen is displayed. See Figure 6.4 Conductivity Calibration Entry Screen.

6. Press and hold the **Enter** key down and press the **Escape** key.

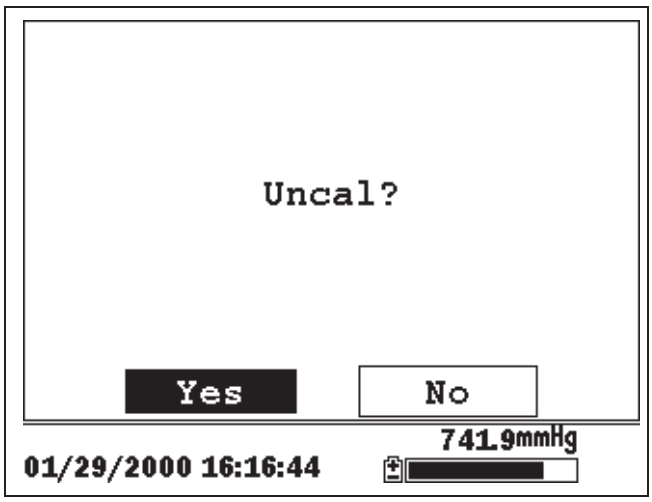


Figure 6.17 ORP Calibration Screen

7. Use the arrow keys to highlight the **YES** selection.

CAUTION: This returns a sensor to the factory settings. For example, in selecting to return specific conductance to the factory setting, salinity and conductivity will automatically return to their factory settings.

8. Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen, See Figure 6.3 Conductivity Calibration Selection Screen.

9. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

7. Run

The Run screen displays data from the sensors in real-time and allows the user to log sample data to memory for later analysis. Refer to Section *9 Logging* for details on logging sample data.

7.1 Real-Time Data

NOTE: Before measuring samples you must prepare the probe module (refer to Section *3.4 Preparing the Probe Module*), attach the probe module to the instrument (refer to Section *3.6 Instrument/Cable Connection*) and calibrate the sensors (refer to Section *6 Calibrate*).

1. Press the **On/off** key.

OR select Run from the main menu to display the run screen.

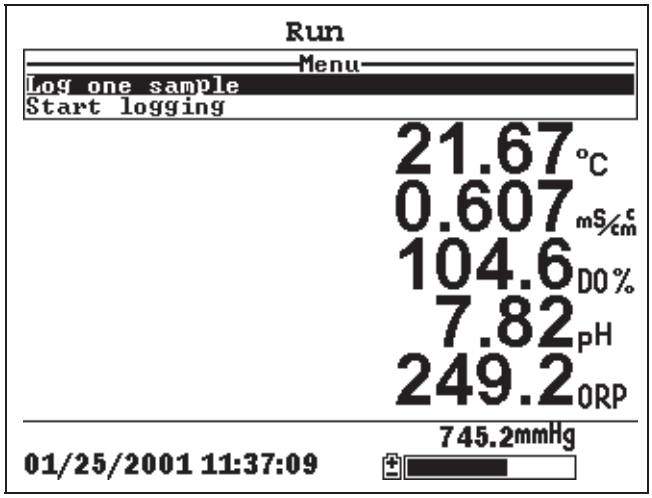


Figure 7.1 Run Screen

2. Make sure the probe sensor guard is installed.

3. Place the probe module in the sample. Be sure to completely immerse all the sensors.

4. Rapidly move the probe module through the sample to provide fresh sample to the DO sensor.

5. Watch the readings on the display until they are stable.

6. Refer to Section *9 Logging* for instructions on logging sample data.

8. File

The File menu allows the user to view, upload or delete sample data and calibration record files stored in the YSI 556 MPS.

8.1 Accessing the File Screen

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.

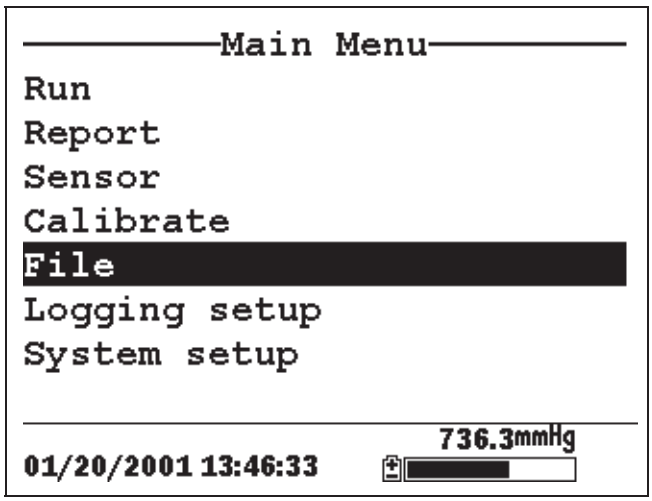


Figure 8.1 Main Menu Screen

3. Use the arrow keys to highlight the **File** selection.

4. Press the **Enter** key. The file screen is displayed.

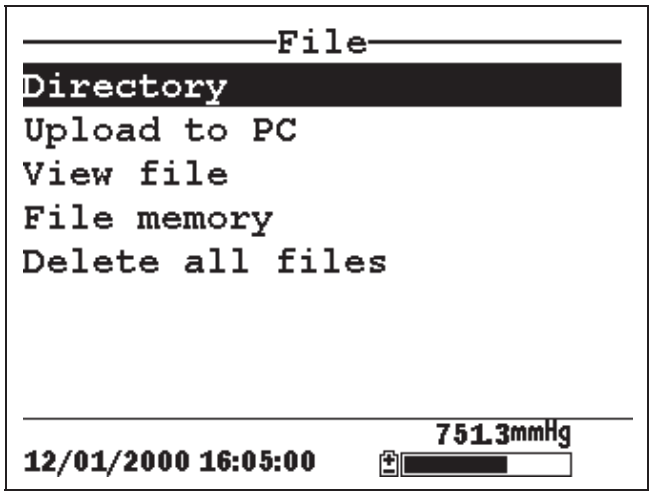


Figure 8.2 File Screen

8.2 Directory

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*.

2. Use the arrow keys to highlight the **Directory** selection. See Figure 8.2 File Screen.

3. Press the **Enter** key. The file list screen is displayed.

   NOTE: Files are listed in the order in which they are logged to memory. Sample Data files have the file extension **.dat**, while Calibration Record files have the file extension **.glp**.

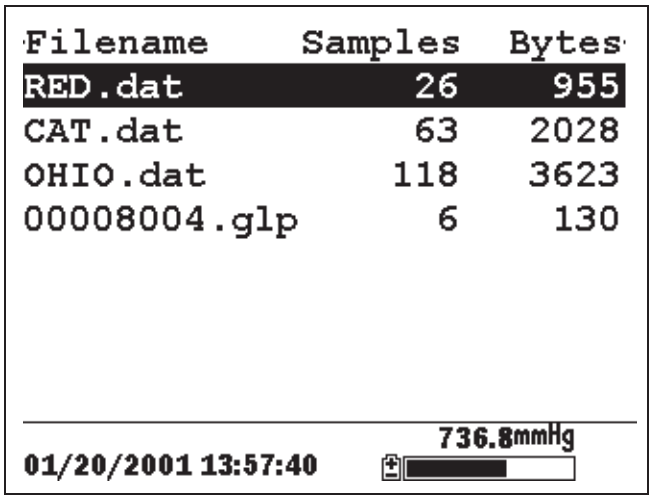


Figure 8.3 File List Screen

4. Use the arrow keys to highlight a file.

5. Press the **Enter** key. The file details screen is displayed.

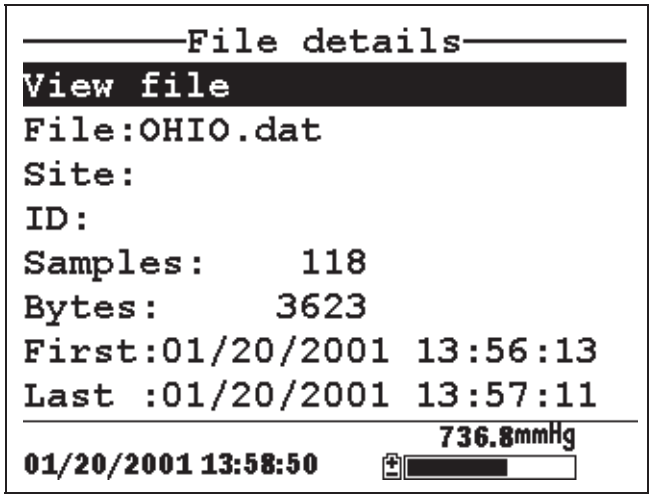


Figure 8.4 File Details Screen

6. Press the **Enter** key to view the file data. Refer to Section *8.3 View File* for details.

7. Press the **Escape** key repeatedly to return to the main menu screen.

8.3 View File

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*. See Figure 8.2 File Screen.

2. Use the arrow keys to highlight the **View file** selection.

3. Press the **Enter** key. A list of files is displayed. See Figure 8.3 File List Screen.

4. Use the arrow keys to highlight an individual file.

   NOTE: You may have to scroll down to see all the files.

5. Press the **Enter** key. The file data is displayed with the file name at the top of the display.

   NOTE: If no file name was specified, the data is stored under the default name NONAME1.dat.

OHIO.dat

Date m/d/y	Time hh:mm:ss	Temp C
01/20/2001	13:56:13	22.54
01/20/2001	13:56:13	22.54
01/20/2001	13:56:14	22.54
01/20/2001	13:56:14	22.54
01/20/2001	13:56:15	22.54
01/20/2001	13:56:15	22.54
01/20/2001	13:56:16	22.54
01/20/2001	13:56:16	22.54
01/20/2001	13:56:17	22.54

736.7mmHg

01/20/2001 13:59:34

Figure 8.5 File Data Screen

6. Use the arrow keys to scroll horizontally and/or vertically to view all the data.

7. Press the **Escape** key repeatedly to return to the main menu screen.

8.4 Upload to PC

EcoWatch™ for Windows™ must be used as the PC software interface to the YSI 556 MPS. Refer to *Appendix G EcoWatch* for more information. EcoWatch for Windows is available at no cost via a download from the YSI Web Site (www.ysi.com) or by contacting YSI Customer Support. Refer to *Appendix E Customer Service.*

8.4.1 Upload Setup

1. Disconnect the YSI 5563 Probe Module from the YSI 556 MPS instrument.

2. Connect the YSI 556 MPS to a serial (Comm) port of your computer via the 655173 PC Interface cable as shown in the following diagram:

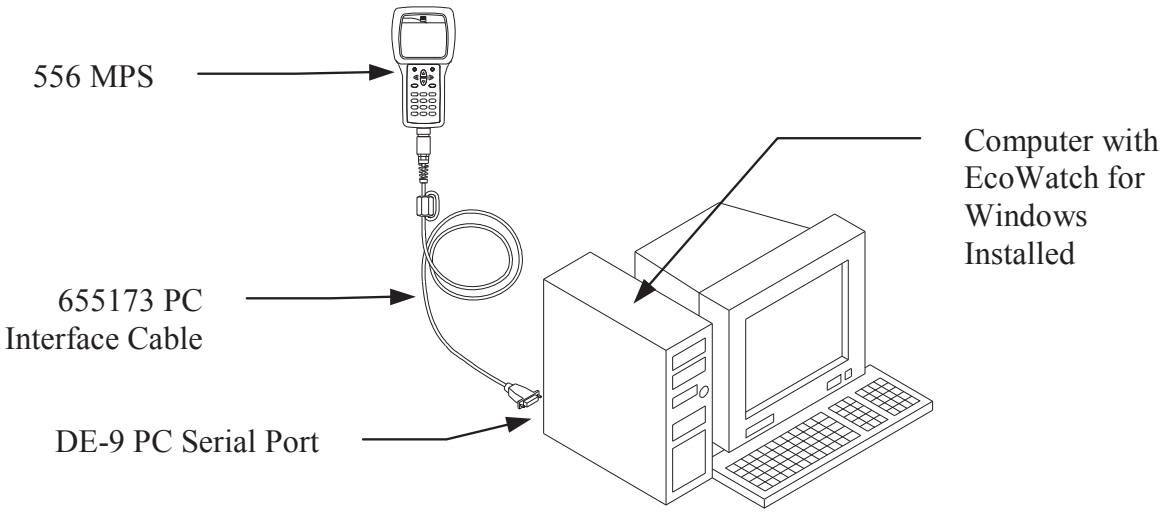


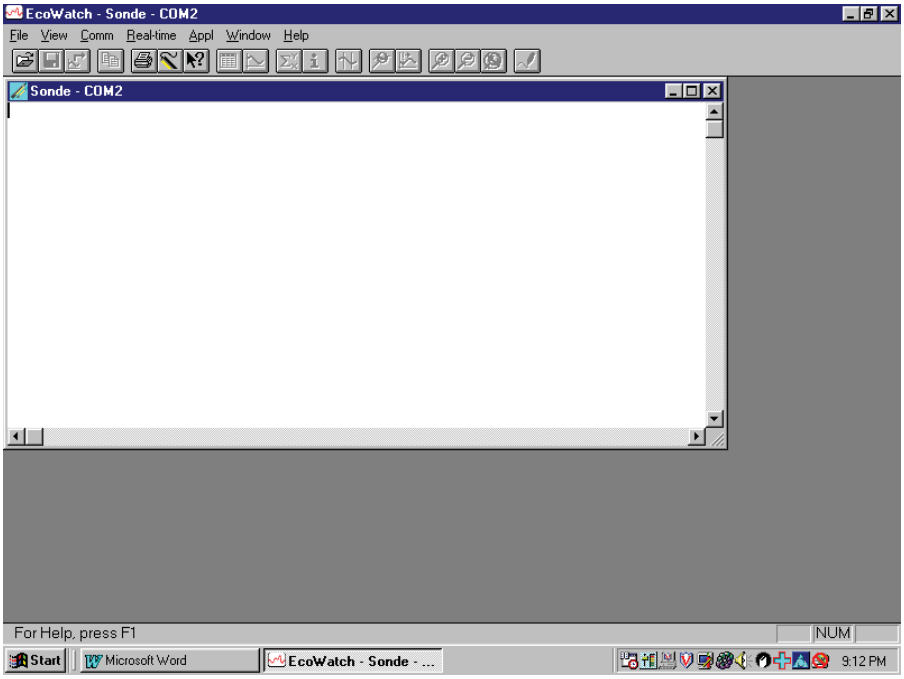
Figure 8.6 Computer/Instrument Interface

3. Open EcoWatch for Windows on your computer.

NOTE: See *Appendix G EcoWatch* for installation instructions.

4. Click on the sonde/probe icon in the upper toolbar.

5. Set the Comm port number to match the port the YSI 556 MPS is connected to. After this setup procedure, the following screen will be present on your PC monitor:



8.4.2 Uploading a .DAT File

1. Setup the instrument as described in Section *8.4.1 Upload Setup*.

2. Go to the YSI 556 MPS file screen as described in Section *8.1 Accessing the File Screen.*

3. Use the arrow keys to highlight the **Upload to PC** selection. See Figure 8.2 File Screen.

4. Press the **Enter** key. The file list screen is displayed. See Figure 8.3 File List Screen.

5. Use the arrow keys to highlight the DAT file that you wish to transfer and press **Enter**, both the YSI 556 MPS and PC displays show the progress of the file transfer.

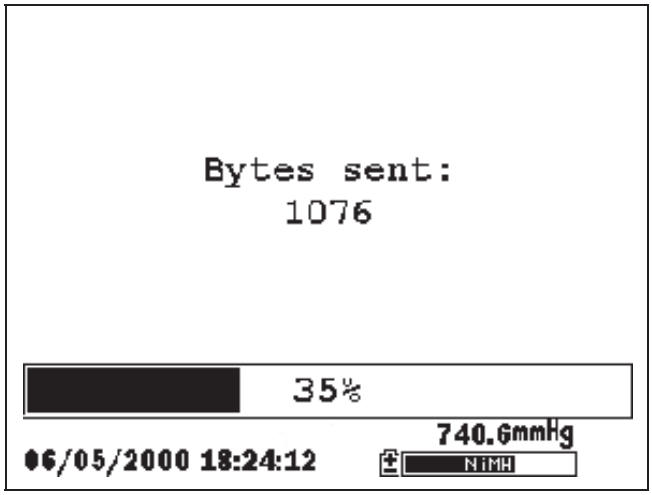
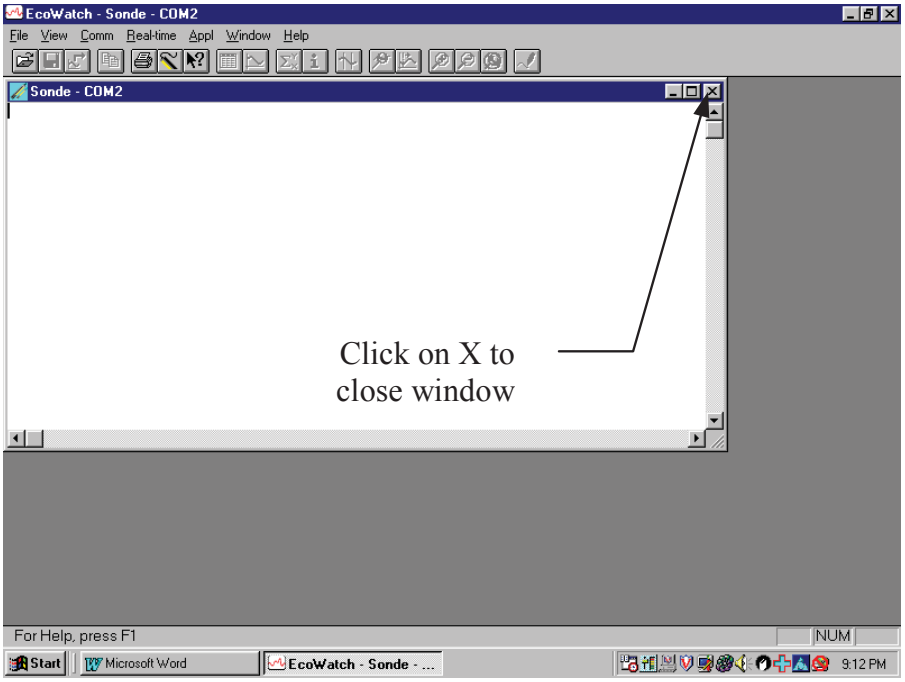


Figure 8.7 File Transfer Progress Screen

NOTE: After transfer, the file will be located in the C:\ECOWWIN\DATA folder of your PC, designated with a .DAT extension.

6. After the file transfer is complete, close the terminal window (small window on the PC) by clicking on the "X" at its upper right corner.



7. Press the **Escape** key on the YSI 556 MPS repeatedly to return to the main menu screen.

8.4.3 Uploading a Calibration Record (.glp) File

For more information on the calibration record, Refer to *Appendix H Calibration Record Information.*

1. Setup up the instrument as described in Section *8.4.1 Upload Setup*.

2. Go to the YSI 556 MPS file screen as described in Section *8.1 Accessing the File Screen.*

3. Use the arrow keys to highlight the **Upload to PC** selection. See Figure 8.2 File Screen.

4. Press the **Enter** key. The file list screen is displayed. See Figure 8.3 File List Screen.

5. Use the arrow keys to highlight the calibration record file that you wish to transfer and press **Enter.**

6. You will then be given a choice of uploading the file in three formats; **Binary, Comma & “” Delimited, and ASCII Text**.

   NOTE: The binary format is reserved for future YSI software packages.

7. Choose an option and press **Enter,** both the YSI 556 and PC displays show the progress of the file transfer.

   NOTE: After transfer, the file will be located in the C:\ECOWWIN\DATA folder of your PC, designated with the appropriate file extension.

   NOTE: To view the Calibration Record data after upload, simply open the .txt file in a general text editor such as Wordpad or Notepad.

8. After the file transfer is complete, close the terminal window (small window on the PC) by clicking on the “X” at its upper right corner.

9. Press the **Escape** key repeatedly to return to the main menu screen.

8.5 File Memory

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*.

2. Use the arrow keys to highlight the **File memory** selection. See Figure 8.2 File Screen.

3. Press the **Enter** key. The file bytes used screen is displayed.

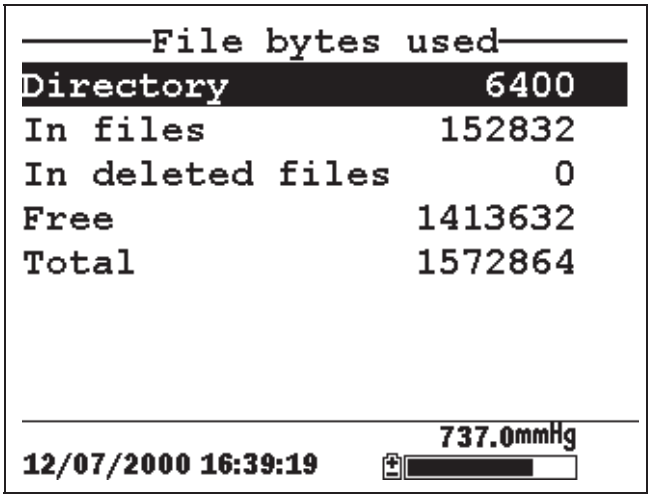


Figure 8.8 File Bytes Used Screen

4. The amount of free memory is listed in line 4 of the file bytes used screen.

   NOTE: If the amount of free memory is low, it may be time to delete all files (after first uploading all data to a PC). Refer to Section *8.6 Delete All Files*.

5. Press the **Escape** key repeatedly to return to the main menu screen.

8.6 Delete All Files

NOTE: It is not possible to delete individual files in order to free up memory. The only way to free up memory is to delete ALL files present. Take care to transfer all files to your computer (refer to Section *8.4 Upload to PC*) *before* deleting them.

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*.

2. Use the arrow keys to highlight the **Delete all files** selection. See Figure 8.2 File Screen.

3. Press the **Enter** key. The Delete all Files screen is displayed.

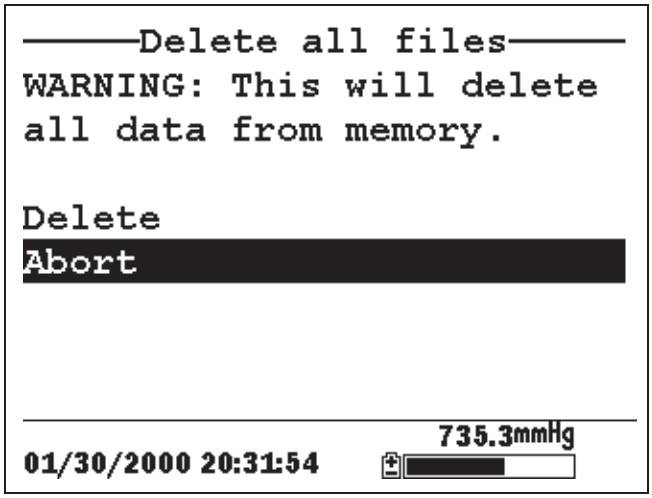


Figure 8.9 Delete All Files Screen

4. Use the arrow keys to highlight the **Delete** selection.

5. Press the **Enter** key.

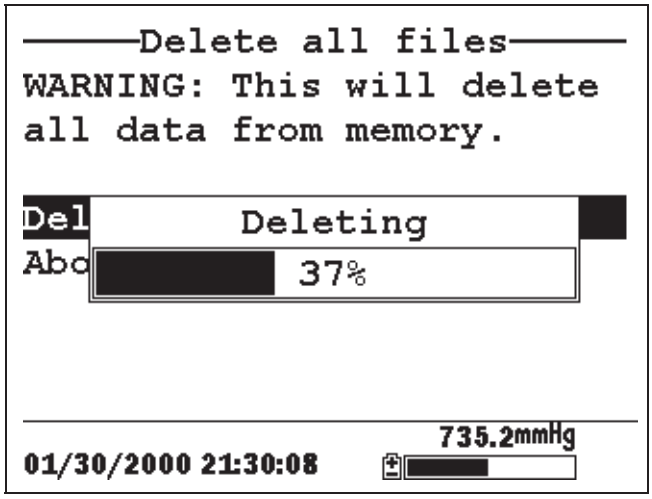


Figure 8.10 Deleting

The progress of file deletion is displayed in bar graph format.

NOTE: Deleting all files in the directory will not change any information in the site list.

6. Press the **Escape** key repeatedly to return to the main menu screen.

9. Logging

9.1 Accessing the Logging Setup Screen

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.

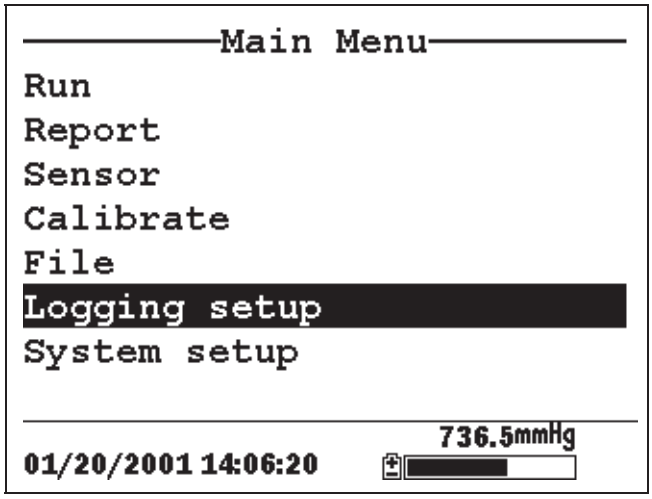


Figure 9.1 Main Menu

3. Use the arrow keys to highlight the **Logging setup** selection.

4. Press the **Enter** key. The logging setup screen is displayed.

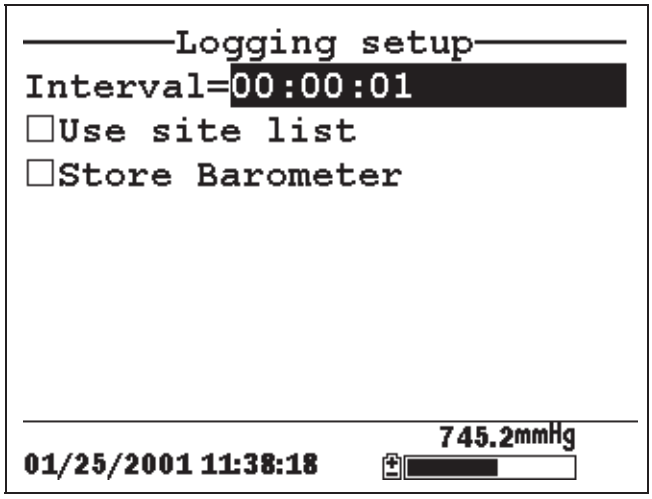


Figure 9.2 Logging Setup Screen

9.2 Setting Logging Interval

Follow steps below to set the interval for logging a data stream.

NOTE: If you do not specify an interval, the instrument will use a default interval setting of 1 second.

NOTE: It is not necessary to set a logging interval when logging a single sample.

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the keypad to enter an interval between 1 second and 15 minutes. Refer to Section *2.9 Keypad Use*.

   NOTE: The interval field has hour, minute and second entry fields. Any entry over 15 minutes will change automatically to a 15-minute setting.

3. Press the **Enter** key. The data stream interval is set.

4. Press the **Escape** key repeatedly to return to the main menu screen.

9.3 Storing Barometer Readings

NOTE: The **Store barometer** option is only available on instruments that are equipped with the optional barometer.

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the arrow keys to highlight the **Store barometer** selection. See Figure 9.2 Logging Setup Screen.

3. Press the **Enter** key until a check mark is entered in the box next to the store barometer selection if you want to log barometric readings.

   OR press the **Enter** key until the box next to the barometer selection is empty if you do not want to log barometric readings.

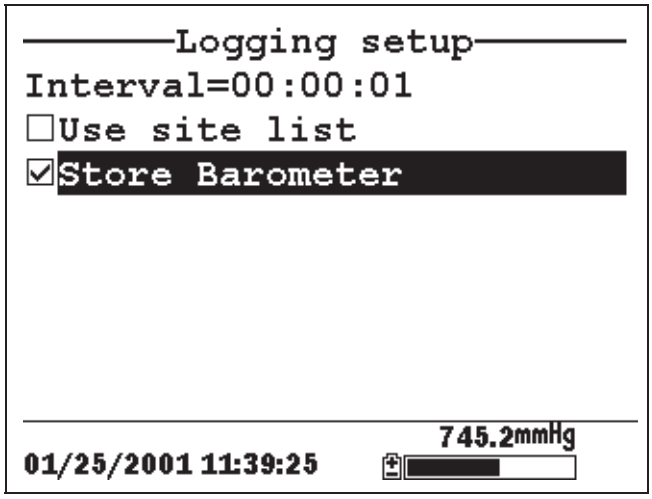


Figure 9.3 Store Barometer

4. Press the **Escape** key repeatedly to return to the main menu screen.

9.4 Creating a Site List

The site list option allows you to define file and site descriptions in the office or laboratory before moving to field logging studies. This is usually more convenient than entering the information at the site and is particularly valuable if you are visiting certain sites on a regular basis. The following section describes how to set up site lists which contain entries designated "Site Descriptions" that will be instantly available to the user in the field to facilitate the logging of data with pre-established naming of files and sites. There are two kinds of **Site Descriptions** available for use in Site lists:

- **Site Descriptions** associated with applications where data from a single site is always logged to a single file. This type is referred to as a "Single-Site Description" and is characterized by two parameters – a file name and a site name. Files logged to YSI 556 MPS memory under a **Single-Site Description** will be characterized primarily by the file name, but will also have the Site name attached, so that it is viewable in either the YSI 556 MPS **File directory** or in EcoWatch for Windows after upload to a PC

- **Site Descriptions** associated with applications where data from multiple sites are logged to a single file. This type is referred to as a "Multi-site Description" and is characterized by three parameters – a file name, a site name, and a site number. Files logged to YSI 556 MPS memory under a **Multi-site Description** are characterized by a file name, but not a site name, since multiple sites are involved. However, each data point has a Site Number attached to it so that the user can easily determine the sampling site when viewing the data from the YSI 556 MPS **File** menu or processing the data in EcoWatch for Windows after upload to a PC.

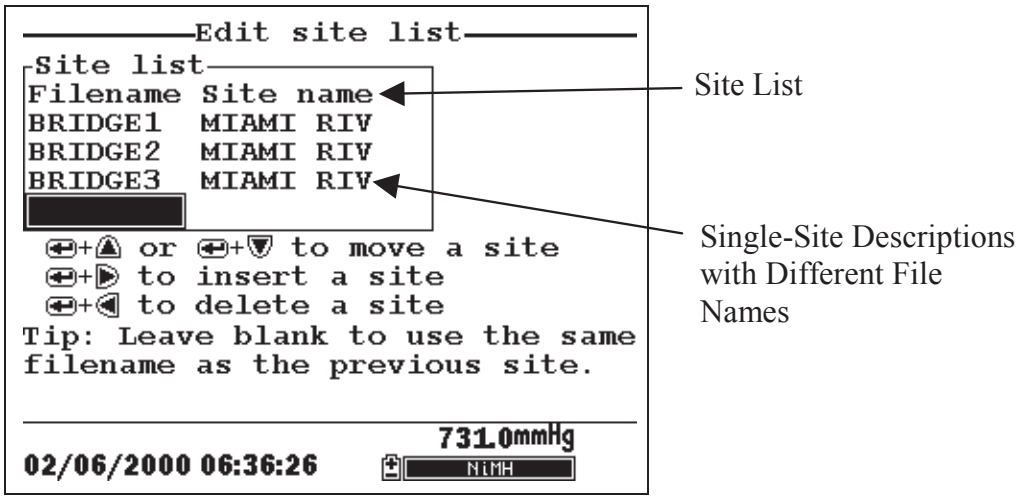


Figure 9.4 Single-Site Descriptions

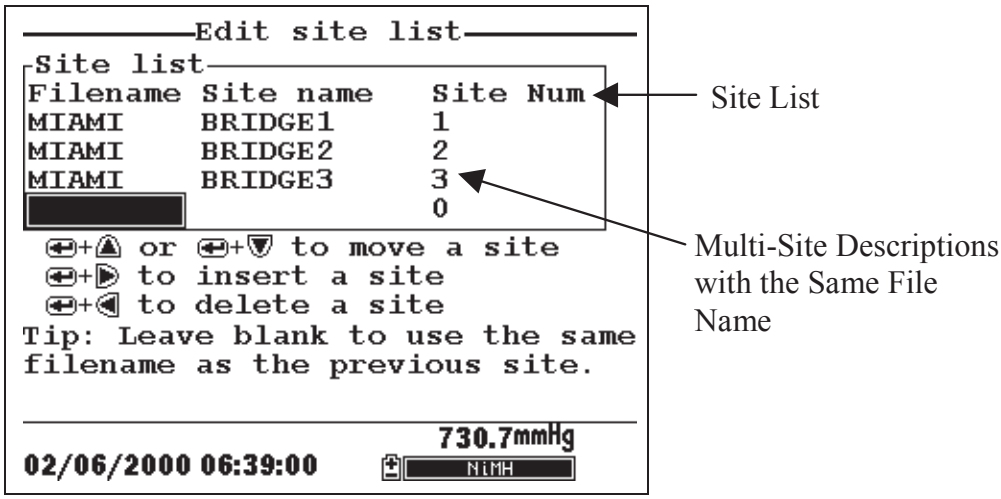


Figure 9.5 Multiple-Site Descriptions

NOTE: Site lists containing Single Site Descriptions are usually input with the designation **Store Site Number** INACTIVE in the YSI 556 MPS **Logging setup** menu. Thus, no site numbers appear in the first **Site list** example. Conversely, **Site lists** containing **Multi-Site Descriptions** MUST be input with the **Store Site Number** selection ACTIVE as shown in the second example.

To create a site list:

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the arrow keys to highlight the **Use site list** selection.

3. Press the **Enter** key. A check mark is entered in the box next to the use site list selection *and* two new entries appear on the logging setup screen. See Figure 9.6 Logging Setup Screen.

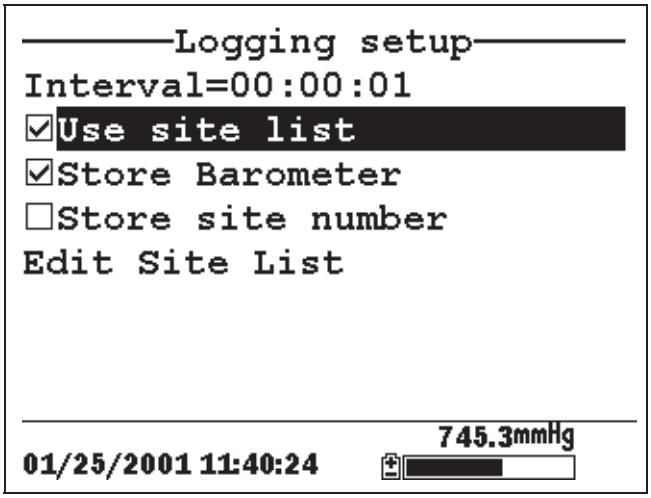


Figure 9.6 Logging Setup Screen

4. Use the arrow keys to highlight the **Store site number** selection.

5. If you are creating Multi-Site Descriptions (which require that the site **number** be stored in your data files), press the **Enter** key until a check mark appears in the box next to the store site number selection.

OR Press the **Enter** key until the box next to the store site number selection is empty, to create Single-Site Descriptions. The site **name** will be stored in the header of your data files.

6. Use the arrow keys to highlight the **Edit site list** selection.

7. Press the **Enter** key. The edit site list screen is displayed. See Figure 9.7 Edit Site List Screen. The **Filename** field is ready for input.

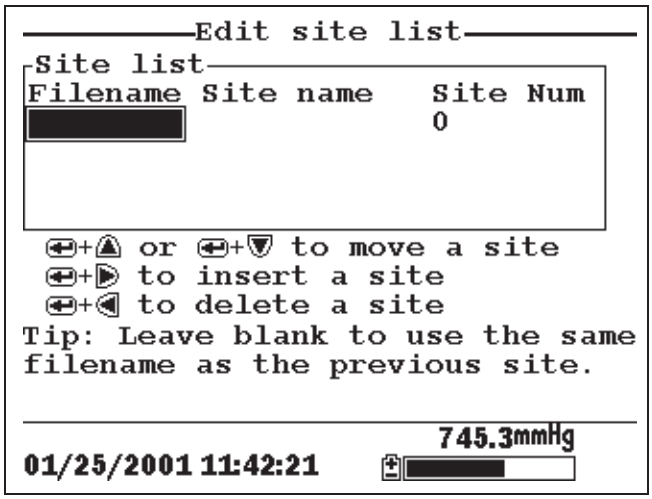


Figure 9.7 Edit Site List Screen

8. Use the keypad to enter a filename up to 8 characters in length. Refer to Section *2.9 Keypad Use*.

9. Press the **Enter** key. The cursor moves to the right for the entry of a **Site name**.

10. Use the keypad to enter a site name up to 11 characters in length. Refer to Section *2.9 Keypad Use*.

NOTE: If the store site number selection is *not* checked, skip to Step 13.

11. Press the **Enter** key. The cursor moves to the site number entry position.

12. Use the keypad to enter a site number up to 7 characters in length. Refer to Section *2.9 Keypad Use*.

13. Press **Enter**. The cursor moves to the next filename entry position.

14. Repeat Steps 8 to 13 until all filenames and sites have been entered.

15. Press **Escape** repeatedly to return to the main menu screen.

9.5 Editing a Site List

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the arrow keys to highlight the **Edit Site List** selection. See Figure 9.6 Logging Setup Screen.

3. Press the **Enter** key. The edit site list screen is displayed.

4. Edit the site list using the keystrokes described below.

   NOTE: Editing the site list will not have any effect on files stored in the instrument memory.

To MOVE a site: Use the arrow keys to highlight a site. Press the Up or Down arrow key while holding down the Enter key.

To INSERT a site above another site: Use the arrow keys to highlight the site. Press the Right arrow key while holding down the Enter key. Use keypad to input letters. Refer to Section *2.9 Keypad Use*.

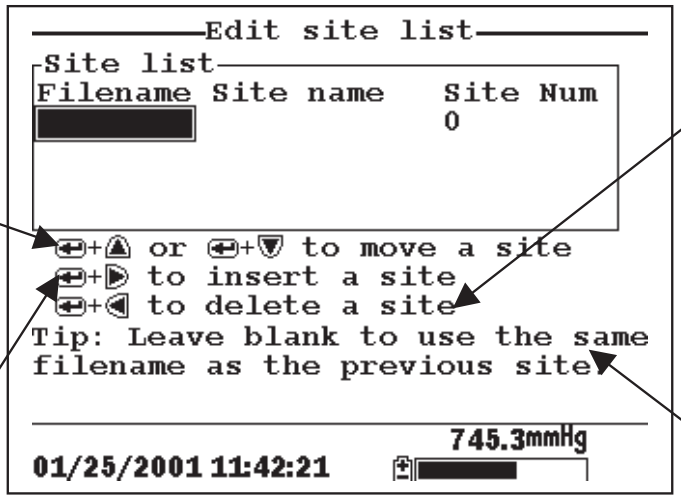


Figure 9.8 Keystrokes for Editing Site List

To DELETE a site: Use the arrow keys to highlight a site. Press the Left arrow key while holding down the Enter key.

To use the same file name as the previous site: Leave the filename blank.

9.6 Logging Data Without a Site List

1. Follow Steps 1 through 5 in Section 7.1 Real-Time Data.

2. Use the arrow keys to highlight the **Log one sample** selection on the run screen if only a single sample is being logged.

   OR Use the arrow keys to highlight the **Start logging** selection on the run screen if a data stream is being logged.

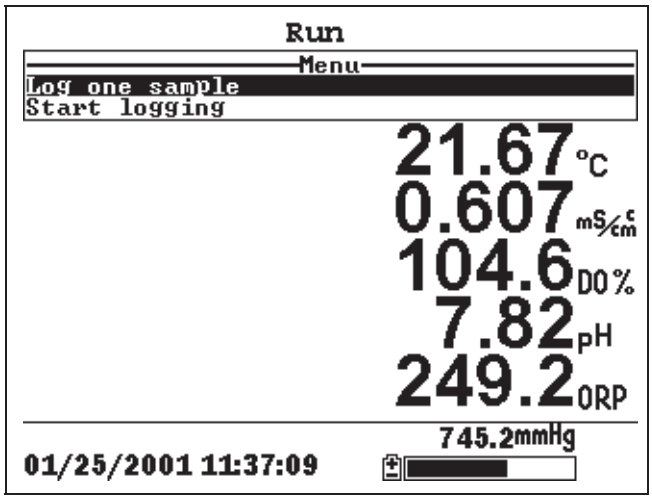


Figure 9.9 Run Screen

3. Press the **Enter** key. The Enter information screen is displayed.

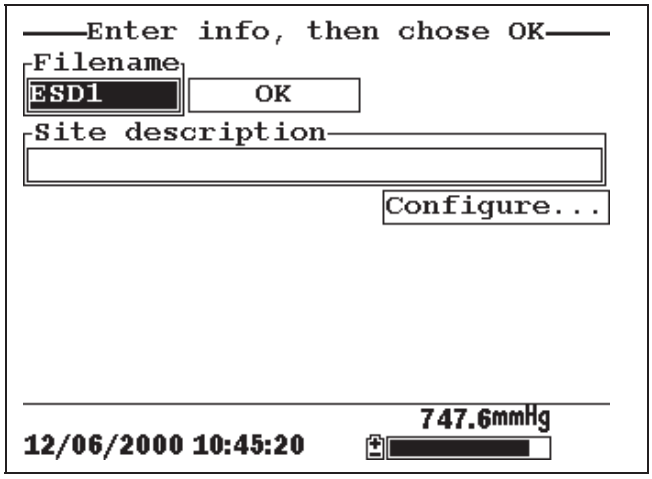


Figure 9.10 Enter Information Screen

NOTE: The last filename used will be displayed.

4. Use the keypad to enter a file name. Refer to Section *2.9 Keypad Use*.

   NOTE: The instrument will assign a default file name of NONAME if no file name is specified.

5. Press the **Enter** key to input the file name.

6. Use the arrow keys to highlight the **Site description** field in the enter information screen.

   NOTE: Entering a Site Description is optional. You may leave the Site Description blank and skip to Step 9.

7. Use the keypad to enter a site description name. Refer to Section *2.9 Keypad Use*.

8. Press the **Enter** key to input the site description.

   NOTE: If you want to change the logging setup, such as sampling interval or storing the barometer reading, use the arrow keys to highlight the **Configure** field, press the **Enter** key, then refer to Section *9.2 Setting Logging Interval* or *9.3 Storing Barometer Readings* for details.

9. Use the arrow keys to highlight the **OK** field in the center of the information screen.

10. Press the **Enter** key to start logging.

    NOTE: If the parameter mismatch screen is displayed, refer to Section *9.8 Adding Data to Existing Files*.

11. If a single point is being logged, the header on the run screen changes momentarily from **Menu** to **Sample logged** to confirm that the point was successfully logged. Skip to Step 13.

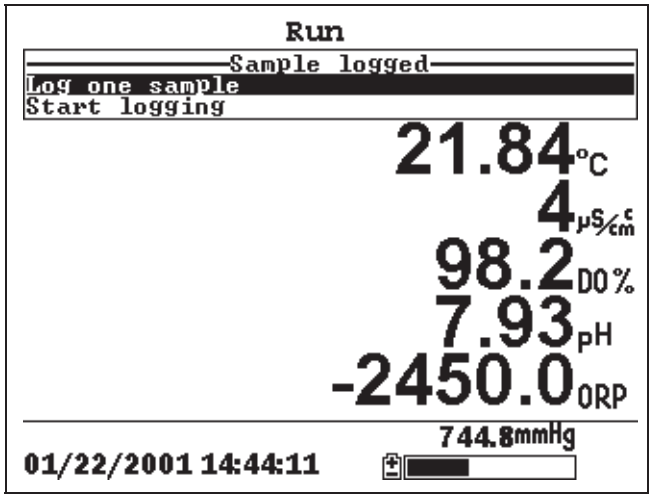


Figure 9.11 Sample Logged Screen

If a continuous stream of points is being logged, the start logging entry in the run screen changes from **Start logging** to **Stop logging**.

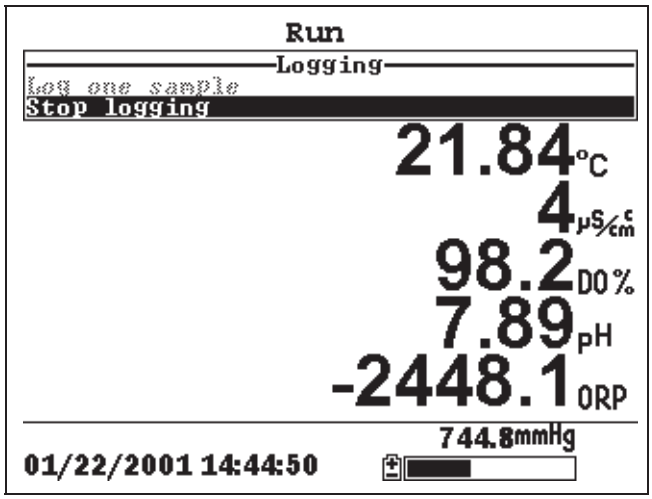


Figure 9.12 Logging Screen

12. At the end of the logging interval, press **Enter** to stop logging.

13. Refer to Section *8.3 View File* to view the data on the instrument display.

9.7 Logging Data With a Site List

1. If you have not already created a site list, refer to Section *9.4 Creating a Site List*.

2. Follow Steps 1 through 5 in Section 7.1 Real-Time Data.

3. Use the arrow keys to highlight the **Log one sample** selection on the run screen if only a single sample is being logged.

   OR Use the arrow keys to highlight the **Start logging** selection on the run screen if a data stream is being logged. See Figure 9.9 Run Screen.

4. Press the **Enter** key. The Pick a site screen is displayed.

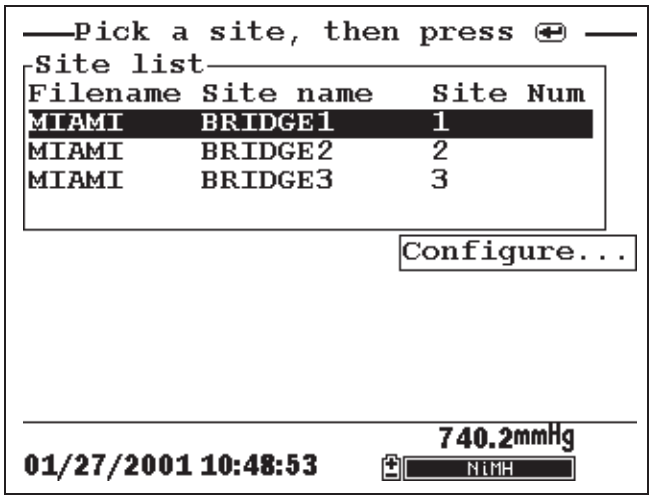


Figure 9.13 Pick a Site Screen

5. Use the arrow keys to highlight the **site** of your choice.

   NOTE: If the site of your choice is grayed out in the site list, refer to Section *9.8 Adding Data to Existing Files*.

   NOTE: Refer to Section *9.5 Editing a Site List* if you want to edit the site list.

6. Press the **Enter** key to start logging.

NOTE: If the parameter mismatch screen is displayed, refer to Section *9.8 Adding Data to Existing Files*.

7. If a single point is being logged, the header on the run screen changes momentarily from **Menu** to **Sample logged** to confirm that the point was successfully logged. See Figure 9.11 Sample Logged Screen. Skip to Step 9.

   If a continuous stream of points is being logged, the start logging entry in the run screen changes from **Start logging** to **Stop logging**. See Figure 9.12 Logging Screen.

8. At the end of the logging interval, press **Enter** to stop logging.

9. Refer to Section *8.3 View File* to view the data on the instrument display.

9.8 Adding Data to Existing Files

In order to add new data to an existing file, the current logging and sensor setup must be *exactly* the same as when the file was created. The following settings must be the same:

- **Sensors enabled** (refer to Section *4 Sensors*)
- **Store Barometer** (refer to Section *9.3 Storing Barometer Readings*)
- **Store Site Number** (refer to Section *9.4 Creating a Site List*)

If the current logging setup is not exactly the same as when the file was created, a parameter mismatch screen is displayed.

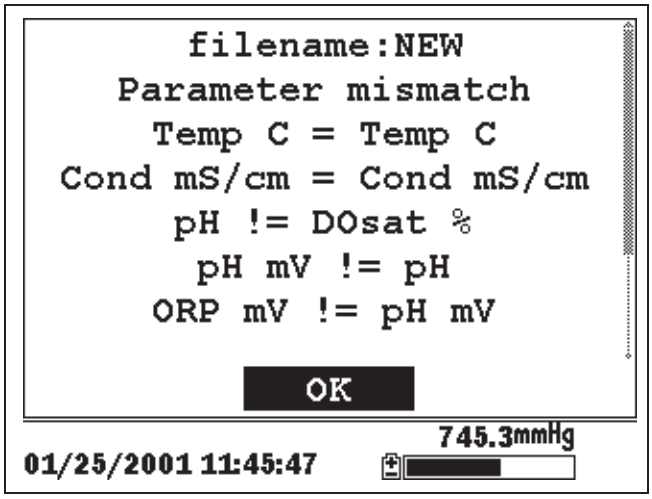


Figure 9.14 Parameter Mismatch Screen

NOTE: The right column shows parameters used when the file was created. The left column shows current parameters.

1. Press the **Down Arrow** key to scroll down and find the mismatch(es).

2. Use the following chart to resolve the mismatch(es).

Mismatch	Action	Reference
Sensor(s) missing from left column	Enable the missing sensor(s)	Section *4 Sensors*
Extra sensor(s) listed in left column	Disable the extra sensor(s)	Section *4 Sensors*
Barometer missing from left column, but present in right column	Enable the Store Barometer setting	Section *9.3 Storing Barometer Readings*
Barometer present in left column, but missing from right column	Disable the Store Barometer setting	Section *9.3 Storing Barometer Readings*
Store Site Number missing from left column, but present in right column	Enable the Store Site Number setting	Section *9.4 Creating a Site List*
Store Site Number present in left column, but missing from right column	Disable the Store Site Number setting	Section *9.4 Creating a Site List*

3. Return to Section *9.6 Logging Data Without a Site List* or *9.7 Logging Data With a Site List*.

10. System Setup

The YSI 556 MPS has a number of features that are user-selectable or can be configured to meet the user's preferences. Most of these choices are found in the **System setup** menu.

10.1 Accessing the System Setup Screen

1. Press the **On/off** key to display the run screen. See Figure 2.1 Front View of YSI 556 MPS.

2. Press the **Escape** key to display the main menu screen.

3. Use the arrow keys to highlight the **System setup** selection.

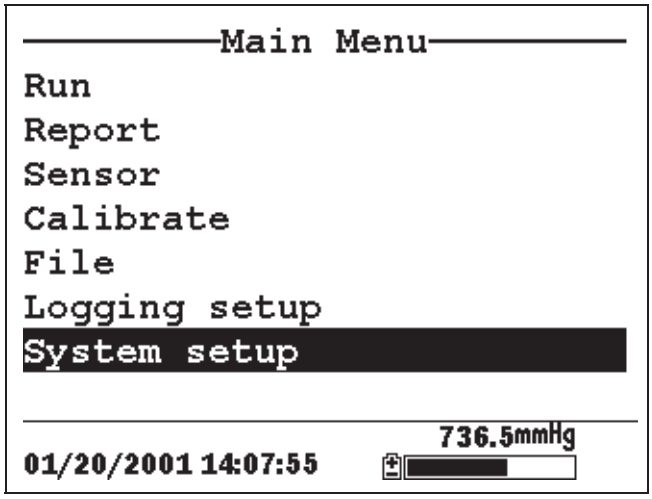


Figure 10.1 Main Menu

4. Press the **Enter** key. The system setup screen is displayed.

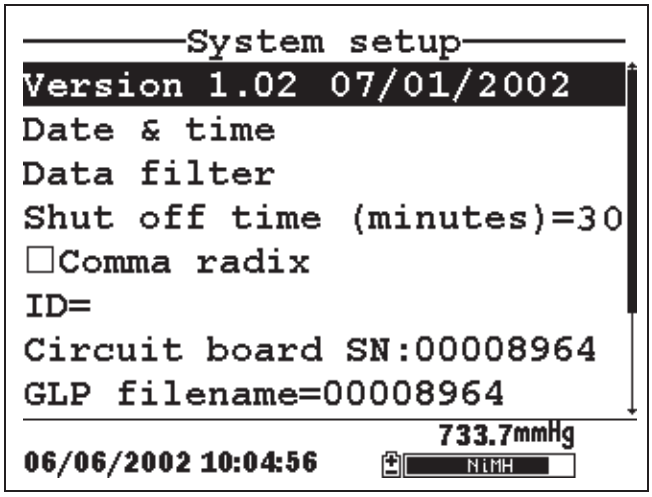


Figure 10.2 System Setup Screen

NOTE: The first line of the **System setup** menu shows the current software version of your YSI 556 MPS. As software enhancements are introduced, you will be able to upgrade your YSI 556 MPS from the YSI Web site. Refer to Section *11.2 Upgrading YSI 556 MPS* Software for details.

10.2 Date and Time Setup

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Date & time** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Press **Enter**. The date and time setup screen is displayed.

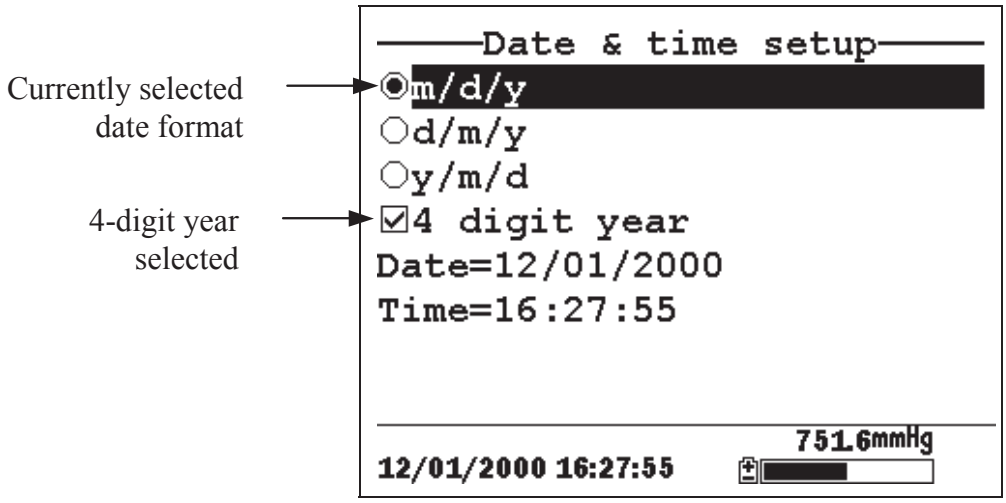


Figure 10.3 Date Setup Screen

NOTE: A black dot to the left of a date format indicates that format is selected.

4. Use the arrow keys to highlight your desired date format.

5. Press **Enter**.

6. Use the arrow keys to highlight the 4-digit year selection.

7. Press **Enter**. A check mark appears in the check box next to the 4-digit year selection.

   NOTE: If unchecked, a 2-digit year is used.

8. Use the arrow keys to highlight the **Date** selection.

9. Press **Enter**. A cursor appears over the first number in the date.

10. Enter the proper number from the keypad for the highlighted date digit. The cursor moves automatically to the next date digit. Refer to Section *2.9 Keypad Use* for more keypad information.

11. Repeat Step 10 until all date digits are correct.

12. Press **Enter** to input the specified date.

13. Use the arrow keys to highlight the **Time** selection.

14. Press **Enter**. A cursor appears over the first number in the time selection.

15. Enter the proper number from the keypad for the highlighted time digit. The cursor moves automatically to the next time digit.

    NOTE: Use military format when entering time. For example, 2:00 PM is entered as 14:00.

16. Repeat Step 15 until all time digits are correct.

17. Press **Enter** to input the correct time.

18. Press the **Escape** key repeatedly to return to the Main menu screen.

10.3 Data Filter

The Data Filter is a software filter that eliminates sensor noise and provides more stable readings.

NOTE: YSI recommends using the default values for the data filter for most field applications.

However, users who are primarily interested in a fast response from their dissolved oxygen sensor should consider a change of the default time constant setting of 8 seconds to one of 2 seconds. This change can be made according to the instructions in Section *10.3.1 Changing the Data Filter Settings* below. The disadvantage of lowering the time constant is that field pH readings may appear somewhat noisy if the cable is in motion.

10.3.1 Changing the Data Filter Settings

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Data filter** selection. See Figure 10.1 Main Menu.

3. Press the **Enter** key. The Data filter setup screen is displayed.

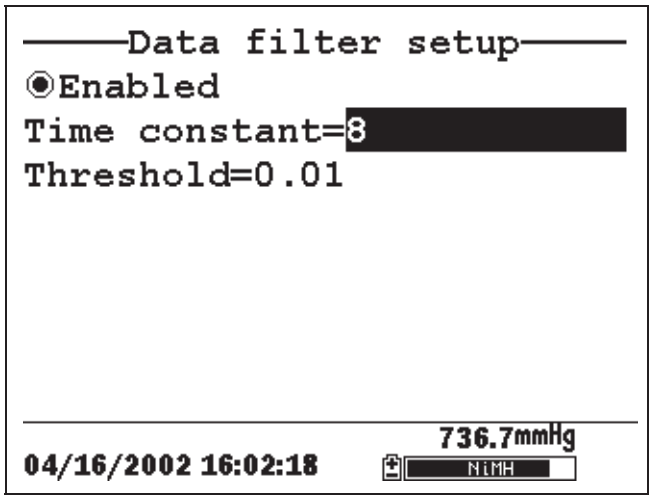


Figure 10.4 Data Filter Screen

4. With Enabled highlighted, press the **Enter** key to Enable or Disable the data filter. A black dot to the left of the selection indicates the data filter is enabled.

5. Use the arrow keys to highlight the **Time constant** field.

   NOTE: This value is the time constant in seconds for the software data filter. Increasing the time constant will result in greater filtering of the data, but will also slow down the apparent response of the sensors.

6. Use the keypad to enter a value. The default value is 8 and this value is ideal for most 556 field applications. As described in Section *10.3 Data Filter* above, users who wish to decrease the response time of the DO readings at the expense of some noise for the pH readings determined concurrently, should change the Time Constant to a value of 2.

7. Press the **Enter** key to enter the time constant.

8. Use the arrow keys to highlight the **Threshold** field.

   NOTE: This value determines when the software data filter will engage/disengage, speeding the response to large changes in a reading. When the difference between two consecutive readings is larger than the threshold, then the reading is displayed unfiltered. When the difference between two consecutive readings drops below the threshold, readings will be filtered again.

9. Use the keypad to enter a value. The default value is 0.01.

10. Press the **Enter** key to enter the threshold.

11. Press the **Escape** key repeatedly to return to the Main menu screen.

10.4 Shutoff Time

The YSI 556 MPS shuts off automatically after 30 minutes of inactivity. The shut off time may be changed as described below.

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Shutoff time** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Use the keypad to enter a value from 0 to 60 minutes. The default value is 30.

   NOTE: To disable the automatic shutoff feature, enter a zero (0).

4. Press the **Enter** key to enter the correct shutoff time.

5. Press the **Escape** key repeatedly to return to the main menu screen.

10.5 Comma Radix

The user can toggle between a period (default) and comma for the radix mark by selecting this item and pressing the **Enter** key as follows:

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Comma radix** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Press the **Enter** key. A check mark appears in the check box next to the comma radix selection indicating that the radix mark is a comma.

10.6 ID

This selection allows you to enter an identification name/number for your YSI 556 MPS. This ID name/number is logged in the header of each file.

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **ID** selection. See Figure 10.1 Main Menu.

3. Use the keypad to enter an alphanumeric ID up to 15 characters in length. Refer to Section *2.9 Keypad Use*.

4. Press the **Enter** key to enter the ID.

5. Press the **Escape** key repeatedly to return to the main menu screen.

10.7 GLP Filename

This selection allows you to enter a different filename for the YSI 556 MPS Calibration Record file.

NOTE: The default filename is the "556 PC board Serial Number.glp."

6. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

7. Use the arrow keys to highlight the **GLP Filename** selection. See Figure 10.1 Main Menu.

8. Use the keypad to enter a filename up to 8 characters in length. Refer to Section *2.9 Keypad Use*.

9. Press the **Enter** key to enter the new filename.

Press the **Escape** key repeatedly to return to the main menu screen.

10.8 TDS Constant

This selection allows you to set the constant used to calculate Total Dissolved Solids (TDS). TDS in g/L is calculated by multiplying this constant times the specific conductance in mS/cm.

10.8.1 Changing the TDS Constant

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **TDS Constant** selection. See Figure 10.1 Main Menu.

3. Use the keypad to enter a value. Refer to Section *2.9 Keypad Use*. The default value is 0.65.

4. Press the **Enter** key to enter the correct TDS constant.

5. Press the **Escape** key repeatedly to return to the main menu screen.

10.9 Barometer Units

The following information is only for instruments with the barometer option.

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Barometer units** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Press the **Enter** key. The Barometer units screen will appear.

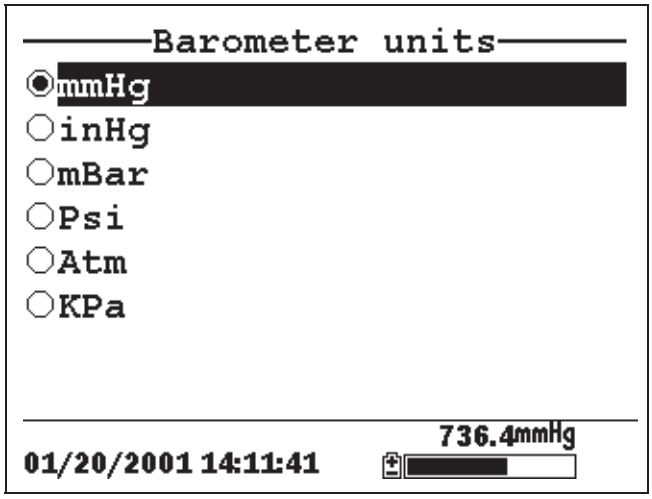


Figure 10.5 Barometer Units Screen

A black dot indicates the currently selected units.

4. Use the arrow keys to highlight your desired barometric unit.

5. Press the **Enter** key to select your choice. A black dot will appear in the circle next to your selected units.

6. Press the **Escape** key repeatedly to return to the main menu screen.

10.10 Calibrate Barometer

The optional barometer has been factory calibrated to provide accurate readings. However, some sensor drift may occur over time, requiring occasional calibration by the user, as follows:

1. Determine your local barometric pressure from an independent laboratory barometer or from your local weather service.

2. If the barometric pressure (BP) reading is from your local weather station, reverse the equation that corrects it to sea level.

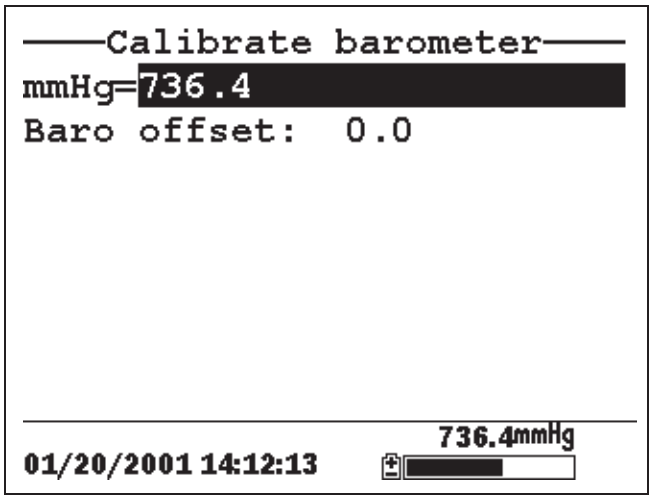
   NOTE: For this equation to be accurate, the barometric pressure units must be in mm Hg.

   True BP = (Corrected BP) – [2.5 * (Local Altitude/100)]

3. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

4. Use the arrow keys to highlight the **Calibrate barometer** selection on the system setup screen. See Figure 10.2 System Setup Screen.

5. Press the **Enter** key. The Calibrate Barometer screen is displayed.



6. Use the keypad to input the known barometric pressure value as determined in Step 2.

7. Press the **Enter** key. The new barometer reading is displayed as well as the approximate offset from the factory reading.

   NOTE: To return the sensor to the factory setting, subtract the offset amount from the current setting and repeat Steps 5 to 7.

8. Press the **Escape** key repeatedly to return to the main menu screen.

11. Maintenance

11.1 Sensor Care and Maintenance

Once the sensors have been properly installed, remember that periodic cleaning and DO membrane changes are required.

11.1.1 DO Sensor

For best results, we recommend that the KCl solution and the membrane cap be changed at least once every 30 days.

1. It is important to recognize that oxygen dissolved in the sample is consumed during sensor operation. It is therefore essential that the sample be continuously stirred at the sensor tip. If stagnation occurs, your readings will be artificially low. Stirring may be accomplished by mechanically moving the sample around the sensor tip, or by rapidly moving the sensor through the sample. The rate of stirring should be at least 1 foot per second.

2. Membrane life depends on usage. Membranes will last a long time if installed properly and treated with care. Erratic readings are a result of loose, wrinkled, damaged, or fouled membranes, or from large (more than 1/8" diameter) bubbles in the electrolyte reservoir. If erratic readings or evidence of membrane damage occurs, you should replace the membrane and the electrolyte solution. The average replacement interval is two to four weeks.

3. If the membrane is coated with oxygen consuming (e.g. bacteria) or oxygen producing organisms (e.g. algae), erroneous readings may occur.

4. Chlorine, sulfur dioxide, nitric oxide, and nitrous oxide can affect readings by behaving like oxygen at the sensor. If you suspect erroneous readings, it may be necessary to determine if these gases are the cause.

5. Avoid any environment that contains substances that may attack the probe module and sensor materials. Some of these substances are concentrated acids, caustics, and strong

solvents. The sensor materials that come in contact with the sample include FEP Teflon, acrylic plastic, EPR rubber, stainless steel, epoxy, polyetherimide and the PVC cable covering.

6. It is possible for the silver anode, which is the entire silver body of the sensor, to become contaminated. This will prevent successful calibration. To restore the anode, refer to Section *11.1.1 DO Sensor, Silver Anode Cleaning*.

7. For correct sensor operation, the gold cathode must always be bright. If it is tarnished (which can result from contact with certain gases), or plated with silver (which can result from extended use with a loose or wrinkled membrane), the gold surface must be restored. To restore the cathode, refer to Section *11.1.1 DO Sensor, Gold Cathode Cleaning*.

8. To keep the electrolyte from drying out, store the sensor in the transport/calibration cup with at least 1/8″ of water.

Silver Anode Cleaning

After extended use, a thick layer of AgCl builds up on the silver anode reducing the sensitivity of the sensor. The anode must be cleaned to remove this layer and restore proper performance. The cleaning can be chemical or mechanical:

Chemical Cleaning: Remove the membrane cap and soak the entire anode section in a 14% ammonium hydroxide solution for 2 to 3 minutes, followed by a thorough rinsing with distilled or deionized water. The anode should then be thoroughly wiped with a wet paper towel to remove the residual layer from the anode.

Mechanical Cleaning: Sand off the dark layer from the silver anode with 400 grit wet/dry sandpaper. Wrap the sandpaper around the anode and twist the sensor. Rinse the anode with clean water after sanding, followed by wiping thoroughly with a wet paper towel.

NOTE: After cleaning, a new membrane cap must be installed. Refer to Section *3.4.3 Membrane Cap Installation*.

Turn the instrument on and allow the system to stabilize for at least 30 minutes. If, after several hours, you are still unable to calibrate, contact your dealer or YSI Customer Service. Refer to *Appendix E Customer Service*.

Gold Cathode Cleaning

For correct sensor operation, the gold cathode must be textured properly. It can become tarnished or plated with silver after extended use. The gold cathode can be cleaned by using the adhesive backed sanding disc and tool provided in the YSI 5238 Probe Reconditioning Kit.

Using the sanding paper provided in the YSI 5238 Probe Reconditioning Kit, wet sand the gold with a twisting motion about 3 times or until all silver deposits are removed and the gold appears to have a matte finish. Rinse the cathode with clean water after sanding, followed by wiping thoroughly with a wet paper towel. If the cathode remains tarnished, contact your dealer or YSI Customer Service. Refer to *Appendix E Customer Service*.

NOTE: After cleaning, a new membrane cap must be installed. Refer to Section *3.4.3 Membrane Cap Installation***.**

11.1.2 DO Sensor Replacement

1. Remove the probe sensor guard.

⚠ **CAUTION:** Thoroughly dry the sensor so that no water enters the probe module sensor port when the sensor is removed.

2. Insert the long end of the hex key wrench into the small hole in the side of the probe module bulkhead. Turn the wrench counterclockwise and remove the screw. (You do not have to remove the screw all the way to release the sensor.)

3. Pull the old DO sensor module straight out of the probe module body.

   NOTE: The DO sensor is not threaded, it is keyed, so it cannot be removed by twisting.

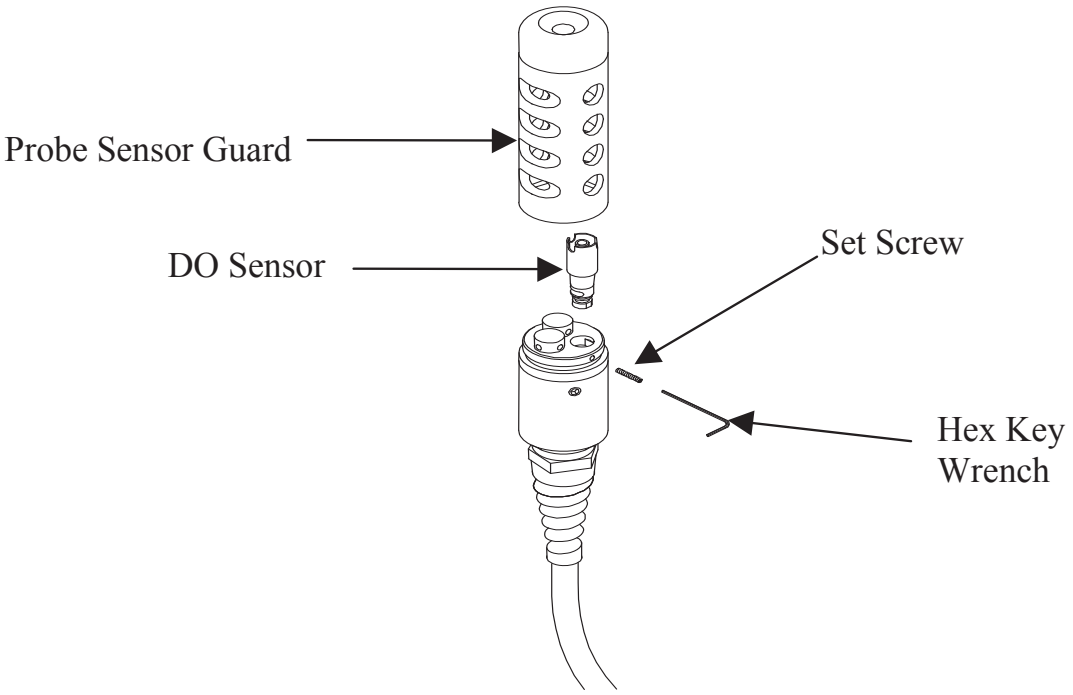


Figure 11.1 DO Sensor Replacement

4. Insert the new DO sensor module. Make sure that the inside of the probe module sensor port and the o-ring on the sensor are clean, with no contaminants, such as grease, dirt, or hair. The DO sensor is keyed, or has a flat side, so that it cannot be aligned improperly.

NOTE: Make sure the DO sensor bottoms out before the set screw is inserted.

5. Insert the set screw into the small hole in the side of the probe module bulkhead, and turn clockwise to rethread.

⚠ **CAUTION:** Make sure that you do not cross-thread the set screw. Use the hex key wrench to tighten the screw in properly, making sure that the screw does not stick out of the side of the probe module bulkhead. The probe sensor guard will not thread

on properly and damage may result if the screw is allowed to stick out.

NOTE: The YSI 5563 DO sensor is shipped dry. A shipping membrane was installed to protect the electrode. A new membrane cap must be installed before the first use. Refer to Section *3.4.1 Sensor Installation.*

11.1.3 YSI 5564 pH and 5565 Combination pH/ORP Sensor Cleaning

Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces of these sensors or when the response of the sensor becomes slow.

1. Remove the sensor from the probe module.

2. Initially, simply use clean water and a soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb (YSI 5564 and YSI 5565) and platinum button (YSI 5565). Then use a moistened cotton swab to carefully remove any material that may be blocking the reference electrode junction of the sensor.

⚠ **CAUTION:** When using a cotton swab with the YSI 5564 or YSI 5565, be careful NOT to wedge the swab tip between the guard and the glass sensor. If necessary, remove cotton from the swab tip, so that the cotton can reach all parts of the sensor tip without stress.

NOTE: If good pH and/or ORP response is not restored by the above procedure, perform the following additional procedure:

1. Soak the sensor for 10-15 minutes in clean water containing a few drops of commercial dishwashing liquid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the cleaning solution.

3. Rinse the sensor in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water.

NOTE: If good pH and/or ORP response is still not restored by the above procedure, perform the following additional procedure:

1. Soak the sensor for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Be sure to follow the safety instructions included with the acid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the acid.

3. Rinse the sensor in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water. To be certain that all traces of the acid are removed from the sensor crevices, soak the sensor in clean water for about an hour with occasional stirring.

NOTE: If biological contamination of the reference junction is suspected or if good response is not restored by the above procedures, perform the following additional cleaning step:

1. Soak the sensor for approximately 1 hour in a 1 to 1 dilution of commercially available chlorine bleach.

2. Rinse the sensor with clean water and then soak for at least 1 hour in clean water with occasional stirring to remove residual bleach from the junction. (If possible, soak the sensor for period of time longer than 1 hour in order to be certain that all traces of chlorine bleach are removed.) Then re-rinse the sensor with clean water and retest.`

11.1.4 Temperature/Conductivity Sensor Cleaning

The single most important requirement for accurate and reproducible results in conductivity measurement is a clean cell. A dirty cell will change the conductivity of a solution by contaminating it. The small cleaning brush included in the YSI 5511 Maintenance Kit is ideal for this purpose.

To clean the conductivity cell:

1. Dip the brush in clean water and insert it into each hole 15-20 times.

2. Rinse the cell thoroughly in deionized or clean tap water.

NOTE: In the event that deposits have formed on the electrodes, perform the following additional procedure:

1. Use a mild detergent solution in combination with the brush. Dip the brush in the solution and insert it into each hole 15-20 times.

2. Rinse the cell thoroughly in deionized or clean tap water.

   NOTE: After cleaning, check the response and accuracy of the conductivity cell with a calibration standard.

   NOTE: If this procedure is unsuccessful, or if sensor performance is impaired, it may be necessary to return the sensor to a YSI authorized service center for service, Refer to *Appendix E Customer Service*.

   The temperature portion of the sensor requires no maintenance.

11.2 Upgrading YSI 556 MPS Software

1. Access the YSI Environmental Software Downloads page as described in *Appendix G EcoWatch* Step 1 through 3.

2. Click on the **YSI Instruments Software Updates** link (or scroll down until you see YSI 556 MPS).

3. Click on the file icon to the right of the **YSI 556 MPS** listing and save the file to a temporary directory on your computer.

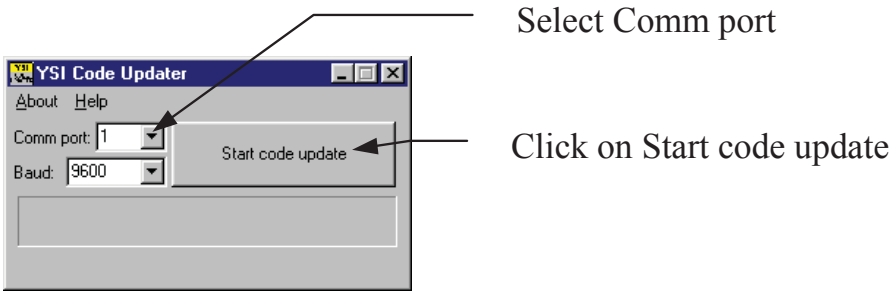
4. After the download is complete, run the file (that you just downloaded) and follow the on screen instructions to install the YSI Code Updater on your computer. If you encounter difficulties, contact YSI customer service for advice. Refer to *Appendix E Customer Service*.

5. If necessary, disconnect the YSI 5563 Probe Module from the YSI 556 MPS instrument.

6. Connect the YSI 556 MPS to a serial port of your computer via the 655173 PC interface cable. See Figure 8.6 Computer/Instrument Interface.

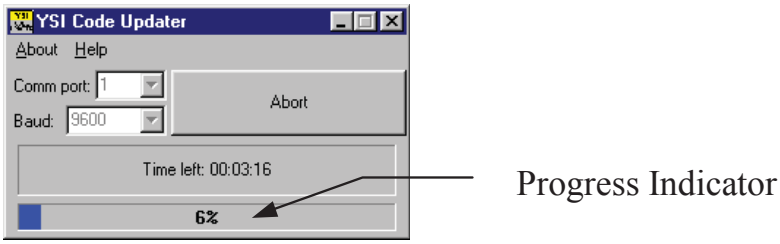
7. Press the **On/off** key on the YSI 556 MPS to display the run screen.

8. Run the YSI Code Updater software that you just installed on your computer. The following window will be displayed:

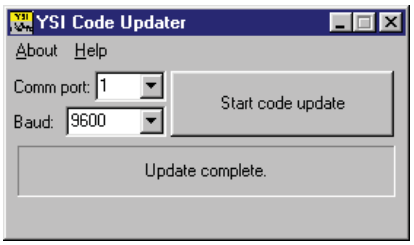


9. Set the Comm port number to match the port that you connected the 655173 PC Interface Cable to, then click on the **Start Code Update button**.

The YSI 556 MPS screen will blank out and a progress indicator will be displayed on the PC.



When the update is finished (indicated on the PC screen), the YSI 556 MPS will return to the Run screen. See Figure 7.1 Run Screen.



10. Close the YSI Code Updater window (on the PC) by clicking on the "X" in the upper right corner of the window.

11. Disconnect the YSI 556 MPS from the 655173 PC interface cable and reconnect it to the YSI 5563 Probe Module. Refer to Section *3.6 Instrument/Cable Connection*.

12. Storage

Proper storage between periods of usage will not only extend the life of the sensors, but will also ensure that the unit will be ready to use as quickly as possible in your next application.

12.1 General Recommendations for Short Term Storage

No matter what sensors are installed in the instrument, it is important to keep them moist without actually immersing them in liquid. Immersing them could cause some of them to drift or result in a shorter lifetime.

YSI recommends that short term storage of all multi-parameter instruments be done by placing approximately 1/2 inch of tap water in the transport/calibration cup that was supplied with the instrument, and by placing the probe module with all of the sensors installed into the cup. The use of a moist sponge instead of a 1/2 inch of tap water is also acceptable, as long as its presence does not compromise the attachment of the cup to the probe module. The transport/calibration cup should be sealed to prevent evaporation.

NOTE: Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body. See Figure 3.7 Transport/Calibration Cup Installation.

⚠ **CAUTION:** The water level has to be low enough so that none of the sensors are actually under water. Check the transport/calibration cup periodically to make certain that the water is still present or the sponge is still moist.

NOTE: If the storage water (tap water) is accidentally lost during field use, environmental water can be used.

12.2 General Recommendations for Long Term Storage

12.2.1 Probe Module Storage

1. Remove the pH or pH/ORP sensor from the probe module and store according to the individual sensor storage instructions found in Section *12.2.2 Sensor Storage*.

2. Seal the empty port with the provided port plug.

NOTE: Leave the conductivity/temperature sensor and dissolved oxygen sensor, with membrane cap still on, in the probe module.

3. Place 1/2″ of water, deionized, distilled or tap, in the transport/calibration cup.

⚠ **CAUTION:** The water level has to be low enough so that none of the sensors are actually under water. Check the transport/calibration cup periodically to make certain that the water is still present or the sponge is still moist.

4. Insert the probe module into the cup.

NOTE: Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body. See Figure 3.7 Transport/Calibration Cup Installation.

12.2.2 Sensor Storage

Temperature/Conductivity Sensor

No special precautions are required. Sensor can be stored dry or wet, as long as solutions in contact with the thermistor and conductivity electrodes are not corrosive (for example, chlorine bleach). However, it is recommended that the sensor be cleaned with the provided brush prior to long term storage. Refer to Section *11.1.4 Temperature/Conductivity Sensor Cleaning.*

pH and Combination pH/ORP Sensor

The key to sensor storage is to make certain that the reference electrode junction does not dry out. Junctions which have been allowed to dry out due to improper storage procedures can usually be rehydrated by soaking the sensor for several hours (overnight is recommended) in a solution which is 2 molar in potassium chloride. If potassium chloride solution is not available, soaking the sensor in tap water or commercial pH buffers may restore sensor function. However in some cases the sensor may have been irreparably damaged by the dehydration and will require replacement.

⚠ **CAUTION:** Do not store the sensor in distilled or deionized water as the glass sensor may be damaged by exposure to this medium.

1. Remove the pH or pH/ORP sensor from the probe module.

2. Seal the empty port with the provided port plug.

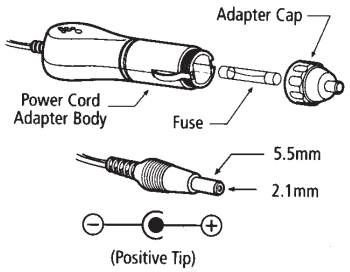
3. Place the sensor in the storage vessel (plastic boot or bottle) which was on the sensor at delivery. The vessel should contain a solution which is 2 molar in potassium chloride.

   NOTE: Make certain that the vessel is sealed to prevent evaporation of the storage solution.

13. Troubleshooting

The following sections describe problems you may encounter when using the YSI 556 MPS and provides suggestions to overcome the symptom.

PROBLEM	POSSIBLE SOLUTION
Display Problems	
No display is visible after pressing the on/off key.	If C cells are used, make certain that they are installed properly with regard to polarity and that good batteries are used. If a rechargeable battery pack is used, place the pack in the instrument and charge for 30 minutes.
Instrument software appears to be locked up as evidenced by no response to keypad entries or display not changing.	First, attempt to reset the instrument by simply turning off and then on again. If this fails, remove battery power from the instrument for 30 seconds and then reapply power. When using C cells, remove the battery lid and one of the batteries; when using the rechargeable battery pack, remove the pack completely from the instrument. After 30 seconds replace the battery or battery pack and check for instrument function.
The 556 display flashes and the instrument speaker makes a continuous clicking sound.	The battery voltage is low. Change to new C cells or recharge the 6117 battery pack.
Water Damage to Instrument	
Leakage detected in battery compartment when using C cells	Dispose of batteries properly. Dry the battery compartment using compressed air if possible. If corrosion is present on battery terminals, contact YSI Customer Service.
Water has contacted rechargeable battery pack	Remove battery pack immediately. Send battery pack to YSI Product Service for evaluation. **CAUTION**: DO NOT REUSE BATTERY PACK UNTIL YSI PRODUCT SERVICE HAS EVALUATED IT.
Leakage suspected into the main cavity of the instrument case	Remove the batteries immediately. Return the instrument to YSI Product Service.

PROBLEM	POSSIBLE SOLUTION
Optional Cigarette Lighter Charger	
Power cord fuse blown 	1. Unscrew adapter's cap, remove tip and pull out fuse. 2. Replace fuse with a new 2-amp fast-blow fuse from an electronics store such as Radio Shack. 3. Reassemble the adapter and securely screw the cap back onto the adapter body.
File Problems	
Upload of files from YSI 556 MPS to PC fails	1. Make sure that cable is connected properly to both 556 and PC. 2. Make certain that the proper Comm port is selected in EcoWatch for Windows.
Barometer data is not stored with sensor data file.	Make sure **Store barometer** is active in the 556 **Logging setup** menu.
Site Descriptions in the **Site List** are "grayed-out" and not available for appending files with additional data.	There is a parameter mismatch between the current 556 setup and that initially used. Change the current logging and sensor setup to match the setup that was initially used to create the file.
Sensor Problems	
Dissolved Oxygen reading unstable or inaccurate. Out of Range message appears during calibration.	Sensor not properly calibrated. Follow DO cal procedures.
	Membrane not properly installed or may be punctured. Replace membrane cap.
	DO sensor electrodes require cleaning. Follow DO cleaning procedure. Use 5511 Maintenance kit.
	Water in sensor connector. Dry connector; reinstall sensor.
	Algae or other contaminant clinging to DO sensor. Rinse DO sensor with clean water.
	Barometric pressure entry is incorrect. Repeat DO cal procedure.
	Calibrated at extreme temperature. Recalibrate at (or near) sample temperature.
	DO sensor has been damaged. Replace sensor.
	Internal failure. Return probe module for service.

PROBLEM	POSSIBLE SOLUTION
Sensor Problems	
pH or ORP readings are unstable or inaccurate. Out of Range message appears during calibration.	Sensor requires cleaning. Follow sensor cleaning procedure.
	Sensor requires calibration. Follow cal procedures.
	pH sensor reference junction has dried out from improper storage. Soak sensor in tap water or buffer until readings become stable.
	Water in sensor connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace sensor.
	Calibration solutions out of spec or contaminated with other solution. Use new calibration solutions.
	ORP fails Zobell check. Take into account temperature dependence of Zobell solution readings.
	Internal failure. Return probe module for service.
Conductivity unstable or inaccurate. Out of Range message appears during calibration.	Conductivity improperly calibrated. Follow calibration procedure.
	Conductivity sensor requires cleaning. Follow cleaning procedure.
	Conductivity sensor damaged. Replace sensor.
	Calibration solution out of spec or contaminated. Use new calibration solution.
	Internal failure. Return probe module for service.
	Calibration solution or sample does not cover entire sensor. Immerse sensor fully.
Temperature, unstable or inaccurate	Water in connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace the 5560 sensor.
Installed sensor has no reading	The sensor has been disabled. Enable sensor.
	Water in sensor connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace the sensor.
	Report output improperly set up. Set up report output.
	Internal failure. Return probe module for service.

If these guidelines and tips fail to correct your problem or if any other symptoms occur, contact YSI Customer Service for Advice. Refer to *Appendix E Customer Service*.

14. Appendix A YSI 556 MPS Specifications

14.1 Sensor Specifications

Dissolved Oxygen		
Sensor Type		Steady state polarographic
Range:	*% air sat'n* *mg/L*	▪ 0 to 500% air saturation ▪ 0 to 50 mg/L
Accuracy:	*% air sat'n* *mg/L*	▪ 0 to 200% air saturation: ±2% of the reading or 2% air saturation; whichever is greater ▪ 200 to 500% air saturation: ±6% of the reading ▪ 0 to 20 mg/L: ±2% of the reading or 0.2 mg/L; whichever is greater ▪ 20 to 50 mg/L: ±6% of the reading
Resolution:	*% air sat'n* *mg/L*	▪ 0.1% air saturation ▪ 0.01 mg/L
Temperature		
Sensor Type:		YSI Precision™ thermistor
Range:		-5 to 45°C
Accuracy:		±0.15°C
Resolution:		0.01°C
Conductivity		
Sensor Type:		4-electrode cell with auto-ranging
Range:		0 to 200 mS/cm
Accuracy:		±0.5% of reading or ±0.001 mS/cm; whichever is greater–4 meter cable ±1.0% of reading or ±0.001 mS/cm; whichever is greater–20 meter cable
Resolution:		0.001 mS/cm to 0.1 mS/cm (range-dependent)
Salinity		
Sensor Type:		Calculated from conductivity and temperature
Range:		0 to 70 ppt
Accuracy:		±1.0% of reading or 0.1 ppt; whichever is greater
Resolution:		0.01 ppt

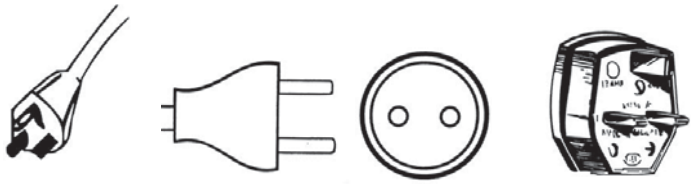
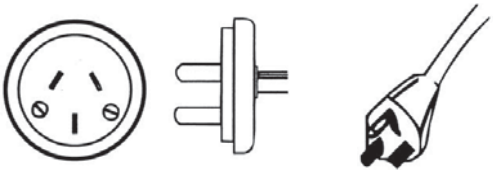
pH (optional)	
Sensor Type:	Glass combination electrode
Range:	0 to 14 units
Accuracy:	±0.2 units
Resolution:	0.01 units
ORP (optional)	
ORP Sensor Type:	Platinum button
Range:	-999 to +999 mV
Accuracy:	±20 mV
Resolution:	0.1 mV

Barometer (optional)	
Range:	500 to 800 mm Hg
Accuracy:	±3 mm Hg within ±15°C temperature range from calibration point
Resolution:	0.1 mm Hg

14.2 Instrument Specifications

Memory Size:	1.5 MB Flash Memory 49,000 data sets (@ 6 parameters per set plus time stamp) 100 Sites
Size:	11.9 cm width x 22.9 cm length (4.7 in. x 9 in.)
Weight with batteries:	0.92 kg (2.1 lbs)
Power:	4 alkaline C-cells; optional rechargeable pack
Cables:	4, 10, and 20 m (13.1, 32.8, 65.6 ft.) lengths
Warranty:	3-Years for the instrument; 1-Year for the probe modules and cable

15. Appendix B Instrument Accessories

ITEM #	ACCESSORY
5563-4	4m Cable with DO/temp/conductivity
5563-10	10m Cable with DO/temp/conductivity
5563-20	20m Cable with DO/temp/conductivity
5564	pH Kit
5565	pH/ORP Kit
6118	Rechargeable Battery Pack Kit for use in US
5094	Rechargeable Battery Pack Kit with universal charger and three adapter cables for use in international applications 
5095	Rechargeable Battery Pack Kit with universal charger and two adapter cables for use in international applications 
5083	Flow Cell – probe module is secured in the flow cell and groundwater is pumped through it
616	Charger, Cigarette Lighter – used to power up the instrument from a car's cigarette lighter
4654	Tripod
614	Ultra Clamp, C Clamp –used to clamp the instrument to a table top or car dashboard
6081	Large Carrying Case, Hard-sided
5085	Hands-free Harness
5065	Carrying Case, Form-fitted, for use in the field – has a clear vinyl window, shoulder strap, belt loop strap and hand strap

16. Appendix C Required Federal Communications Notice

The Federal Communications Commission defines this product as a computing device and requires the following notice.

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A or Class B computing device in accordance with the specification in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna
- Relocate the computer with respect to the receiver
- Move the computer away from the receiver
- Plug the computer into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet, prepared by the Federal Communications Commission, helpful: "How to Identify and Resolve Radio-TV Interference Problems". This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No.0004-000-00345-4.

17. Appendix D Health and Safety

YSI Conductivity solutions: 3161, 3163, 3165, 3167, 3168, 3169

INGREDIENTS:

- ❑ Iodine
- ❑ Potassium Chloride
- ❑ Water

WARNING: INHALATION MAY BE FATAL.

⚠ ***CAUTION*: AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY EVOLVE TOXIC FUMES IN FIRE.**

Harmful if ingested or inhaled. Skin or eye contact may cause irritation. Has a corrosive effect on the gastro-intestinal tract, causing abdominal pain, vomiting, and diarrhea. Hyper-sensitivity may cause conjunctivitis, bronchitis, skin rashes etc. Evidence of reproductive effects.

FIRST AID:
INHALATION: Remove victim from exposure area. Keep victim warm and at rest. In severe cases seek medical attention.
SKIN CONTACT: Remove contaminated clothing immediately. Wash affected area thoroughly with large amounts of water. In severe cases seek medical attention.
EYE CONTACT: Wash eyes immediately with large amounts of water, (approx. 10 minutes). Seek medical attention immediately.
INGESTION: Wash out mouth thoroughly with large amounts of water and give plenty of water to drink. Seek medical attention immediately.

YSI pH 4.00, 7.00, and 10.00 Buffer Solutions: 3821, 3822, 3823

pH 4 INGREDIENTS:

- ❑ Potassium Hydrogen Phthalate
- ❑ Formaldehyde
- ❑ Water

pH 7 INGREDIENTS:

- ❑ Sodium Phosphate, Dibasic
- ❑ Potassium Phosphate, Monobasic
- ❑ Water

pH 10 INGREDIENTS:

- ❑ Potassium Borate, Tetra
- ❑ Potassium Carbonate
- ❑ Potassium Hydroxide
- ❑ Sodium (di) Ethylenediamine Tetraacetate
- ❑ Water

⚠ ***CAUTION*** **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

Inhalation may cause severe irritation and be harmful. Skin contact may cause irritation; prolonged or repeated exposure may cause Dermatitis. Eye contact may cause irritation or conjunctivitis. Ingestion may cause nausea, vomiting and diarrhea.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

YSI Zobell Solution: 3682

INGREDIENTS:

- ❑ Potassium Chloride
- ❑ Potassium Ferrocyanide Trihydrate
- ❑ Potassium Ferricyanide

⚠ ***CAUTION*** **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

May be harmful by inhalation, ingestion, or skin absorption. Causes eye and skin irritation. Material is irritating to mucous membranes and upper respiratory tract. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities can cause weakness, gastrointestinal irritation and circulatory disturbances.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

18. Appendix E Customer Service

For information on Authorized Service Centers, refer to *Authorized Service Centers* in this appendix.

Equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected before being returned or presented for service. A cleaning certificate must accompany the equipment. Refer to *18.2 Cleaning Instructions* in this appendix.

18.1 YSI Environmental Authorized Service Centers

For information on the nearest authorized service center, please contact:

YSI Technical Support • 1725 Brannum Lane
Yellow Springs, Ohio • 45387 • Phone: +1 (937) 767-7241
Phone: 800-897-4151 (US) • Email: environmental@ysi.com

or visit our website for the most current information:

www.ysi.com

18.2 Cleaning Instructions

Equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected before being serviced. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the responsibility of the sender.

When service is required, either at the user's facility or at a YSI Service Center, the following steps must be taken to ensure the safety of service personnel.

- In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4-cup bleach to 1-gallon tap water is suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol if this is more convenient to the user.
- The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.
- If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.
- Any product being returned to the YSI Repair Center should be packed securely to prevent damage.
- Cleaning must be completed and certified on any product before returning it to YSI.

18.3 Packing Procedure

- Clean and decontaminate items to ensure the safety of the handler.
- Complete and include the Cleaning Certificate.
- Place the product in a plastic bag to keep out dirt and packing material.
- Use a large carton, preferably the original, and surround the product completely with packing material.
- Insure for the replacement value of the product.

18.4 Cleaning Certificate

Organization _____

Department _____

Address _____

City _____ State __ Zip _____

Country _____ Phone _____

Model No. of Device __ Lot Number _____

Contaminant (if known) _____

Cleaning Agent(s) used _____

Radioactive Decontamination Certified?

(Answer only if there has been radioactive exposure)

_____ Yes _____ No

Cleaning Certified By _____

Name Date

18.5 Warranty

The instrument is warranted for three years against defects in workmanship and materials when used for its intended purposes and maintained according to instructions. The probe module and cables are warranted for one year. The dissolved oxygen, temperature/conductivity, pH, and pH/ORP combination sensors are warranted for one year. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered. The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, write or call your local YSI representative, or contact YSI Customer Service in Yellow Springs, Ohio. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI's written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI's written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI'S LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

19. Appendix F Ferrite Bead Installation

⚠ **WARNING:** If you are using your YSI 556 in a European Community (CE) country or in Australia or New Zealand, you must attach a ferrite bead to the 655173 PC Interface Cable and the YSI 6117 Charger Adapter Cable in order to comply with the Residential, Commercial and Light Industrial Class B Limits for radio-frequency emissions specified in EN55011 (CISPR11) for Industrial, Scientific and Medical laboratory equipment. These ferrite assemblies are supplied as part of cable kits.

1. Make a small loop (approximately 5 cm in diameter) in the cable near the YSI 556 MS-19 connector.

2. Lay the open ferrite bead assembly under the loop with the cable cross-over position within the cylinder of the ferrite bead.

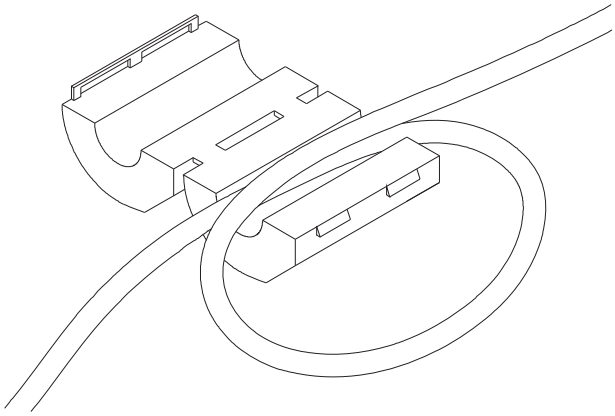


Figure 19.1 Ferrite Bead Installation

3. Snap the two pieces of the bead together making certain that the tabs lock securely.

4. When the installation is complete, the 655173 and YSI 6117 cables should resemble the following drawings.

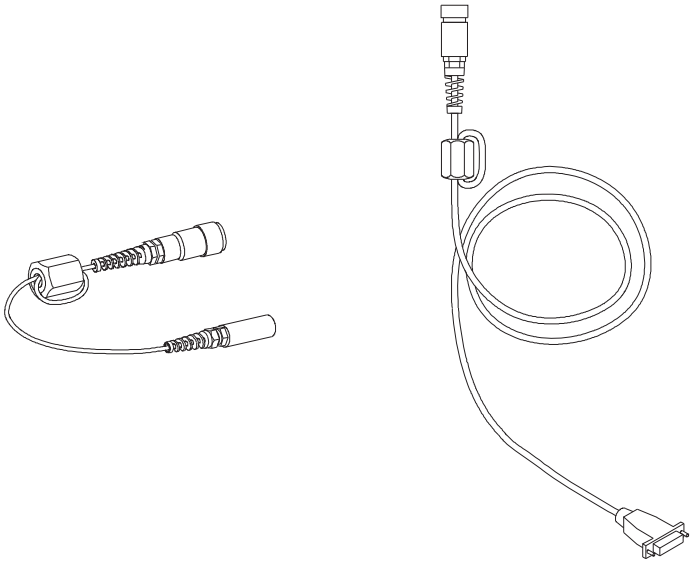


Figure 19.2 Cables with Ferrite Beads

20. Appendix G EcoWatch

EcoWatch™ for Windows™ must be used as the PC software interface to the YSI 556 MPS. EcoWatch is a powerful tool that can also be used with YSI 6-series sondes. Many features of the software will only be utilized by advanced users or are not relevant to the 556 MPS at all. This section is designed in tutorial format to familiarize you with the commonly used features of EcoWatch so that it will be possible to:

- Upload data from a 556 MPS to a PC
- Assemble plots and reports of your data
- Zoom in on certain segments of the plots of your data to facilitate analysis
- Show statistical data for your studies
- Export data in spreadsheet-compatible formats
- Print plots and reports

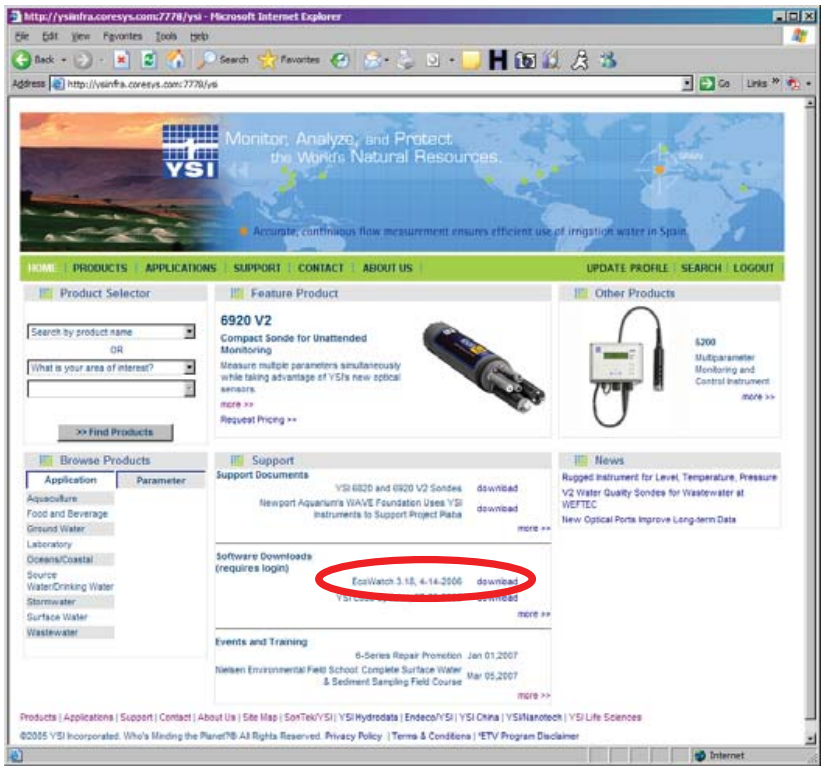
The advanced features of EcoWatch can be explored by downloading a 6-series manual from the YSI Web Site (www.ysi.com), purchasing a hard copy of the manual through YSI Customer Service (Item # 069300), or utilizing the on-line help feature of the software.

20.1 Installing EcoWatch for Windows

EcoWatch for Windows is available at no cost via a download from the YSI Web Site.

1. Access the YSI Web Site at www.ysi.com.

2. Click on the **Login** link and login (or register if you have not previously registered).



3. Click on the EcoWatch link and save the file to a directory on your computer.

4. After the download is complete, run the EcoWatch file (that you just downloaded) and follow the on screen instructions to install the software on your computer.

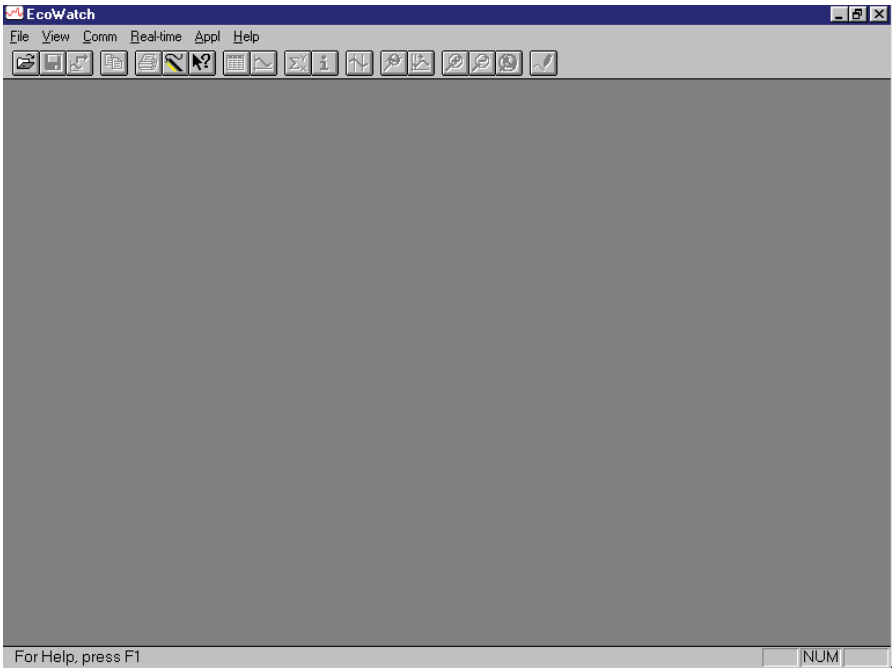
If you encounter difficulties in the download procedure, contact YSI Customer Service. Refer to ***Appendix E Customer Service***. Alternatively, you may purchase the software on CD ROM (Item #006075) by contacting YSI Customer Service.

20.2 EcoWatch Tutorial

This EcoWatch tutorial is designed to teach you the commonly used operations associated with the software when used with your 556 MPS.

After you have uploaded a file, Refer to Section 8.4 Upload to PC, you will see two files in the C:\ECOWWIN\DATA directory; the file you transferred and a file supplied by YSI designated SAMPLE.DAT. This SAMPLE.DAT file is referred to in the remainder of this tutorial section. After following the instructions below for the analysis of SAMPLE.DAT, you apply the same analysis to the data file which was uploaded from your 556 MPS to assure that you are familiar with the basic features and capabilities of EcoWatch for Windows.

To start the analysis of the SAMPLE.DAT file, note that a shortened menu bar is visible and many of the tools in the toolbar appear dimmed or “grayed out” before any file is opened (see below).



Full activation of EcoWatch features will be realized after a file is opened.

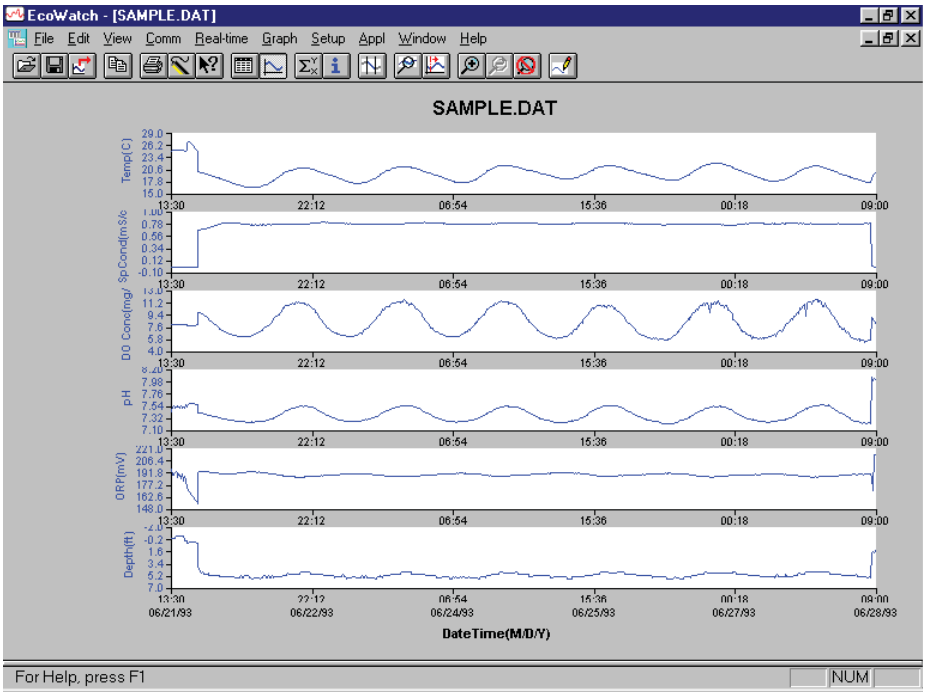
To open the sample data file:

5. 1. Click the **File** menu button in the toolbar.

6. 2. Select the **SAMPLE.DAT** file.

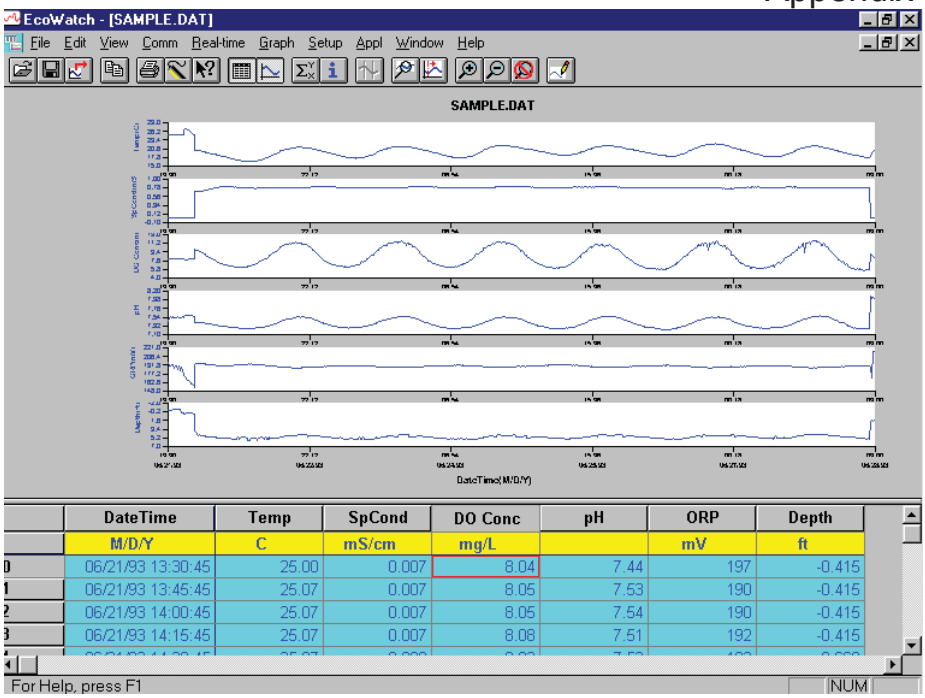
7. 3. Click **OK** to open the file.

The following display will appear:



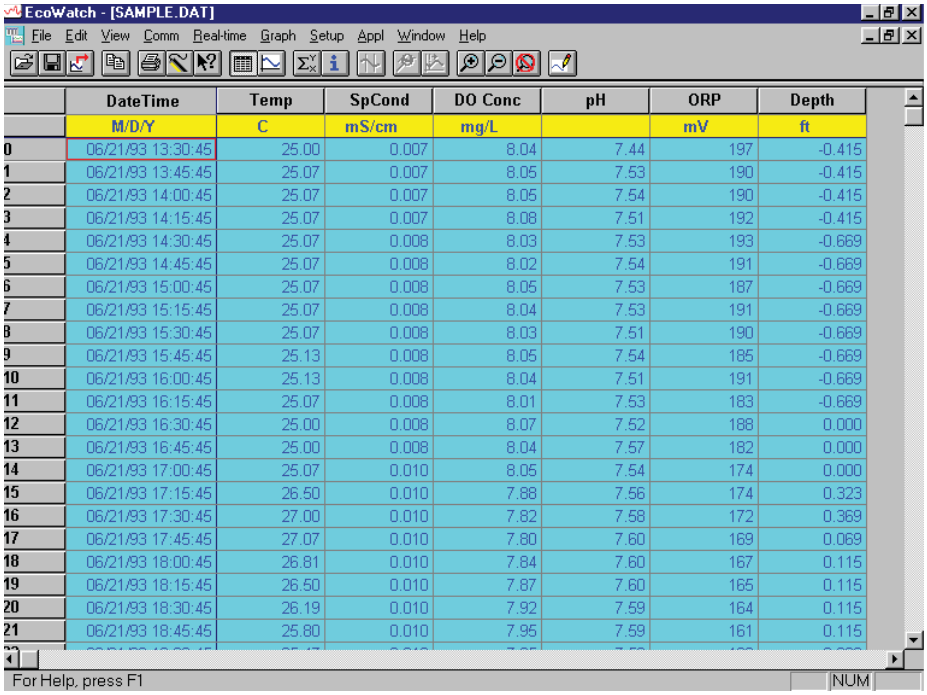
Note that the data in this file appears as a graph of temperature, specific conductance, dissolved oxygen, pH, ORP, and depth, all versus time. The graphs are scaled automatically so that all data fits comfortably on the computer screen. Note also that this data file was obtained with a 6-series sonde for which a depth sensor is available. Depth is NOT a current parameter for the 556 MPS.

The **Table** and **Graph** buttons on the toolbar are on/off switches that are used to display or hide the graph and table pages respectively. When displaying a graph and a table at the same time, you can control the relative size of the two pages by placing the cursor over the small bar that separates them and then dragging it to the desired location. Click the **Table** button to generate the following dual display of data.



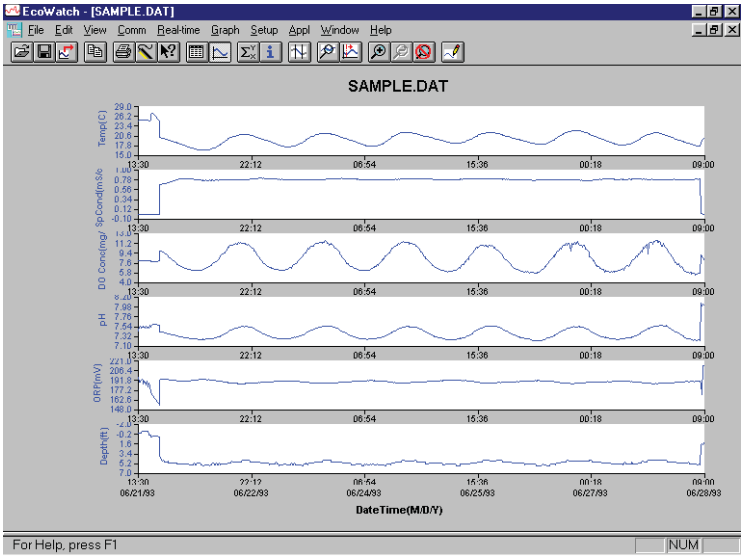
	DateTime	Temp	SpCond	DO Conc	pH	ORP	Depth
	M/D/Y	C	mS/cm	mg/L		mV	ft
0	06/21/93 13:30:45	25.00	0.007	8.04	7.44	197	-0.415
1	06/21/93 13:45:45	25.07	0.007	8.05	7.53	190	-0.415
2	06/21/93 14:00:45	25.07	0.007	8.05	7.54	190	-0.415
3	06/21/93 14:15:45	25.07	0.007	8.08	7.51	192	-0.415

Now click the **Graph** button (turn it off) to display only a report of your data as shown below. Note that the size of the report can be varied by clicking on the and buttons in the Toolbar.

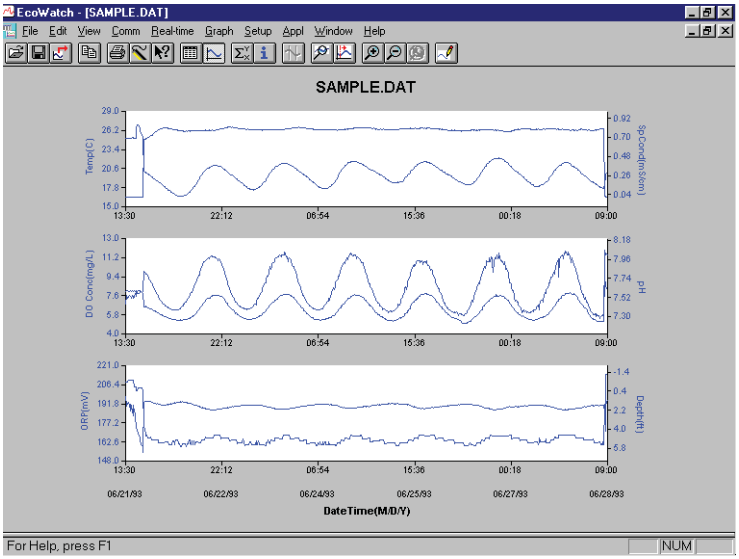


	DateTime	Temp	SpCond	DO Conc	pH	ORP	Depth
	M/D/Y	C	mS/cm	mg/L		mV	ft
0	06/21/93 13:30:45	25.00	0.007	8.04	7.44	197	-0.415
1	06/21/93 13:45:45	25.07	0.007	8.05	7.53	190	-0.415
2	06/21/93 14:00:45	25.07	0.007	8.05	7.54	190	-0.415
3	06/21/93 14:15:45	25.07	0.007	8.08	7.51	192	-0.415
4	06/21/93 14:30:45	25.07	0.008	8.03	7.53	193	-0.669
5	06/21/93 14:45:45	25.07	0.008	8.02	7.54	191	-0.669
6	06/21/93 15:00:45	25.07	0.008	8.05	7.53	187	-0.669
7	06/21/93 15:15:45	25.07	0.008	8.04	7.53	191	-0.669
8	06/21/93 15:30:45	25.07	0.008	8.03	7.51	190	-0.669
9	06/21/93 15:45:45	25.13	0.008	8.05	7.54	185	-0.669
10	06/21/93 16:00:45	25.13	0.008	8.04	7.51	191	-0.669
11	06/21/93 16:15:45	25.07	0.008	8.01	7.53	183	-0.669
12	06/21/93 16:30:45	25.00	0.008	8.07	7.52	188	0.000
13	06/21/93 16:45:45	25.00	0.008	8.04	7.57	182	0.000
14	06/21/93 17:00:45	25.07	0.010	8.05	7.54	174	0.000
15	06/21/93 17:15:45	26.50	0.010	7.88	7.56	174	0.323
16	06/21/93 17:30:45	27.00	0.010	7.82	7.58	172	0.369
17	06/21/93 17:45:45	27.07	0.010	7.80	7.60	169	0.069
18	06/21/93 18:00:45	26.81	0.010	7.84	7.60	167	0.115
19	06/21/93 18:15:45	26.50	0.010	7.87	7.60	165	0.115
20	06/21/93 18:30:45	26.19	0.010	7.92	7.59	164	0.115
21	06/21/93 18:45:45	25.80	0.010	7.95	7.59	161	0.115

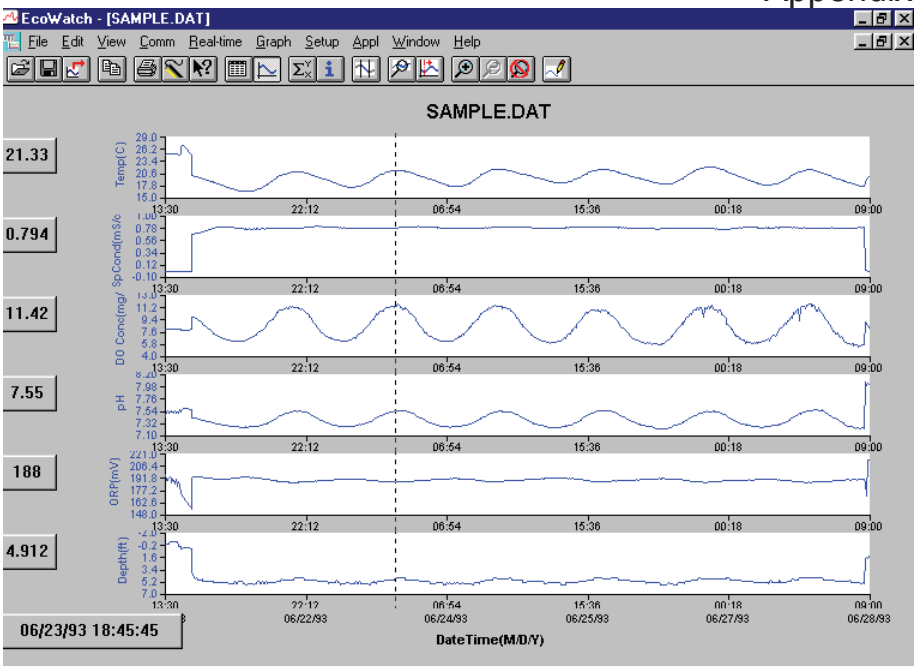
Now return to the original graphic display by toggling the **Table** button “off” and **Graph** button “on”.



From the **Setup** menu, click **Graph**. Click **2 Traces per Graph** and notice that the parameters are now graphed in pairs for easy comparison of parameters.

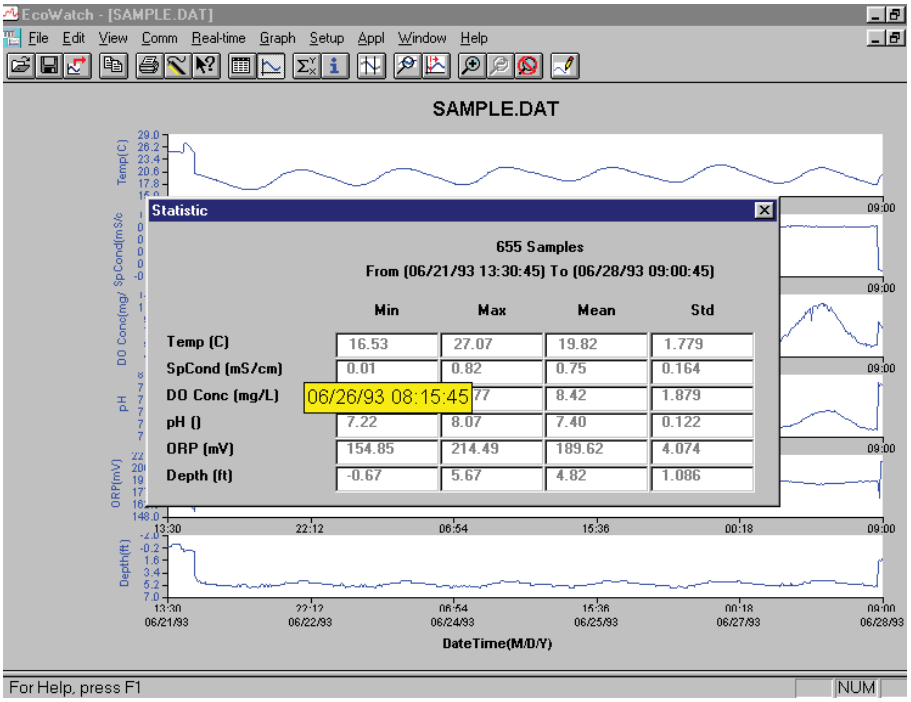


Click **1 Trace per Graph** to return the display to the original setting. Move the cursor to any position in the graph, then click and hold the right mouse button.



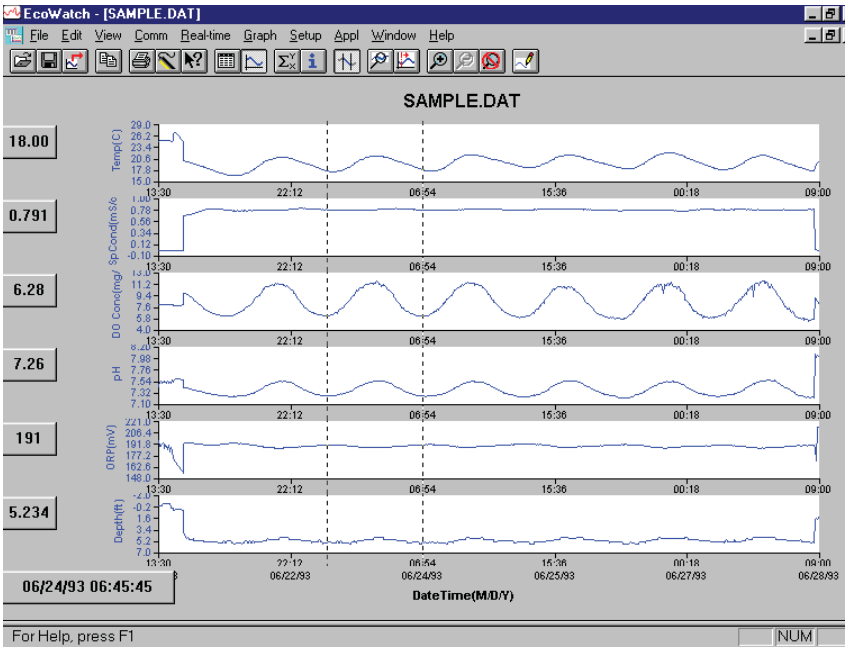
Note that the exact measurements for this point in time are displayed to the left of the graph. While holding down the right mouse button, move to another area on the graph. Notice how the measurements change as you move. When you release the mouse button, the display returns to normal.

To view statistical information for the study, click the **Statistics** button on the toolbar. On the statistics window, click on any min or max value to display the time when it occurred.

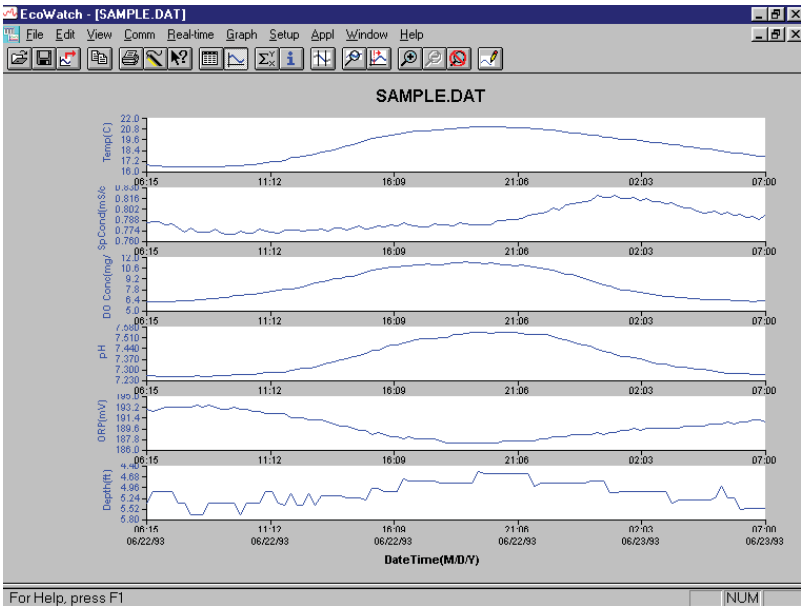


After viewing statistics, click the “x” at the upper right to close the window and return to the normal display.

Now click on the delimiter icon in the toolbar and then move the displayed icon to the graph. Click at the two points shown by dotted lines in the display below, being sure that the first click is to the left of the second.

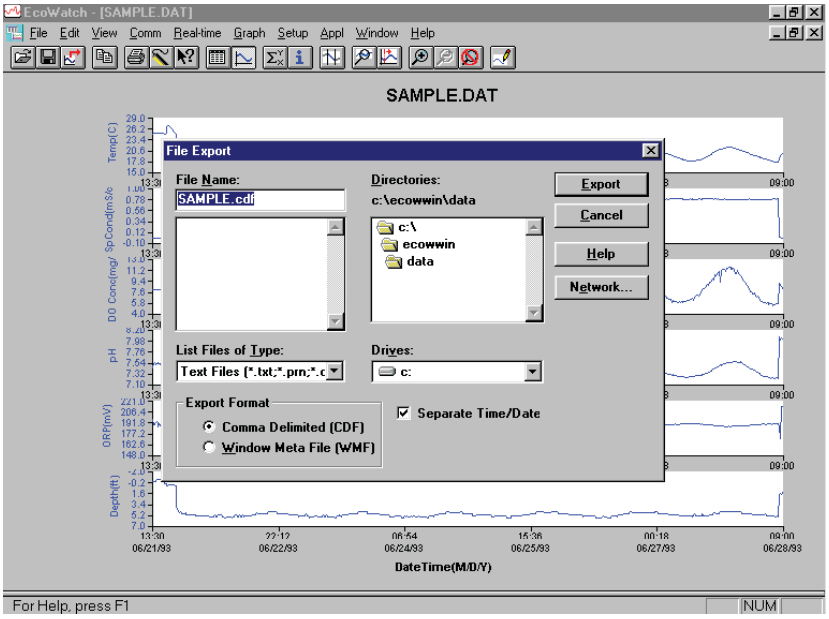


The data between the two selected points will then be graphed in higher resolution as shown below.

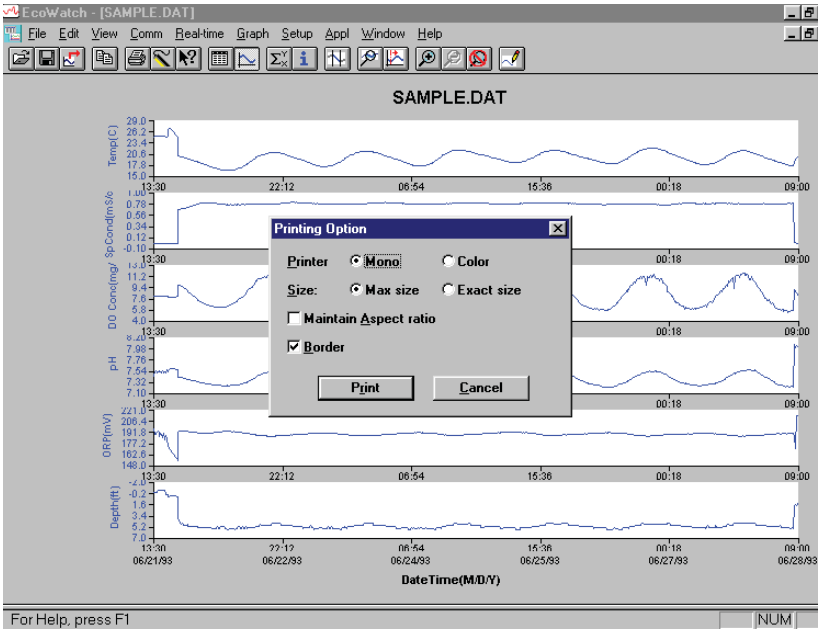


To return to the complete data set, select **Graph** from the toolbar and then click **Cancel Limits**.

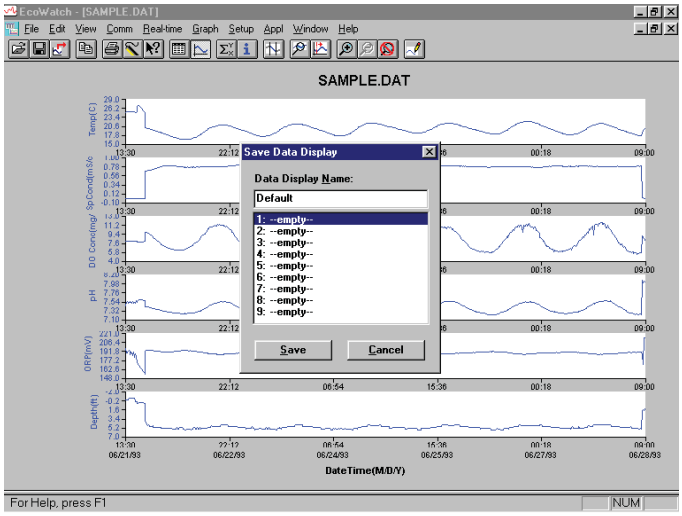
Now select the icon from the Toolbar to create a new data file which will allow your data to be imported into spreadsheets. Select the default export settings for a Comma Delimited File (.CDF) and click OK. A new spreadsheet-importable file (SAMPLE.CDF) is now present in the same folder as the SAMPLE.DAT file.



Now select the icon from the toolbar to print the plot. Accept the default settings and click OK to complete the printing operation.



Finally, end the tutorial by saving the **Data Display** in the format shown. From the **File** menu, click **Save Data Display**.



Then type "Default" for the file name and click **Save**. The parameters, colors, format, and x-axis time interval associated with the current display are now saved and can be accessed any time in the future. Nine different data displays may be saved for any data file. You can easily switch between various displays of the data. The data files can be accessed by clicking **Load Data Display** from the file menu and then selecting the desired presentation.

20.2.1 Summary of Toolbar Capability

The EcoWatch toolbar includes buttons for some of the most common commands in EcoWatch, such as **File Open**. To display or hide the toolbar, open the **View** menu and click on the **Toolbar** command. A check mark appears next to the menu item when the toolbar is displayed.

The toolbar is displayed across the top of the application window, below the menu bar.

Click To:

Open an existing data file (.DAT). EcoWatch displays the **Open** dialog box, in which you can locate and open the desired file.

Save the working Data Display of the active data file. EcoWatch displays the **Save Data Display** dialog box in which you can overwrite existing Data Display or save to a new one.

Export data as a graph in Window Meta File (.WMF) format or as data in Comma Delimited (.CDF) format.

Copy the whole graph page or data from the selection on the table to the clipboard.

Print the active graph page or table page depending on which one is currently active.

Open a new terminal window to communicate with the sonde.

Access context sensitive help (Shift+F1).

Toggle table window during file processing.

Toggle graph window during file processing.

Display study statistics.

Display study info.

Limit the data to be processed in a study.

Enlarge a selective portion of graph.

Center the graph under the cursor.

Enlarge graph or table 20%.

Reduce graph or table 20%.

Return graph or table to its normal state (unzoom)

Redraw the graph.

20.2.2 Other Capabilities

The above tutorial and function list for the toolbar provide basic information to allow you to view and analyze the field data which was stored in your 556 MPS. Some of the other commonly used capabilities of EcoWatch which the user may want to explore are listed below:

- Customize the units for each parameter, e.g., report uS/cm instead of mS/cm for conductivity.
- Customize the order of parameters in each plot or report.
- Customize the colors and fonts of each data display.
- Manually scale the y-axis sensitivity for each parameter.
- Merging of two or more data files with compatible parameter formats
- View information about the study such as number of points, instrument serial number, etc. which was stored in the 556 with the data.
- Print data reports in different statistical formats.
- Create plots of parameter vs. parameter rather than parameter vs. time.

These additional features of EcoWatch for Windows are explained in detail in the YSI 6-series manual (which can be downloaded at no cost from the YSI Web Site as described above) and the Help selection in the EcoWatch menubar. To purchase a hard copy of the 6-series manual, contact YSI Customer Service using the contact information in *Appendix E Customer Service*.

21. Appendix H Calibration Record Information

When your YSI 556 MPS sensors are initially calibrated, relevant information about the sensors will be stored in a separate file in the YSI 556 MPS memory.

NOTE: This file, by default, will have the name "556 Circuit Board Serial Number.glp." The circuit board serial number is assigned at the factory and has a hexadecimal format such as 000080A4. Thus the default calibration record file would be designated 00080A4.glp. Refer to Section *10.7 GLP Filename* to change the filename.

The information in the calibration record will track the sensor performance of your instrument and should be particularly useful for programs operating under Good Laboratory Practices (GLP) protocols.

21.1 Viewing the Calibration Record (.glp) File

NOTE: Make certain that you have performed a calibration on at least one of the sensors associated with your YSI 556 MPS.

1. Follow the procedures outlined in Section *8.3 View File*.

21.2 Uploading the Calibration Record (.glp) File

NOTE: Make certain that you have performed a calibration on at least one of the sensors associated with your YSI 556 MPS.

1. Follow the procedures outlined in Section *8.4 Upload to PC*.

21.3 Understanding the Calibration Record (.glp) File

1. Open a calibration record file. Refer to Section *8.3 View File*.

2. Use the arrow keys to scroll horizontally and/or vertically to view all the data.

00008003.glp

m/d/y	hh:mm:ss	S/N
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:25:40	00008003
01/24/2001	08:25:40	00008003

735.9mmHg

01/24/2001 08:39:53

Figure 21.1 Calibration Record Screen 1

00008003.glp

Type	Value
Conductivity gain	1.000000
DO gain	1.000000
pH gain (pH-7)*K/mV	-5.05833
pH offest (pH-7)*K	0.000000
ORP offset mV	0.000000
TDS constant	0.650000
Barometer offset PSI	0.000000
DO gain	1.110250
pH gain (pH-7)*K/mV	-5.05833
pH offest (pH-7)*K	-12.2899

735.9mmHg

01/24/2001 08:39:19

Figure 21.2 Calibration Record Screen 2

NOTE: Each sensor (not parameter) is characterized by either 1 line (Conductivity, Dissolved Oxygen, ORP, TDS, or Barometer (Optional)) or 2 lines (pH) of calibration documentation.

The left hand portion of each calibration entry shows the date and time that a calibration of a particular sensor was performed. In addition, each calibration entry is characterized by the instrument serial number, as defined by YSI. See Figure 21.1 Calibration Record Screen 1. The right hand portion shows the YSI designation of the calibration constants and their values after their calibration has been performed. A more detailed description of the calibration constants is provided below:

- **Conductivity Gain** – A relative number which describes the sensitivity of the sensor. Basically, the value represents the calculated cell constant divided by the typical value of the cell constant (5 cm^{-1}).

- **DO Gain** – A relative number which describes the sensitivity of the sensor. Basically, the value represents the sensor current at the time of calibration divided by the typical value of the sensor current (15 uA).

- **pH Gain** – A number which basically represents the sensitivity of the pH sensor. To remove the effect of temperature on the slope of the relationship of probe output in mv versus pH, the value of pH/mv is multiplied by the temperature in degrees Kelvin (K).

- **pH Offset** – A number which basically represents the offset (or intercept) of the relationship of probe output in mv versus pH, the value of pH is multiplied by the temperature in degrees Kelvin (K).

Anytime you perform a calibration, information concerning the calibration constants will be logged to the Calibration Record file (.glp file). However, if the **Delete All Files** command is used, Refer to Section *8.6 Delete All Files*, the Calibration Record file will also be lost. It is critical that this file should be uploaded to your PC prior to issuing a **Delete All Files** command. Refer to Section *8.4 Upload to PC*.

YSI *incorporated*

YSI Environmental
1700/1725 Brannum Lane
Yellow Springs, OH
45387 USA
937.767.7241
937.767.9353 fax
environmental@YSI.com

www.YSI.com

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STANDARD OPERATING PROCEDURE

Water-Level Measurements

I. Purpose and Scope

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

II. Equipment and Materials

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

III. Procedures and Guidelines

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

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

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

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

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

Where WL_c = Corrected water-level elevation

Wl_a = Apparent water-level elevation

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

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

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

IV. Attachments

None.

V. Key Checks

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

STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Monitoring well installations are planned for shallow and/or deep unconsolidated aquifers and/or for bedrock aquifers. The SOPs *Installation of Shallow Monitoring Wells, Installation of Surface-Cased Monitoring Wells, Installation of Bedrock Monitoring Wells,* and *Installation of Monitoring Wells Using Sonic Drilling* provide more specifics.

III. Equipment and Materials

1. Drilling rig (hollow stem auger, sonic, air hammer, air rotary, or mud rotary)
2. Well-construction materials (i.e., surface casing, screens, riser, casing, caps, bottom plugs, centering guides, sand, bentonite, grout, and surface-finish materials)
3. Development equipment

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double-cased.
2. The threaded connections will be water-tight.
3. Well screens generally will be constructed of 10-slot or 20-slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact slot size and length will be determined by the field team supervisor. Stainless-steel may be required under certain contaminant conditions.
4. Stick-up wells will be surrounded by four concrete-filled guard posts at least 2 inches in diameter.

5. A record of the finished well construction will be compiled.

6. All soils and liquids generated during well installations will be drummed for proper disposal.

Monitoring Well Installation

- 2″ monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.

- All monitoring wells penetrating a confining layer will be surface-cased from the ground surface to approximately 5 feet into the confining layer. Exceptions to this may be allowed under certain circumstances (e.g., evidence of significant natural gaps in the confining layer).

- Monitoring wells in unconsolidated materials will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, Schedule 40 PVC (or stainless-steel) screen with threaded bottom plug and riser.

- Screens will be filter packed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. For rotary-drilled wells, the height of the sand pack also will be sounded with a weighted tape.

- The primary filter sand pack (typically Morie #00 or DSI #1 for a 10-slot screen) will extend from 1 to 2 feet below the base of the well to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken. For wells deeper than 30 feet, the filter pack will be placed using a tremie pipe and flowing water.

Screen Size Opening (Inches)	Screen Size Slot Number	Typical Sand Pack Mesh Size (U.S. Standard Sieve Number)
0.005	5	100
0.010	10	20 to 40
0.020	20	10 to 20
0.030	30	10 to 20

- A secondary filter sand pack (typically a fine sand seal) 1-foot thick may be placed above the primary sand pack.

- Annular well seals will consist of 2 feet of pelletized, chip, or granular bentonite clay placed above the filter pack. If necessary, the pellets will be hydrated using potable water. For wells installed using hollow-stem augers, the bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. A

high-solids bentonite slurry using powdered bentonite introduced with a side-discharging tremie pipe will be used for the bentonite seals in wells greater than 30 feet deep. For rotary-drilled wells, the height of the well seal also will be sounded with a weighted tape. High-solids slurries will have solids content of at least 20 percent.

- The top of the annular seal will be measured after the bentonite seal has been allowed to hydrate and before the grout is applied. The seal will be allowed to hydrate for at least 30 minutes before work in the well continues.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage. A grout density scale is recommended for determining the correct density. See attached grout volume and weights chart for calculation of grout volume.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the top of the bentonite seal to ground surface.
- After allowing the grout to settle and set up overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and 3 feet below grade and will be painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- If information is available, begin developing in the least-contaminated well first.
- Development will include surging the well by either abruptly stopping flow and allowing water in the well column to fall back into the well or through the use of a surge block that is slightly smaller in diameter than the well casing inner diameter.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.

- The air-lift method may be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt. A Horiba-U22 meter, YSI meter with separate Hanna turbidity meter, or equivalent should be used to determine when the turbidity is low and parameters have stabilized.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums. CH2M HILL will label and date the drums as pending analysis and transport the drums to a designated site for storage.

V. Attachments

Grout Volume and Weights Chart

VI. Key Check and Items

- Ensure that all equipment is properly decontaminated as needed.
- Only new, sealed materials (e.g., screens, risers, and sand) will be used in constructing the well.
- Care shall be taken when making downhole measurements to ensure that proper heights of sand, seal, and grout are achieved.

Bentonite as % of cement weight	Density	Mixing water		Volume of Slurry
		gal/94 lb sack	ft^3/94 lb sack	ft^3/94 lb sack
2%	1.73	6.98	0.94	1.43
	1.77	6.53	0.88	1.37
	1.80	6.08	0.82	1.31
	1.84	5.63	0.76	1.25
	1.88	5.18	0.69	1.19
4%	1.63	8.79	1.18	1.68
	1.66	8.34	1.12	1.62
	1.68	7.89	1.06	1.56
	1.71	7.44	1.00	1.50
	1.74	6.98	0.94	1.44
7%	1.59	9.91	1.33	1.84
	1.61	9.46	1.27	1.78
	1.63	9.01	1.21	1.72
	1.65	8.56	1.15	1.66
	1.68	8.11	1.09	1.60
8%	1.53	11.72	1.57	2.10
	1.54	11.27	1.51	2.04
	1.56	10.81	1.45	1.98
	1.57	10.36	1.39	1.92
	1.59	9.91	1.33	1.86

No. of bags	Volume of cement		Weight of cement	Volume of water		Weight of water	Volume of Bentonite	Weight of Bentonite	Volume of Slurry		Slurry density
	gallons	ft3	lbs	gallons	ft3	lbs	ft3	lbs	gallons	ft3	lbs/gall.
1	3.59	0.48	94.00	6.53	0.87	54.39	0.01	1.88	10.70	1.43	14.69
1	3.59	0.48	94.00	6.53	0.87	54.39	0.01	1.88	10.25	1.37	14.69
1	3.59	0.48	94.00	6.08	0.81	50.65	0.01	1.88	9.80	1.31	14.99
1	3.59	0.48	94.00	5.63	0.75	46.90	0.01	1.88	9.35	1.25	15.31
1	3.59	0.48	94.00	5.63	0.75	46.90	0.01	1.88	8.90	1.19	15.31
1	3.59	0.48	94.00	8.79	1.17	73.22	0.02	3.76	12.57	1.68	13.59
1	3.59	0.48	94.00	8.34	1.11	69.47	0.02	3.76	12.12	1.62	13.78
1	3.59	0.48	94.00	7.80	1.04	64.97	0.02	3.76	11.67	1.56	14.04
1	3.59	0.48	94.00	7.44	0.99	61.98	0.02	3.76	11.22	1.50	14.22
1	3.59	0.48	94.00	6.98	0.93	58.14	0.02	3.76	10.77	1.44	14.48
1	3.59	0.48	94.00	9.80	1.31	81.63	0.04	6.58	13.77	1.84	13.27
1	3.59	0.48	94.00	9.46	1.26	78.80	0.04	6.58	13.32	1.78	13.40
1	3.59	0.48	94.00	9.10	1.21	75.80	0.04	6.58	12.87	1.72	13.54
1	3.59	0.48	94.00	8.56	1.14	71.30	0.04	6.58	12.42	1.66	13.76
1	3.59	0.48	94.00	8.11	1.08	67.56	0.04	6.58	11.97	1.60	13.97
1	3.59	0.48	94.00	11.72	1.56	97.63	0.05	7.52	15.71	2.10	12.69
1	3.59	0.48	94.00	11.27	1.50	93.88	0.05	7.52	15.26	2.04	12.82
1	3.59	0.48	94.00	10.81	1.44	90.05	0.05	7.52	14.81	1.98	12.96
1	3.59	0.48	94.00	10.36	1.38	86.30	0.05	7.52	14.36	1.92	13.10
1	3.59	0.48	94.00	9.91	1.32	82.55	0.05	7.52	13.91	1.86	13.26

Bags of cement	1		Weight of cement =	94.00 lbs
Volume of cemer	0.48	ft3	Weight of water =	64.97 lbs
Volume of water	7.8	gallons	Total weight =	158.97 lbs
Volume of water	1.04	ft3		
Total volume of slu	1.52	ft3	Slurry density	13.93 lbs/gall.

Bentonite as percent of cement	**Sacks of Cement**	**Volume of cement**		**Weight of cement**	**Volume of water**		**Weight of water**	**Weight of Bentonite**	**Volume of Bentonite**	**Volume of Slurry**		**Slurry density**	
		gallons	**ft3**	**lbs**	**gallons**	**ft3**	**lbs**	**lbs**	**ft3**	**gallons**	**ft3**	**lbs/gal.**	**SG**
4%	1	3.59	0.48	94	7.80	1.04	64.97	3.76	0.02	11.56	1.55	14.04	1.68
	2	7.18	0.96	188	15.60	2.08	129.95	7.52	0.05	23.12	3.09	14.04	1.68
	3	10.77	1.44	282	23.40	3.12	194.92	11.28	0.07	34.68	4.64	14.04	1.68
	4	14.36	1.92	376	31.20	4.17	259.90	15.04	0.10	46.25	6.18	14.04	1.68
	5	17.95	2.40	470	39.00	5.21	324.87	18.80	0.12	57.81	7.73	14.04	1.68
	6	21.55	2.88	564	46.80	6.25	389.84	22.56	0.15	69.37	9.27	14.04	1.68
	7	25.14	3.36	658	54.60	7.29	454.82	26.32	0.17	80.93	10.82	14.04	1.68
	8	28.73	3.84	752	62.40	8.33	519.79	30.08	0.19	92.49	12.36	14.04	1.68
	9	32.32	4.32	846	70.20	9.37	584.77	33.84	0.22	104.05	13.91	14.04	1.68
	10	35.91	4.80	940	78.00	10.41	649.74	37.60	0.24	115.61	15.45	14.04	1.68

STANDARD OPERATING PROCEDURE

Soil Sampling

I. Purpose and Scope

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

II. Equipment and Materials

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

III. Procedures and Guidelines

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

A. Surface and Shallow Subsurface Sampling

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

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

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

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

B. Split-Spoon Sampling

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

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

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

C. Thin-Walled Tube Sampling

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

IV. Attachments

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

ASTM D 1587 *Standard Practice for Thin-Walled Tube Sampling of Soils* (ASTM D1587.pdf)

V. Key Checks and Preventative Maintenance

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

Designation: D 1587 – 00 (Reapproved 2007)$^{\epsilon 1}$

Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

ϵ^1 NOTE—Editorial changes were made in June 2007.

1. Scope*

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.

NOTE 1—This practice does not apply to liners used within the samplers.

1.2 This Practice is limited to soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing gravel or larger size soil particles cemented or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (D 1586, D 3550, and D 6151). For information on appropriate use of other soil samplers refer to D 6169.

1.3 This practice is often used in conjunction with fluid rotary drilling (D 1452, D 5783) or hollow-stem augers (D 6151). Subsurface geotechnical explorations should be reported in accordance with practice (D 5434). This practice discusses some aspects of sample preservation after the sampling event. For information on preservation and transportation process of soil samples, consult Practice D 4220. This practice does not address environmental sampling; consult D 6169 and D 6232for information on sampling for environmental investigations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information purposes only. The tubing tolerances presented in Table 1 are from sources available in North America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 1452 Practice for Soil Investigation and Sampling by Auger Borings

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved May 1, 2007. Published July 2007. Originally approved in 1958. Last previous edition approved in 2003 as D 1587 – 03.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

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TABLE 1 Dimensional Tolerances for Thin-Walled Tubes

Nominal Tube Diameters from Table 2[A] Tolerances						
Size Outside Diameter	2 in.	50.8 mm	3 in.	76.2 mm	5 in.	127 mm
Outside diameter, D_o	+0.007	+0.179	+0.010	+0.254	+0.015	0.381
	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
Inside diameter, D_i	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
	-0.007	-0.179	-0.010	-0.254	-0.015	-0.381
Wall thickness	±0.007	±0.179	±0.010	±0.254	±0.015	±0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

[A] Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i, or D_o and Wall thickness, or D_i and Wall thickness.

as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6232 Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *inside clearance ratio, %, n*—the ratio of the difference in the inside diameter of the tube, D_i, minus the inside diameter of the cutting edge, D_e, to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.2 *ovality, n*—the cross section of the tube that deviates from a perfect circle.

4. Summary of Practice

4.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

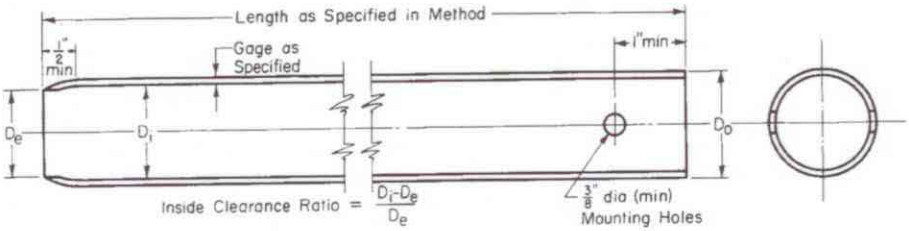
5. Significance and Use

5.1 This practice, or Practice D 3550 with thin wall shoe, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice. are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably



NOTE 1—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).

NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.

NOTE 3—Tube held with hardened screws or other suitable means.

NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalent Conversions

in.	mm
3/8	9.53
1/2	12.7
1	25.4
2	50.8
3	76.2
4	101.6
5	127

FIG. 1 Thin-Walled Tube for Sampling

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TABLE 2 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter (D_o):			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Inside clearance ratio, %	<1	<1	<1

[A] The three diameters recommended in Table 2 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

6.3 *Thin-Walled Tubes*, should be manufactured to the dimensions as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having adequate strength for the type of soil to be sampled. Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here.

6.3.1 *Length of Tubes*—See Table 2 and 7.4.1.

6.3.2 *Tolerances*, shall be within the limits shown in Table 1.

6.3.3 *Inside Clearance Ratio*, should be not greater than 1 % unless specified otherwise for the type of soil to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled, except for sensitive soils or where local experience indicates otherwise. See 3.2.1 and Fig. 1 for definition of inside clearance ratio.

6.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is to be extruded less than 3 days. The type of coating to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. Galvanized tubes are often used when long term storage is required. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, zinc oxide, and others.

NOTE 3—Most coating materials are not resistant to scratching by soils that contain sands. Consideration should be given for prompt testing of the sample because chemical reactions between the metal and the soil sample con occur with time.

6.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable check valve with the venting area to the outside equal to or greater than the area through the check valve. In some special cases, a check valve may not be required but venting is required to avoid sample compression. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 4—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1-ft (.03 m)

7.3.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.4 Advance the sampler without rotation by a continuous relatively rapid downward motion and record length of advancement to the nearest 1 in. (25 mm).

7.4.1 Determine the length of advance by the resistance and condition of the soil formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3-in. (75 mm) for sludge and end cuttings.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 2.

7.5 When the soil formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. The tube can be slowly rotated to shear the material at the end of the tube, and to relieve water and/or suction pressures and improve recovery. Where the soil formation is soft, a delay before withdraw of the sampler (typically 5 to 30 minutes) may improve sample recovery.

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube and measure the length of the soil

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sample recovered to the nearest 0.25 in. (5 mm) in the tube. Seal the upper end of the tube. Remove at least 1 in. (25 mm) of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

8.1.1 Tubes sealed over the ends, as opposed to those sealed with expanding packers, should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Depending on the requirements of the investigation, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination and classification of the sample. Samples are extruded in special hydraulic jacks equipped with properly sized platens to extrude the core in a continuous smooth speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (D 4220). Bent or damaged tubes should be cut off before extruding.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Assure that the markings or labels are adequate to survive transportation and storage.

NOTE 6—Top end of the tube should be labeled "top".

9. Field Log

9.1 Record the information that may be required for preparing field logs in general accordance to ASTM D 5434 "Guide for Field Logging of Subsurface Explorations of Soil and Rock". This guide is used for logging explorations by drilling and sampling. Some examples of the information required include;

9.1.1 Name and location of the project,

9.1.2 Boring number,

9.1.3 Log of the soil conditions,

9.1.4 Surface elevation or reference to a datum to the nearest foot (0.5 m) or better,

9.1.5 Location of the boring,

9.1.6 Method of making the borehole,

9.1.7 Name of the drilling foreman and company, and

9.1.8 Name of the drilling inspector(s).

9.1.9 Date and time of boring-start and finish,

9.1.10 Depth to groundwater level: date and time measured,

9.2 Recording the appropriate sampling information is required as follows:

9.2.1 Depth to top of sample to the nearest 0.1 ft. (.03 m) and number of sample,

9.2.2 Description of thin-walled tube sampler: size, type of metal, type of coating,

9.2.3 Method of sampler insertion: push or drive,

9.2.4 Method of drilling, size of hole, casing, and drilling fluid used,

9.2.5 Soil description in accordance with Practice D 2488,

9.2.6 Length of sampler advance (push), and

9.2.7 Recovery: length of sample obtained.

10. Keywords

10.1 geologic investigations; sampling; soil exploration; soil investigations; subsurface investigations; undisturbed

SUMMARY OF CHANGES

In accordance with committee D18 policy, this section identifies the location of changes to this standard since the last edition, 200, which may impact the use of this standard.

(1) Added parts of speech to terms.

(2) Corrected reference in Note 2 from D 5740 to D 3740.

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DRAFT FINAL STANDARD OPERATING PROCEDURE – NAVY CLEAN PROGRAM

Soil Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose

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

- A hand auger or other device that can be used to remove the soil from the ground. Stainless steel tools, carbon steel tools, or steel DPT tooling with acetate sleeves are preferred for PFAS sampling. Avoid any sampling materials containing PFAS (such as Teflon, Viton, PTFE, or other fluorinated compounds). Any plastic sampling materials should be evaluated thoroughly before selection to ensure they are fluorine-free.
- A stainless steel spatula or fluorine-free disposable plastic scoop should be used to remove material from the sampling device.
- Unpainted wooden stakes or pin flags
- Fiberglass measuring tape (at least 200 feet in length)
- GPS Unit
- PFAS-free labels (if available[1]) shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard (if using loose-leaf paper)
- Pen (not Sharpie)
- Personal protection equipment (rubber or latex gloves, boots, etc.). Check with your SME prior to selecting PPE to ensure there are no fluorine-containing components.
- Sample jars (sample jars should be made of high density polyethylene (HDPE) as glass jars may sorb PFAS, please notify the project manager [PM] if glass jars are provided by the lab). Sample containers should not contain Teflon lids.

[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.

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

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect soil samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton).

If a driller is supporting collection of soil samples in split spoons or acetate DPT sleeves, ensure the driller has not used and will not use drilling lube containing polytetrafluoroethylene (PTFE) or any other fluorine-containing substance. Biolube has been determined to be an acceptable substitute.

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- 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

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. Make sure to stake location after sample collection in case professional surveying is to be completed.

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

g. Or, a GPS unit can be used to identify each location based on map coordinates, 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. Make sure to stake location after sample collection in case professional surveying is to be completed.

e. Repeat 2a through 2d 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.

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 hand tools:

1. Use a decontaminated stainless steel scoop/trowel or disposable plastic scoop to scrape away surficial organic material (grass, leaves, etc.) adjacent to the stake. New disposable scoops or trowels may also be used to reduce the need for equipment blanks if the disposable scoops have been confirmed by your project PFAS subject matter expert (SME) to be PFAS free.

2. If sampling:

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

8. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.

9. Backfill the hole with soil removed from the borehole. To the extent possible, replace topsoil and grass and attempt to return appearance of sampling area to its pre-sampled condition. For samples in non-residential, unmowed areas, mark the sample number on the stake and leave stake in place. In mowed areas, remove stake.

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.

Equipment Decontamination

Whenever possible, use disposable equipment when collecting soil samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

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STANDARD OPERATING PROCEDURE

Direct-Push Soil Sample Collection

I. Purpose

To provide a general guideline for the collection of soil samples using direct-push (e.g., Geoprobe®) sampling methods.

II. Scope

Standard direct-push (e.g., Geoprobe®) soil sampling methods.

III. Equipment and Materials

- Truck-mounted hydraulic percussion hammer
- Sampling rods
- Sampling tubes and acetate liners
- Pre-cleaned sample containers and stainless-steel sampling implements
- Personal Protective Equipment as specified by the Health and Safety Plan

IV. Procedures and Guidelines

1. Decontaminate sampling tubes and other non-dedicated downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment*.

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, beginning with the containers for VOC analysis, using a decontaminated or dedicated sampling implement. For the VOC samples, place the sample into a pre-preserved VOA vial or direct sample container such as an **En Core®** or **Terra Core®** sampler and seal the cap tightly. Ideally, the operation should be completed in one minute. Label the vials 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*.

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. Key Checks and Items

1. Verify that the hydraulic percussion hammer is clean and in proper working order.

2. Ensure that the direct-push operator thoroughly completes the decontamination process between sampling locations.

3. Verify that the borehole made during sampling activities has been properly backfilled.

Surface Water Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose and Scope

This SOP provides guidelines for surface water sample collection for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with the most recent version of the Quality Systems Manual (QSM) for which the lab is certified at the time of analysis. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Materials and Equipment

Equipment and Materials Required

- Open tube sampler
- Dip sampler
- Weighted bottle sampler (no glass)
- Hand pump without Teflon components
- Van Dorn sampler (Kemmerer cannot be used as it has Teflon caps)
- Depth-integrating sampler
- Peristaltic pump and PFAS-free tubing
  - High density polyethylene tubing (unlined)
  - Masterflex tubing such as Cole Parmer C-Flex (06424 series) and Tygon E-3603 (06509 series) are suitable options
- Sample containers (high density polyethylene [HDPE] with HDPE screw cap [no Teflon caps])
- PFAS-free labels (if available[1]) and shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard
- Pen (not Sharpie)
- Nitrile or Latex gloves (Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine)

[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.

- Meters for specific conductance, temperature, pH, and dissolved oxygen

Equipment and materials used to collect surface water samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton). Neoprene and rubber waders should not be an issue, however, check with your PFAS subject matter expert (SME) during field preparation to ensure all equipment is free of fluorine-containing components.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect groundwater samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine.

Before surface water samples are taken, all sampler assemblies and sample containers are cleaned and decontaminated as described in SOP *Decontamination of Personnel and Equipment* as well as this SOP (see below). Surface water samples collected from water bodies tidally influenced should be collected at low tide and under low flow conditions to minimize the dilution of potential

contaminants. Once the area has been determined to be free of materials potentially containing PFAS, follow the methods for surface water sample collection described below.

Surface water samples are collected manually by submerging a clean stainless steel or polypropylene container into the water body. Samples may be collected at depth with a covered bottle that can be removed with a tripline provided the bottle or bottle cap does not contain Teflon. The most common sampler types are sealable bottles, pond samplers, peristaltic pumps, and weighted bottle samplers. Pond samplers have a fixed or telescoping pole attached to the sample container. Weighted bottle samplers are lowered below water surface, where the attached bottle is opened, allowed to fill, and pulled out of the water. When retrieved, the bottle is tightly capped and removed from the sampler assembly. A specific type of weighted bottle sampler is the Van Dorn and is acceptable in most instances. The Kemmerer weighted bottle sampler cannot be used for PFAS sampling due to the Teflon caps.

A sample is taken with the following specific steps:

1. The location and desired depth for water sampling are selected.
2. The sample site is approached from downstream in a manner that avoids disturbance of bottom sediments as much as possible. The sample bottle is gently submerged with the mouth pointed upstream and the bottle tilted slightly downstream. Bubbles and floating materials should be prevented from entering the bottle. If using a Peristaltic pump, lower the tubing into the water to the desired depth.
3. For weighted bottle samplers, the assembly is slowly lowered to the desired depth. The bottle stopper is unseated with a sharp tug and the bottle is allowed to fill until bubbles stop rising to the surface.
4. When the bottle is full, it is gently removed from the water. If sample transfer is required, it should be performed at this time. Fill all sample containers. Affix labels after sample containers are closed; collect only one sample at a time to avoid mislabeling.
5. Measure dissolved oxygen, specific conductance, temperature, and pH at the sampling location.

Equipment Decontamination

Whenever possible, use disposable equipment when collecting surface water samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

Use of Water Quality Equipment

Water quality meters typically do not contain PFAS. However, consistent with general sampling SOPs, disconnect the water quality meter prior to sampling.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

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

DRAFT FINAL NAVY CLEAN STANDARD OPERATING PROCEDURE

Sediment Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose and Scope

This SOP provides guidelines for sediment sample collection and handling for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with the most recent version of the Quality Systems Manual (QSM) for which the lab is certified at the time of analysis. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- Sample collection device (hand corer, scoop, dredge, grab sampler, or other suitable device). Check with your PFAS subject matter expert (SME) during field preparation to ensure all equipment is free of fluorine-containing components.
- Stainless steel spoon or spatula or fluorine-free plastic disposable scoop for media transfer
- Measuring tape
- GPS Unit
- PFAS-free labels (if available[1]) shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard (if using loose-leaf paper)
- Pen (not Sharpie)
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.). Check with your SME prior to selecting PPE to ensure there are no fluorine-containing components.
- Materials for classifying soils, particularly the percentage of fines
- Sample jars (high density polyethylene [HDPE] with HDPE screw cap [no Teflon caps])
- Laboratory prepared deionized, certified PFAS-free water for field blank collection

[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect soil samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine.

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

1. Field personnel will start downstream and work upstream to prevent contamination of unsampled areas. In surface water bodies that are tidally influenced, sampling will be performed at low tide and under low flow conditions to minimize the dilution of possible contaminants. Sediment sampling activities will not occur immediately after periods of heavy rainfall.

2. Make a sketch of the sample area that shows important nearby river features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features.

Also include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (along shore, mid-channel, etc).

3. Note in the field book any possible outside sources of contamination; for example, the outlet to a drainage culvert in the water body near your sampling location.

4. Transfer sample into appropriate sample jars with a stainless steel utensil or plastic disposable scoop confirmed to be fluorine-free. Be especially careful to avoid the loss of the very fine clay/silt particles when collecting the sample. The fine particles have a higher adsorption capacity than larger particles. Minimize the amount of water that is collected within the sample matrix. Decant the water off the sample slowly and carefully to maximize retention of the very fine particles. The sampler's fingers should never touch the sediment. Classify the soil type of the sample using the Unified Soil Classification System, noting particularly the percentage of silt and clay. Affix the sample label to the container after the container has been closed; collect only one sample at a time to avoid mislabeling.

5. Rocks and other debris should be removed before placement in jars.

6. For channel sampling, be on the alert for submerged hazards (rocks, tree roots, drop-offs, loess silt and muck) which can make wading difficult.

7. Immediately upon collection, all samples are to be placed in a closed container on ice. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.

Equipment Decontamination

Whenever possible, use disposable equipment when collecting sediment samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

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

STANDARD OPERATING PROCEDURE

Homogenization of Soil and Sediment Samples

I. Purpose

The homogenization of soil and sediment samples is performed to minimize any bias of sample representativeness introduced by the natural stratification of constituents within the sample.

II. Scope

Standard techniques for soil and sediment homogenization and equipment are provided in this SOP. These procedures do not apply to aliquots collected for VOCs or field GC screening; samples for these analyses should NOT be homogenized.

III. Equipment and Materials

Sample containers, stainless steel spoons or spatulas, stainless steel pans, disposable scoop/trowel, and dedicated sealable bag.

IV. Procedures and Guidelines

Soil and sediment samples to be analyzed for semivolatiles, pesticides, PCBs, metals, cyanide, or field XRF screening should be homogenized in the field. After a sample is taken, a stainless-steel spatula or disposable plastic scoop should be used to remove the sample from the split spoon or other sampling device. The sampler should not use fingers to do this, as gloves may introduce organic interferences into the sample.

Samples for VOCs should be taken immediately upon collection and should not be homogenized.

Prior to homogenizing the soil or sediment sample, any rocks, twigs, leaves, or other debris should be removed from the sample. The sample should be placed in a decontaminated stainless-steel pan and thoroughly mixed using a stainless-steel spoon or disposable plastic scoop. The soil or sediment material in the pan should be scraped from the sides, corners, and bottom, rolled into the middle of the pan, and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually, and then rolled to the center of the pan and mixed with the entire sample again.

Alternatively, the contents of the scoop/trowel can be placed into dedicated sealable bag. The contents should then be thoroughly mixed by kneading the bag, breaking up any clods.

All stainless-steel spoons, spatulas, and pans must be decontaminated following procedures specified in SOP *Decontamination of Personnel and Equipment* prior to homogenizing the sample. A composite equipment rinse blank of homogenization equipment should be taken each day it is used.

V. Attachments

None.

VI. Key Checks and Items

- Take VOC samples immediately and do not homogenize the soil.
- Homogenize soil for analyses other than VOCs in a clean, stainless-steel bowl or dedicated sealable bag.

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 the most recent version of the Quality Systems Manual (QSM) for which the lab is certified. This SOP should be used in conjunction with approved region-specific groundwater sampling SOPs which provide methods for general and low-flow groundwater sampling. In cases in which information in this SOP conflicts with region-specific groundwater sampling SOPs, this SOP will supersede the information in the general SOPs.

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program 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 and the Solinst Model 101 with the P2 meter 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.

STANDARD OPERATING PROCEDURE

Sampling Contents of Tanks and Drums

I. Scope and Application

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

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

II. Summary of Methods

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

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

III. Comments

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

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

any headspace gases is warranted. As a minimum, a preliminary check with a Multi RAE or equivalent may be of aid in selecting a sampling method.

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

IV. Required Equipment and Apparatus

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

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

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

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

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

V. Procedures

A. Drums

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

1. Drums will be sampled on an area-by-area basis. Drums will be sampled after they have been placed in overpack drums but before they are transferred from the excavation to the onsite storage area.

2. Record, in logbook, all pertinent information from visual inspection of drum (e.g., physical condition, leaks, bulges, and labels). Label each drum with a unique identifying number.

3. If possible, stage drums for easy access.

4. If necessary, attach ground strap to drums and grounding point.

5. Remove any standing material (water, etc.) from container top.

6. Using non-sparking tools, carefully remove the bung or lid while monitoring air quality with appropriate instruments. If necessary (and as a last resort), the non-sparking spike affixed to the backhoe can also be used to puncture the drum for sampling. See Attachment D for method of drum opening. Record air-quality monitoring results.

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

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

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

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

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

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

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

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

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

B. Underground Storage Tanks

1. A sampling team of at least two people is required for sampling—one will collect samples, the other will relay required equipment and implements.

2. Sampling team will locate a sampling port on the tank. Personnel should be wearing appropriate protective clothing at this time and carrying sampling gear.

3. Do not attempt to climb down into tank. Sampling MUST BE accomplished from the top.

4. Collect a sample from the upper, middle, and lower section of the tank contents with one of the recommended sampling devices.

5. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.

6. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

C. Tank Trailers or Above-Ground Storage Tanks

1. A sampling team of two is required. One will collect samples, the other will relay required equipment and implements.

2. Samples will be collected through the manhole (hatch) on top of the tanker or the fill port. Do not open valves at the bottom. Before opening the hatch, check for a pressure gauge or release valve. Open the release valve slowly to bring the tank to atmospheric pressure.

3. If tank pressure is too great, or venting releases large amounts of toxic gas, discontinue venting and sampling immediately. Measure vented gas with organic vapor analyzer and explosimeter.

4. If no release valve exists, slowly loosen hatch cover bolts to relieve pressure in the tank. (Again, stop if pressure is too great.)

5. Once pressure in tank has been relieved, open the hatch and withdraw sample using one of the recommended sampling devices.

6. Sample each trailer compartment.

7. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.

8. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

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

<u>Drum</u>

Glass tube — Procedure 1

COLIWASA	–	Procedure 2

Storage Tank and Tank Trailer

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

VI. Contamination Control

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

VIII. Attachments

A. Collection of Liquid-Containerized Wastes Using Glass Tubes

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

C. Sampling Containerized Wastes Using the Bacon Bomb Sampler

D. Gravity Corer for sampling Sludges in Large Containers

E. Construction of a Typical COLIWASA

F. Drum Opening Techniques and Equipment

IX. References

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

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

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

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

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

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

X. Field Checklist

_____ Sampling Instruments

_____ Tools

_____ Rubber Mallet

_____ Logbook

_____ Safety Glasses or Monogoggles

_____ Safety Shoes

_____ Ice/Cooler, as required

_____ Custody Seals, as required

_____ Chain-of-Custody Forms

_____ Drum Labels, as required

_____ Paint Marker, if drum sampling

_____ Black Indelible Pen

_____ Monitoring Instruments

_____ Labels

_____ Sampling and Analysis Plan

_____ Health and Safety Plan

_____ Decontamination Equipment

_____ Lab Wipes

_____ Lab Spatulas or Stainless Steel Spoons

_____ Chemical Preservatives, as required

_____ Appropriate Containers for Waste and Equipment

_____ Duct Tape

_____ Plastic Sheeting

Attachment A Collection of Liquid-Containerized Wastes Using Glass Tubes

Discussion

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

Uses

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

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

Procedures for Use

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

Optional Method (if sample of bottom sludge is desired)

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

Note:

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

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

Discussion

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

Uses

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

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

Procedures for Use

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

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

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

4. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

5. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a laboratory wipe with the other hand. A phase boundary, if present, can be observed through the tube.

6. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

7. Unscrew the T-handle of the sampler and disengage the locking block.

Attachment C: Sampling Containerized Wastes using the Bacon Bomb Sampler

Discussion

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

Uses

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

Procedures for Use

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

Attachment D: Gravity Corer for Sampling Sludges in Large Containers

Discussion

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

Uses

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

Procedures for Use

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

Attachment E: Construction of a Typical COLIWASA

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

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

The sampler is assembled as follows:

a. Attach the swivel to the T-handle with the 3.18-cm (1-1/4 in) long bolt and secure with the 0.48-cm (3/16-in) National Coarse (NC) washer and lock nut.

b. Attach the PFTE stopper to one end of the stopper rod and secure with the 0.95-cm (3/8-in) washer and lock nut.

c. Install the stopper and stopper rod assembly in the sampling tube.

d. Secure the locking block sleeve on the block with glue or screw. This block can also be fashioned by shaping a solid plastic rod on a lathe to the required dimension.

e. Position the locking block on top of the sampling tube such that the sleeveless portion of the block fits inside the tube, the sleeve sits against the top end of the tube, and the upper end of the stopper rod slips though the center hole of the block.

f. Attach the upper end of the stopper rod to the swivel of the T-handle.

g. Place the sampler in the close position and adjust the tension on the stopper by screwing the T-handle in or out.

Attachment F: Drum Opening Techniques and Equipment [1]

I. Introduction

The opening of closed drums prior to sampling entails considerable risk if not done with the proper techniques, tools, and safety equipment. The potential for vapor exposure, skin exposure due to splash or spraying, or even explosion resulting from sparks produced by friction of the tools against the drum, necessitate caution when opening any closed container. Both manual drum opening and remote drum opening will be discussed in the following paragraphs. When drums are opened manually risks are greater than when opened remotely; for this reason, the remote opening of drums is advised whenever possible.

Prior to sampling, the drums should be staged to allow easy access. Also, any standing water or other material should be removed from the container top so that the representative nature of the sample is not compromised when the container is opened. There is also the possibility of encountering a water-reactive substance.

II. Manual Drum Opening

A. Bung Wrench

A common method for opening drums manually is using a universal bung wrench. These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium (a non-sparking alloy formulated to reduce the likelihood of sparks). The use of bung wrenches marked "NON SPARKING" is encouraged. However, the use of a "NON SPARKING" wrench does not completely eliminate the possibility of spark being produced. Such a wrench only prevents a spark caused by wrench-to-bung friction, but it cannot prevent sparking between the threads on the drum and the bung.

A simple tool to use, the fitting on the bung wrench matching the bung to be removed is inserted into the bung and the tool is turned counterclockwise to remove the bung. Since the contents of some drums may be under pressure (especially, when the ambient temperature is high), the bung should be turned very slowly. If any hissing is heard, the person opening the drum should back off and wait for the hissing to stop. Since drums under pressure can spray out liquids when opened, the wearing of appropriate eye and skin protection in addition to respiratory protection is critical.

B. Drum Deheader

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way

[1] Taken from EPA Training Course: "Sampling for Hazardous Materials," U.S. Environmental Protection Agency, Office of Emergency and Remedial Response Support Division, March 24, 1987.

off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums (i.e., DOT Specification 17E and 17F drums); drums with removable heads must be opened by other means.

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off if so desired. If the top chime of a drum has been damaged or badly dented it may not be possible to cut the entire top off. Since there is always the possibility that a drum may be under pressure, the initial cut should be made very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote pressure release method prior to using the deheader.

C. Hand Pick or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, then it can be opened for sampling by using a hand pick, pickaxe, or spike. These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available, whereas the spikes are generally uniquely fabricated 4- foot long poles with a pointed end. Often the drum lid or head must be hit with a great deal of force in order to penetrate it. Because of this, the potential for splash or spraying is greater than with other opening methods and therefore this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes used for drum opening have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

Since drums, some of which may be under pressure, cannot be opened slowly with these tools, “sprayers” may result and appropriate safety measures must be taken. The pick or spike should be decontaminated after each drum is opened to avoid cross contamination and/or adverse chemical reaction from incompatible materials.

III. Remote Opening

A. Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

Drums should be “staged,” or placed in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with the spike.

The spike should be decontaminated after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is

used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This, combined with the normal sampling safety gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system. The hole in the drum can be sealed with a cork.

B. Hydraulic Devices

Recently, remotely operated hydraulic devices have been fabricated to open drums remotely. One such device is discussed here. This device uses hydraulic pressure to pierce through the wall of a drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line. A piercing device with a metal point is attached to the end of this line and is pushed into the drum by the hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head/lid of the drum. Some of the metal piercers are hollow or tube-like so that they can be left in place, if desired, and serve as a permanent tap or sampling port. The piercer is designed to establish a tight seal after penetrating the container.

C. Pneumatic Devices

Pneumatically-operated devices utilizing compressed air have been designed to remove drum bungs remotely. A pneumatic bung remover consists of a compressed air supply (usually SCBA cylinders) that is controlled by a heavy-duty, 2-stage regulator. A high pressure air line of desired length delivers compressed air to a pneumatic drill that is adapted to turn a bung fitting (preferably, a bronze-beryllium alloy) selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This attachment and removal procedure is time- consuming and is the major drawback of this device. This remote bung opener does not permit the slow venting of the container, and therefore appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device.

IV. Summary

The opening of closed containers is one of the most hazardous site activities. Maximum efforts would be made to ensure the safety of the sampling team. Proper protective equipment and a general wariness of the possible dangers will minimize the risk inherent to sampling operations. Employing proper drum opening techniques and equipment will also safeguard personnel. The use of remote sampling equipment whenever feasible is highly recommended.

STANDARD OPERATING PROCEDURE – Navy CLEAN PROGRAM

Management of Liquid Waste Containing Per- and Polyfluoroalkyl Substances (PFAS)

I. Purpose and Scope

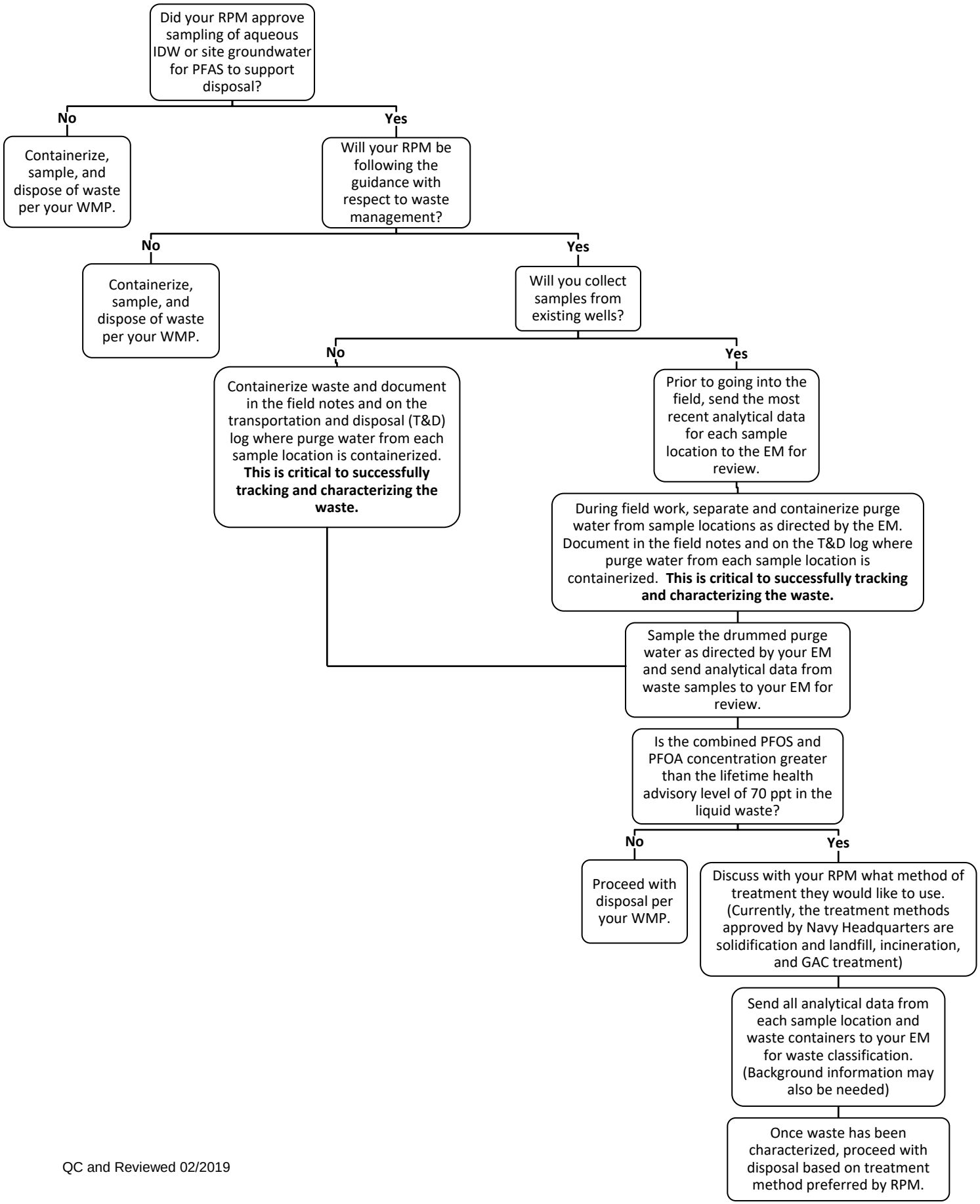
This SOP provides guidelines for managing waste containing per- and polyfluoalklyl substances (PFAS) in accordance with the *Interim Per- and Polyfluoralkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update* (guidance). This SOP should be used in conjunction 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.



QC and Reviewed 02/2019

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

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

II. Scope

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

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

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

III. Equipment and Materials

- Coolers
- Clear tape
- Strapping tape
- Contractor bags
- Absorbent pads or equivalent
- Resealable bags
- Bubble bags (for glass bottle ware)
- Bubble wrap (if needed)
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

A. Prepare coolers for shipment:

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

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

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

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

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

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

G. Fill remaining spaces with bubble wrap if needed.

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

J Close lid and latch.

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

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

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

Medium- and High-Concentration Samples:

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

V. Attachments

None.

VI. Key Checks and Items

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

From: Cook, Laura/VBO
Sent: Thursday, July 19, 2018 2:31 PM
To: Navy Clean Members
Subject: Changes to PFAS SOPs
Attachments: https__www.denix.osd.pdf

CLEAN Team,

In accordance with the attached guidance we received from the Navy, I have updated the PFAS SOPs to reflect sample collection into HDPE bottleware with the exception of drinking water, which will still be collected into polypropylene bottles. The revised SOPs are saved here:

\\orion\Proj\CLEANII\SOPS\1 - MASTER\PFAS SOPs\Updated July_19_2018

Please update any SAP attachments and fieldwork approaches accordingly.

The IDW SOP was also changed today to correct a typographical error.

Please let me know if you have questions.

Laura J Cook, PG*, LEED GA
CH2M is now a Jacobs Company
Senior Hydrogeologist
757.671-6214
Laura.Cook1@jacobs.com

www.jacobs.com

*Licensed in Virginia and Washington

Upcoming Vacation: August 24th through September 3rd, October 30th and 31st

Appendix D
Laboratory DoD ELAP Accreditation Letters

PERRY JOHNSON LABORATORY ACCREDITATION, INC.

Certificate of Accreditation

Perry Johnson Laboratory Accreditation, Inc. has assessed the Laboratory of:

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061

(Hereinafter called the Organization) and hereby declares that Organization has met the requirements of ISO/IEC 17025:2017 "General Requirements for the competence of Testing and Calibration Laboratories" and the DoD Quality Systems Manual for Environmental Laboratories Version 5.3 February 2018 and is accredited is accordance with the:

United States Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP)

This accreditation demonstrates technical competence for the defined scope:

Environmental Testing

(As detailed in the supplement)

Accreditation claims for such testing and/or calibration services shall only be made from addresses referenced within this certificate. This Accreditation is granted subject to the system rules governing the Accreditation referred to above, and the Organization hereby covenants with the Accreditation body's duty to observe and comply with the said rules.

For PJLA:

Initial Accreditation Date:	*Issue Date:*	*Expiration Date:*
November 17, 2016	December 20, 2018	February 28, 2021
Revision Date:	*Accreditation No.:*	*Certificate No.:*
July 17, 2020	91667	L18-588-R4

Tracy Szerszen
President

Perry Johnson Laboratory Accreditation, Inc. (PJLA)
755 W. Big Beaver, Suite 1325
Troy, Michigan 48084

The validity of this certificate is maintained through ongoing assessments based on a continuous accreditation cycle. The validity of this certificate should be confirmed through the PJLA website: www.pjlabs.com

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle
141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Drinking Water	EPA 537.1	LC/MS/MS	4,8-dioxa-3H-perfluorononanoic acid (ADONA)
Drinking Water	EPA 537.1	LC/MS/MS	9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)
Drinking Water	EPA 537.1	LC/MS/MS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)
Drinking Water	EPA 537.1	LC/MS/MS	Hexafluoropropylene oxide dimer acid (HFPO-DA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-hexanoic acid (PFHxA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-heptanoic Acid (PFHpA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-octanoic Acid (PFOA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluorononanoic acid (PFNA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-decanoic Acid (PFDA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-undecanoic acid (PFUnA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-dodecanoic acid (PFDoA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-tridecanoic acid (PFTrDA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-tetradecanoic acid (PFTeDA)
Drinking Water	EPA 537.1	LC/MS/MS	N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)
Drinking Water	EPA 537.1	LC/MS/MS	N-ethylperfluoro-octanesulfonamidoacetic acid (NEtFOSAA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-1-butanesulfonic Acid (PFBS)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-1-hexanesulfonic Acid (PFHxS)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-1-octanesulphonic Acid (PFOS)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	3-Perfluoropropyl propanoic Acid (3:3 FTCA)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	3-Perfluoropropyl propanoic acid (5:3 FTCA)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	3-Perfluoropropyl propanoic acid (7:3 FTCA)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-octanesulfonamide (PFOSA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	4,8-dioxa-3H-perfluorononanoic acid (Adona)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9CI-PF3ONS)

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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/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11CI-PF3OUdS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Hexafluoropropylene oxide dimer acid (HFPO-DA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Sodium perfluoro-1-pentanesulfonate (PFPeS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-nonanesulfonate (PFNS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-heptanesulfonate (PFHpS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	N-ethylperfluoro-octanesulfonamidoacetic acid (NEtFOSAA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorohexane sulfonate (4:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorooctane sulfonate (6:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorodecane sulfonate (8:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-butanoic Acid (PFBA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-pentanoic acid (PFPeA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-hexanoic acid (PFHxA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-heptanoic Acid (PFHpA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-octanoic Acid (PFOA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluorononanoic acid (PFNA)

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-decanoic Acid (PFDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-undecanoic acid (PFUnA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-dodecanoic acid (PFDoA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-tridecanoic acid (PFTrDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-n-tetradecanoic acid (PFTeDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-butanesulfonic Acid (PFBS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-hexanesulfonic Acid (PFHxS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-octanesulphonic Acid (PFOS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15	LC/MS/MS	Perfluoro-1-decanesulfonate (PFDS)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,3',4,5-Hexachlorobiphenyl (BZ 129)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',6,6'-Heptachlorobiphen yl (BZ 184)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,5'-Tetrachlorobiphenyl (BZ 49)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',5-Trichlorobiphenyl (BZ 18)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3,3',4,4'-Pentachlorobiphenyl (BZ 105)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3',4,4',5-Pentachlorobiphenyl (BZ 118)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4,4'-Trichlorobiphenyl (BZ 28)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDD
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDE
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDT
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-Dichlorobiphenyl (BZ 8)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4',5,5'-Hexachlorobiphenyl (BZ 169)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4',5-Pentachlorobiphenyl (BZ 126)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4'-Tetrachlorobiphenyl (BZ 77)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDD
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDE
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDT
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Aldrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	alpha-BHC (alpha-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	alpha-Chlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	beta-BHC (beta-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Chlorpyrifos
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	cis-Nonachlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Decachlorobiphenyl (BZ 209)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	delta-BHC
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Dieldrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan II
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan I
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan sulfate
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin aldehyde
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin ketone
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	gamma-Chlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Heptachlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Heptachlor epoxide
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Hexachlorobenzene

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Methoxychlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Mirex
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Oxychlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	trans-Nonachlor
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	1,4-Dichlorobenzene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	1-Methylnaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	1-Methylphenanthrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (BZ 206)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5,5'-Octachlorobiphenyl (BZ 194)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl (BZ 207)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5,6-Octachlorobiphenyl (BZ 195)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',5-Heptachlorobiphenyl (BZ 170)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',6,6'-Octachlorobiphenyl (BZ 197)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4',6-Heptachlorobiphenyl (BZ 171)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (BZ 208)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,5',6-Octachlorobiphenyl (BZ 198)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,5',6'-Octachlorobiphenyl (BZ 199)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,5'-Heptachlorobiphenyl (BZ 172)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,6,6'-Octachlorobiphenyl (BZ 200)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5',6,6'-Octachlorobiphenyl (BZ 201)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,6-Heptachlorobiphenyl (BZ 173)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5,6'-Heptachlorobiphenyl (BZ 174)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5',6-Heptachlorobiphenyl (BZ 175)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5',6'-Heptachlorobiphenyl (BZ 177)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,5'-Hexachlorobiphenyl (BZ 130)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,6,6'-Heptachlorobiphenyl (BZ 176)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4,6-Hexachlorobiphenyl (BZ 131)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',4-Pentachlorobiphenyl (BZ 82)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,5',6,6'-Octachlorobiphenyl (BZ 202)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,5',6-Heptachlorobiphenyl (BZ 178)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,6,6'-Heptachlorobiphenyl (BZ 179)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,6-Hexachlorobiphenyl (BZ 134)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5,6'-Hexachlorobiphenyl (BZ 135)

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',5-Pentachlorobiphenyl (BZ 83)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',6,6'-Hexachlorobiphenyl (BZ 136)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3',6-Pentachlorobiphenyl (BZ 84)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,3'-Tetrachlorobiphenyl (BZ 40)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5,5',6-Octachlorobiphenyl (BZ 203)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5-Hexachlorobiphenyl (BZ 137)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',6,6'-Heptachlorobiphenyl (BZ 184)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',6-Hexachlorobiphenyl (BZ 139)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4',6'-Hexachlorobiphenyl (BZ 140)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,4'-Pentachlorobiphenyl (BZ 85)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,5,5',6-Heptachlorobiphenyl (BZ 185)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,5,5'-Hexachlorobiphenyl (BZ 141)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5,5'-Hexachlorobiphenyl (BZ 146)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5,6,6'-Heptachlorobiphenyl (BZ 188)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5',6-Hexachlorobiphenyl (BZ 149)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,5',6-Hexachlorobiphenyl (BZ 144)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',5'-Pentachlorobiphenyl (BZ 97)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4',6-Pentachlorobiphenyl (BZ 91)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4-Tetrachlorobiphenyl (BZ 41)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,4'-Tetrachlorobiphenyl (BZ 42)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5,5',6-Hexachlorobiphenyl (BZ 151)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5,5'-Pentachlorobiphenyl (BZ 92)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5',6-Pentachlorobiphenyl (BZ 95)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5-Tetrachlorobiphenyl (BZ 43)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,6'-Tetrachlorobiphenyl (BZ 46)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3,6-Tetrachlorobiphenyl (BZ 45)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',3-Trichlorobiphenyl (BZ 16)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',5,6'-Hexachlorobiphenyl (BZ 154)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',5-Pentachlorobiphenyl (BZ 99)

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',6,6'-Hexachlorobiphenyl (BZ 155)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4',6-Pentachlorobiphenyl (BZ 100)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,4'-Tetrachlorobiphenyl (BZ 47)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,5-Tetrachlorobiphenyl (BZ 48)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,5'-Tetrachlorobiphenyl (BZ 49)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,6,6'-Pentachlorobiphenyl (BZ 104)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,6'-Tetrachlorobiphenyl (BZ 51)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4,6-Tetrachlorobiphenyl (BZ 50)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',4-Trichlorobiphenyl (BZ 17)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',5,6'-Tetrachlorobiphenyl (BZ 53)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',5-Trichlorobiphenyl (BZ 18)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',6,6'-Tetrachlorobiphenyl (BZ 54)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2',6-Trichlorobiphenyl (BZ 19)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,2'-Dichlorobiphenyl (BZ 4)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5,5',6-Octachlorobiphenyl (BZ 205)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5,5'-Heptachlorobiphenyl (BZ 189)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5,6-Heptachlorobiphenyl (BZ 190)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5',6-Heptachlorobiphenyl (BZ 191)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5-Hexachlorobiphenyl (BZ 156)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',5'-Hexachlorobiphenyl (BZ 157)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4',6-Hexachlorobiphenyl (BZ 158)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4,4'-Pentachlorobiphenyl (BZ 105)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4',5,5',6-Heptachlorobiphenyl (BZ 193)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4',5,6-Hexachlorobiphenyl (BZ 163)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4',5',6-Hexachlorobiphenyl (BZ 164)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,3',4'-Tetrachlorobiphenyl (BZ 56)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,4',5,5'-Hexachlorobiphenyl (BZ 167)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4,4',5,6-Hexachlorobiphenyl (BZ 166)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4,4',5-Pentachlorobiphenyl (BZ 114)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,4',5-Pentachlorobiphenyl (BZ 118)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,4',5'-Pentachlorobiphenyl (BZ 123)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4,4',6-Pentachlorobiphenyl (BZ 115)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4,4'-Tetrachlorobiphenyl (BZ 60)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle
141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4',5,5'-Pentachlorobiphenyl (BZ 124)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4',5',6-Pentachlorobiphenyl (BZ 125)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4',5-Tetrachlorobiphenyl (BZ 63)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4,5-Tetrachlorobiphenyl (BZ 67)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4',5-Tetrachlorobiphenyl (BZ 70)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4',6-Tetrachlorobiphenyl (BZ 64)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4',6-Tetrachlorobiphenyl (BZ 71)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,4'-Trichlorobiphenyl (BZ 22)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4-Trichlorobiphenyl (BZ 25)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',4'-Trichlorobiphenyl (BZ 33)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',5-Trichlorobiphenyl (BZ 26)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,5-Trimethylnaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3,6-Trichlorobiphenyl (BZ 24)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3',6-Trichlorobiphenyl (BZ 27)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3-Dichlorobiphenyl (BZ 5)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,3'-Dichlorobiphenyl (BZ 6)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,4',5-Tetrachlorobiphenyl (BZ 74)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,4',6-Tetrachlorobiphenyl (BZ 75)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,4'-Trichlorobiphenyl (BZ 28)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,5-Trichlorobiphenyl (BZ 29)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4',5-Trichlorobiphenyl (BZ 31)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4,6-Trichlorobiphenyl (BZ 30)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4',6-Trichlorobiphenyl (BZ 32)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4'-DDD
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4'-DDE
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4'-DDT
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4-Dichlorobiphenyl (BZ 7)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,4'-Dichlorobiphenyl (BZ 8)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,5-Dichlorobiphenyl (BZ 9)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2,6-Dimethylnaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2-Chlorobiphenyl (BZ 1)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2-Chloronaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2-Methylnaphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	2-Methylphenanthrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',4,4',5,5'-Hexachlorobiphenyl (BZ 169)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle
141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',4,4',5-Pentachlorobiphenyl (BZ 126)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',4,4'-Tetrachlorobiphenyl (BZ 77)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',4,5,5'-Pentachlorobiphenyl (BZ 127)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3',5,5'-Tetrachlorobiphenyl (BZ 80)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,3'-Dichlorobiphenyl (BZ 11)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,4,4',5-Tetrachlorobiphenyl (BZ 81)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,4,4'-Trichlorobiphenyl (BZ 37)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,4-Dichlorobiphenyl (BZ 12)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,4'-Dichlorobiphenyl (BZ 13)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	3,6-Dimethylphenanthrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	4,4'-Dichlorobiphenyl (BZ 15)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	4-Chlorobiphenyl (BZ 3)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Acenaphthene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Acenaphthylene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Anthracene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(a)anthracene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(a)pyrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(b)fluoranthene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(b)thiophene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(e)pyrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(g,h,i)perylene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Benzo(k)fluoranthene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Biphenyl
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Chrysene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	cis-Decalin
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Decachlorobiphenyl (BZ 209)
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Dibenz(a,h)anthracene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Dibenzofuran
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Dibenzothiophene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Fluoranthene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Fluorene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	lndeno(l,2,3-cd)pyrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Naphthalene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Perylene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Phenanthrene
Aqueous/Solid/Tissue	EPA 8270E MOD	GC-MS	Pyrene

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Battelle
141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270DE MOD	GC-MS	trans-Decalin
Aqueous	EPA 3510 C	Separatory Funnel	Prep
Aqueous	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Aqueous	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Solid	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Solid	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Solid	NOAA NOS ORCA 71	Orbital Shaker	Prep
Tissue	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Tissue	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Tissue	NOAA NOS ORCA 71	Tissuemizer	Prep

PERRY JOHNSON LABORATORY ACCREDITATION, INC.

Certificate of Accreditation

Perry Johnson Laboratory Accreditation, Inc. has assessed the Laboratory of:

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216

(Hereinafter called the Organization) and hereby declares that Organization has met the requirements of ISO/IEC 17025:2017 "General Requirements for the competence of Testing and Calibration Laboratories" and the DoD Quality Systems Manual for Environmental Laboratories Version 5.3 May 2019 and is accredited is accordance with the:

United States Department of Defense
Environmental Laboratory Accreditation Program
(DoD-ELAP)

This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (as outlined by the joint ISO-ILAC-IAF Communiqué dated April 2017):

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:*
March 7, 2019	August 9, 2019	August 9, 2021
Revision Date:	*Accreditation No.:*	*Certificate No.:*
July 6, 2020	104509	L19-405-R1

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 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck, Jesse Shuck, Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 150.1	Electrode	pH
Aqueous	EPA 160.1 / SM 2540C	Gravimetric	Total Dissolve Solids (TDS)
Aqueous	EPA 160.2 / SM 2540D	Gravimetric	Total Suspended Solids (TSS)
Aqueous	EPA 160.3 / SM 2540B	Gravimetric	Total Solids (TS)
Aqueous	EPA 1631E	CVAFS	Low Level Mercury
Aqueous	EPA 1650C	Coulometry	Absorbable Organic Halides (AOX)
Aqueous	EPA 1664B	Gravimetric	Oil & Grease
Aqueous	EPA 180.1	Turbidimeter	Turbidity
Aqueous	EPA 200.7	ICP-OES	Aluminum
Aqueous	EPA 200.7	ICP-OES	Antimony
Aqueous	EPA 200.7	ICP-OES	Arsenic
Aqueous	EPA 200.7	ICP-OES	Barium
Aqueous	EPA 200.7	ICP-OES	Beryllium
Aqueous	EPA 200.7	ICP-OES	Boron
Aqueous	EPA 200.7	ICP-OES	Cadmium
Aqueous	EPA 200.7	ICP-OES	Calcium
Aqueous	EPA 200.7	ICP-OES	Chromium
Aqueous	EPA 200.7	ICP-OES	Cobalt
Aqueous	EPA 200.7	ICP-OES	Copper
Aqueous	EPA 200.7	ICP-OES	Iron
Aqueous	EPA 200.7	ICP-OES	Lead
Aqueous	EPA 200.7	ICP-OES	Lithium
Aqueous	EPA 200.7	ICP-OES	Magnesium
Aqueous	EPA 200.7	ICP-OES	Manganese
Aqueous	EPA 200.7	ICP-OES	Molybdenum
Aqueous	EPA 200.7	ICP-OES	Nickel
Aqueous	EPA 200.7	ICP-OES	Potassium
Aqueous	EPA 200.7	ICP-OES	Selenium
Aqueous	EPA 200.7	ICP-OES	Silica as SiO2
Aqueous	EPA 200.7	ICP-OES	Silver
Aqueous	EPA 200.7	ICP-OES	Sodium
Aqueous	EPA 200.7	ICP-OES	Strontium
Aqueous	EPA 200.7	ICP-OES	Thallium
Aqueous	EPA 200.7	ICP-OES	Tin
Aqueous	EPA 200.7	ICP-OES	Titanium

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck, Jesse Shuck, Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 200.7	ICP-OES	Vanadium
Aqueous	EPA 200.7	ICP-OES	Zinc
Aqueous	EPA 200.8	ICP-MS	Aluminum
Aqueous	EPA 200.8	ICP-MS	Antimony
Aqueous	EPA 200.8	ICP-MS	Arsenic
Aqueous	EPA 200.8	ICP-MS	Barium
Aqueous	EPA 200.8	ICP-MS	Beryllium
Aqueous	EPA 200.8	ICP-MS	Boron
Aqueous	EPA 200.8	ICP-MS	Cadmium
Aqueous	EPA 200.8	ICP-MS	Chromium
Aqueous	EPA 200.8	ICP-MS	Cobalt
Aqueous	EPA 200.8	ICP-MS	Copper
Aqueous	EPA 200.8	ICP-MS	Iron
Aqueous	EPA 200.8	ICP-MS	Lead
Aqueous	EPA 200.8	ICP-MS	Manganese
Aqueous	EPA 200.8	ICP-MS	Molybdenum
Aqueous	EPA 200.8	ICP-MS	Nickel
Aqueous	EPA 200.8	ICP-MS	Selenium
Aqueous	EPA 200.8	ICP-MS	Silver
Aqueous	EPA 200.8	ICP-MS	Strontium
Aqueous	EPA 200.8	ICP-MS	Thallium
Aqueous	EPA 200.8	ICP-MS	Tin
Aqueous	EPA 200.8	ICP-MS	Titanium
Aqueous	EPA 200.8	ICP-MS	Uranium
Aqueous	EPA 200.8	ICP-MS	Vanadium
Aqueous	EPA 200.8	ICP-MS	Zinc
Aqueous	EPA 245.1	CV-AA	Mercury
Aqueous	EPA 300.0	Ion Chromatography	Bromide
Aqueous	EPA 300.0	Ion Chromatography	Chloride
Aqueous	EPA 300.0	Ion Chromatography	Flouride
Aqueous	EPA 300.0	Ion Chromatography	Nitrate
Aqueous	EPA 300.0	Ion Chromatography	Nitrate + Nitrite as N

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck, Jesse Shuck, Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 300.0	Ion Chromatography	Nitrite
Aqueous	EPA 300.0	Ion Chromatography	Orthophosphate
Aqueous	EPA 300.0	Ion Chromatography	Sulfate
Aqueous	EPA 310.1	Manual	Alkalinity
Aqueous	EPA 410.4	Spectrophotometry	Chemical Oxygen Demand (COD)
Aqueous	EPA 6010 / SM 3500-Fe B	Calculation	Ferric Iron
Aqueous	EPA 6010C	ICP-OES	Lithium
Aqueous	EPA 6010C	ICP-OES	Silica as SiO2
Aqueous	EPA 6020A	ICP/MS	Aluminum
Aqueous	EPA 6020A	ICP/MS	Iron
Aqueous	EPA 6020A	ICP-MS	Uranium
Aqueous	EPA 608.3	GC/ECD	4,4'-DDD
Aqueous	EPA 608.3	GC/ECD	4,4'-DDE
Aqueous	EPA 608.3	GC/ECD	4,4'-DDT
Aqueous	EPA 608.3	GC/ECD	Aldrin
Aqueous	EPA 608.3	GC/ECD	alpha-BHC
Aqueous	EPA 608.3	GC/ECD	Alpha-Chlordane
Aqueous	EPA 608.3	GC/ECD	Aroclor 1016
Aqueous	EPA 608.3	GC/ECD	Aroclor 1221
Aqueous	EPA 608.3	GC/ECD	Aroclor 1232
Aqueous	EPA 608.3	GC/ECD	Aroclor 1242
Aqueous	EPA 608.3	GC/ECD	Aroclor 1248
Aqueous	EPA 608.3	GC/ECD	Aroclor 1254
Aqueous	EPA 608.3	GC/ECD	Aroclor 1260
Aqueous	EPA 608.3	GC/ECD	beta-BHC
Aqueous	EPA 608.3	GC/ECD	Chlordane (Tech)
Aqueous	EPA 608.3	GC/ECD	delta-BHC
Aqueous	EPA 608.3	GC/ECD	Dieldrin
Aqueous	EPA 608.3	GC/ECD	Endosulfan I
Aqueous	EPA 608.3	GC/ECD	Endosulfan II
Aqueous	EPA 608.3	GC/ECD	Endosulfan Sulfate
Aqueous	EPA 608.3	GC/ECD	Endrin
Aqueous	EPA 608.3	GC/ECD	Endrin Aldehyde

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216

Contact Name: Brandon Beck, Jesse Shuck, Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 608.3	GC/ECD	gamma-BHC (Lindane)
Aqueous	EPA 608.3	GC/ECD	gamma-chlordane
Aqueous	EPA 608.3	GC/ECD	Heptachlor
Aqueous	EPA 608.3	GC/ECD	Heptachlor Epoxide (beta)
Aqueous	EPA 608.3	GC/ECD	Methoxychlor
Aqueous	EPA 608.3	GC/ECD	Toxaphene
Aqueous	EPA 624.1	GC/MS	1,1 Dichloroethane
Aqueous	EPA 624.1	GC/MS	1,1,1-Trichloroethane
Aqueous	EPA 624.1	GC/MS	1,1,2,2-Tetrachloroethane
Aqueous	EPA 624.1	GC/MS	1,1,2-Trichloroethane
Aqueous	EPA 624.1	GC/MS	1,1-Dichloroethene
Aqueous	EPA 624.1	GC/MS	1,2-Dichlorobenzene
Aqueous	EPA 624.1	GC/MS	1,2-Dichloroethane
Aqueous	EPA 624.1	GC/MS	1,2-Dichloropropane
Aqueous	EPA 624.1	GC/MS	1,3-Dichlorobenzene
Aqueous	EPA 624.1	GC/MS	1,4-Dichlorobenzene
Aqueous	EPA 624.1	GC/MS	2-Chloroethyl vinyl ether
Aqueous	EPA 624.1	GC/MS	Acrolein
Aqueous	EPA 624.1	GC/MS	Acrylonitrile
Aqueous	EPA 624.1	GC/MS	Benzene
Aqueous	EPA 624.1	GC/MS	Bromodichloromethane
Aqueous	EPA 624.1	GC/MS	Bromoform
Aqueous	EPA 624.1	GC/MS	Bromomethane (Methyl Bromide)
Aqueous	EPA 624.1	GC/MS	Carbon Tetrachloride
Aqueous	EPA 624.1	GC/MS	Chlorobenzene
Aqueous	EPA 624.1	GC/MS	Chloroethane
Aqueous	EPA 624.1	GC/MS	Chloroform
Aqueous	EPA 624.1	GC/MS	Chloromethane (Methyl Chloride)
Aqueous	EPA 624.1	GC/MS	cis 1,2 Dichloroethene
Aqueous	EPA 624.1	GC/MS	cis 1,3 Dichloropropene
Aqueous	EPA 624.1	GC/MS	Dibromochloromethane
Aqueous	EPA 624.1	GC/MS	Dichlorodifluoromethane
Aqueous	EPA 624.1	GC/MS	Ethylbenzene
Aqueous	EPA 624.1	GC/MS	Methyl tert-butyl Ether (MTBE)
Aqueous	EPA 624.1	GC/MS	Methylene Chloride
Aqueous	EPA 624.1	GC/MS	Tetrachloroethene
Aqueous	EPA 624.1	GC/MS	Toluene

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck Jesse Shuck Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 624.1	GC/MS	trans-1,2-dichloroethene
Aqueous	EPA 624.1	GC/MS	trans-1,3-Dichloropropene
Aqueous	EPA 624.1	GC/MS	Trichloroethene
Aqueous	EPA 624.1	GC/MS	Trichlorofluoromethane
Aqueous	EPA 624.1	GC/MS	Vinyl chloride
Aqueous	EPA 624.1	GC/MS	Xylene-mp
Aqueous	EPA 624.1	GC/MS	Xylene-o
Aqueous	EPA 624.1	GC/MS	Xylenes, Total
Aqueous	EPA 625.1	GC/MS	1 Methylnaphthalene
Aqueous	EPA 625.1	GC/MS	1,2 Dichlorobenzene
Aqueous	EPA 625.1	GC/MS	1,2,4-Trichlorobenzene
Aqueous	EPA 625.1	GC/MS	1,3 Dichlorobenzene
Aqueous	EPA 625.1	GC/MS	1,4 Dichlorobenzene
Aqueous	EPA 625.1	GC/MS	2 Methylnaphthalene
Aqueous	EPA 625.1	GC/MS	2,3-Dichloroaniline
Aqueous	EPA 625.1	GC/MS	2,4,6-Trichlorophenol
Aqueous	EPA 625.1	GC/MS	2,4-Dichlorophenol
Aqueous	EPA 625.1	GC/MS	2,4-Dimethylphenol
Aqueous	EPA 625.1	GC/MS	2,4-Dinitrophenol
Aqueous	EPA 625.1	GC/MS	2,4-Dinitrotoluene
Aqueous	EPA 625.1	GC/MS	2,6 Dichlorophenol
Aqueous	EPA 625.1	GC/MS	2,6-Dinitrotoluene
Aqueous	EPA 625.1	GC/MS	2-Chloronaphthalene
Aqueous	EPA 625.1	GC/MS	2-Chlorophenol
Aqueous	EPA 625.1	GC/MS	2-methyl phenol (o-cresol)
Aqueous	EPA 625.1	GC/MS	2-Methyl-4,6-Dinitrophenol
Aqueous	EPA 625.1	GC/MS	2-Nitrophenol
Aqueous	EPA 625.1	GC/MS	3,3'-Dichlorobenzidine
Aqueous	EPA 625.1	GC/MS	3+4-methyl phenol (MPcresol)
Aqueous	EPA 625.1	GC/MS	4-Bromophenyl-phenylether
Aqueous	EPA 625.1	GC/MS	4-Chloro-3-methylphenol
Aqueous	EPA 625.1	GC/MS	4-Chlorophenyl-phenylether
Aqueous	EPA 625.1	GC/MS	4-Nitrophenol
Aqueous	EPA 625.1	GC/MS	Acenaphthene
Aqueous	EPA 625.1	GC/MS	Acenaphthylene

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.
6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck, Jesse Shuck, Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 625.1	GC/MS	Acetephone
Aqueous	EPA 625.1	GC/MS	alpha-Terpineol
Aqueous	EPA 625.1	GC/MS	Aniline
Aqueous	EPA 625.1	GC/MS	Anthracene
Aqueous	EPA 625.1	GC/MS	Benzidine
Aqueous	EPA 625.1	GC/MS	Benzo(a)anthracene
Aqueous	EPA 625.1	GC/MS	Benzo(a)pyrene
Aqueous	EPA 625.1	GC/MS	Benzo(b)fluoranthene
Aqueous	EPA 625.1	GC/MS	Benzo(g,h,i)perylene
Aqueous	EPA 625.1	GC/MS	Benzo(k)fluoranthene
Aqueous	EPA 625.1	GC/MS	Benzoic acid
Aqueous	EPA 625.1	GC/MS	bis(2-Chloroethoxy)methane
Aqueous	EPA 625.1	GC/MS	bis(2-Chloroethyl)ether
Aqueous	EPA 625.1	GC/MS	bis(2-Chloroiospropyl) ether
Aqueous	EPA 625.1	GC/MS	Bis(2-ethylhexyl) phthalate
Aqueous	EPA 625.1	GC/MS	Butyl Benzyl Phthalate
Aqueous	EPA 625.1	GC/MS	Carbazole
Aqueous	EPA 625.1	GC/MS	Chrysene
Aqueous	EPA 625.1	GC/MS	Dibenzo(a,h)anthracene
Aqueous	EPA 625.1	GC/MS	Dibenzofuran
Aqueous	EPA 625.1	GC/MS	Diethyl phthalate
Aqueous	EPA 625.1	GC/MS	Dimethyl phthalate
Aqueous	EPA 625.1	GC/MS	Di-n-butylphthalate
Aqueous	EPA 625.1	GC/MS	Di-n-octylphthalate
Aqueous	EPA 625.1	GC/MS	Fluoranthene
Aqueous	EPA 625.1	GC/MS	Fluorene
Aqueous	EPA 625.1	GC/MS	Hexachlorobenzene
Aqueous	EPA 625.1	GC/MS	Hexachlorobutadiene
Aqueous	EPA 625.1	GC/MS	Hexachlorocyclopentadiene
Aqueous	EPA 625.1	GC/MS	Hexachloroethane
Aqueous	EPA 625.1	GC/MS	Indeno(1,2,3, cd)pyrene
Aqueous	EPA 625.1	GC/MS	Isophorone
Aqueous	EPA 625.1	GC/MS	Naphthalene
Aqueous	EPA 625.1	GC/MS	n-Decane
Aqueous	EPA 625.1	GC/MS	Nitrobenzene
Aqueous	EPA 625.1	GC/MS	n-Nitrosodimethylamine
Aqueous	EPA 625.1	GC/MS	n-Nitroso-di-n-propylamine

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck Jesse Shuck Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 625.1	GC/MS	n-Nitrosodiphenylamine
Aqueous	EPA 625.1	GC/MS	n-Octadecane
Aqueous	EPA 625.1	GC/MS	Pentachlorophenol
Aqueous	EPA 625.1	GC/MS	Phenanthrene
Aqueous	EPA 625.1	GC/MS	Phenol
Aqueous	EPA 625.1	GC/MS	Pyrene
Aqueous	EPA 625.1	GC/MS	Pyridine
Aqueous	EPA 7470A	CV-AA	Mercury
Aqueous	EPA 8011	GC/ECD	(DBCP) 1,2 Dibromo-3-chloropropane
Aqueous	EPA 8011	GC/ECD	(EDB) 1,2 Dibromoethane
Aqueous	EPA 8081 B	GC/ECD	Hexachlorobenzene
Aqueous	EPA 9020B	Coulometry	Total Organic Halides (TOX)
Aqueous	EPA 8260C D SIM	GC/MS	1,2-Dibromo-3-chloropropane (DBCP)
Aqueous	EPA 8260C D SIM	GC/MS	1,2-Dibromoethane (EDB)
Aqueous	EPA 8260C D SIM	GC/MS	1,4-Dioxane
Aqueous	EPA 8270D, E	GC/MS	Dinoseb
Aqueous	EPA 8270 D, E	GC/MS	Di(2-ethylhexyl)adipate
Aqueous	EPA 8270D, E SIM	GC/MS	1,4 Dioxane
Aqueous	EPA 9040C	Electrode	Corrositivity
Aqueous	RSK-175	GC/FID	Ethane
Aqueous	RSK-175	GC/FID	Ethylene
Aqueous	RSK-175	GC/FID	Methane
Aqueous	SM 2320B	Titration	Alkalinity (as CaCO3)
Aqueous	SM 2340B	Calculation	Ca Hardness
Aqueous	SM 2340B	Calculation	Total Hardness
Aqueous	SM 3500-Cr D / EPA 7196	Spectrophotometry	Hexavalent Chromium
Aqueous	SM 3500-Fe D	Spectrophotometry	Ferrous Iron
Aqueous	SM 4500-PE	Spectrophotometer	Orthophosphate as P
Aqueous	SM 4500-S D/UVVIS	Spectrophotometer	Sulfide
Aqueous	SM 5210B	Demand	Biochemical Oxygen Demand (BOD)
Solid	EPA 1030	Manual	Ignitibility
Solid	EPA 160.3 / SM 2540G	Gravimetric	Total Solids (TS)
Solid	EPA 7471A	CV-AA	Mercury
Solid	EPA 8270D, E	GC/MS	3,3'-Dimethyloxybenzidine
Solid	EPA 9023	Coulometry	Extractable Organic Halides (EOX)
Solid	EPA 9045	Electrode	Corrositivity

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Matrix	Standard/Method	Technology	Analyte
Solid	EPA 9045	Electrode	pH
Solid	EPA 9056A	Ion Chromatography	Bromide
Solid	EPA 9056A	Ion Chromatography	Chloride
Solid	EPA 9056A	Ion Chromatography	Flouride
Solid	EPA 9056A	Ion Chromatography	Nitrate
Solid	EPA 9056A	Ion Chromatography	Nitrate and Nitrite as N (NOX)
Solid	EPA 9056A	Ion Chromatography	Nitrite
Solid	EPA 9056A	Ion Chromatography	Orthophosphate
Solid	EPA 9056A	Ion Chromatography	Sulfate
Solid	EPA 9095	Manual	Paint Filter
Solid	MADEP-EPH	GC/FID	C9-C18 Aliphatic
Solid	MADEP-EPH	GC/FID	C19-C36 Aliphatic
Solid	MADEP-EPH	GC/FID	C11-C22 Aromatic (Unadjusted)
Solid	MADEP-VPH	GC/FID	C5-C8 Aliphatic (Unadjusted)
Solid	MADEP-VPH	GC/FID	C9-C12 Aliphatic (Unadjusted)
Solid	MADEP-VPH	GC/FID	C9-C10 Aromatic (Unadjusted)
Aqueous/Solid	EPA 1020	Manual	Flashpoint
Aqueous/Solid	EPA 6010C	ICP-OES	Aluminum
Aqueous/Solid	EPA 6010C	ICP-OES	Antimony
Aqueous/Solid	EPA 6010C	ICP-OES	Arsenic
Aqueous/Solid	EPA 6010C	ICP-OES	Barium
Aqueous/Solid	EPA 6010C	ICP-OES	Beryllium
Aqueous/Solid	EPA 6010C	ICP-OES	Boron
Aqueous/Solid	EPA 6010C	ICP-OES	Cadmium
Aqueous/Solid	EPA 6010C	ICP-OES	Calcium
Aqueous/Solid	EPA 6010C	ICP-OES	Chromium
Aqueous/Solid	EPA 6010C	ICP-OES	Cobalt
Aqueous/Solid	EPA 6010C	ICP-OES	Copper
Aqueous/Solid	EPA 6010C	ICP-OES	Iron
Aqueous/Solid	EPA 6010C	ICP-OES	Lead
Aqueous/Solid	EPA 6010C	ICP-OES	Magnesium
Aqueous/Solid	EPA 6010C	ICP-OES	Manganese
Aqueous/Solid	EPA 6010C	ICP-OES	Molybdenum
Aqueous/Solid	EPA 6010C	ICP-OES	Nickel
Aqueous/Solid	EPA 6010C	ICP-OES	Potassium
Aqueous/Solid	EPA 6010C	ICP-OES	Selenium

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 6010C	ICP-OES	Silver
Aqueous/Solid	EPA 6010C	ICP-OES	Sodium
Aqueous/Solid	EPA 6010C	ICP-OES	Strontium
Aqueous/Solid	EPA 6010C	ICP-OES	Thallium
Aqueous/Solid	EPA 6010C	ICP-OES	Tin
Aqueous/Solid	EPA 6010C	ICP-OES	Titanium
Aqueous/Solid	EPA 6010C	ICP-OES	Vanadium
Aqueous/Solid	EPA 6010C	ICP-OES	Zinc
Aqueous/Solid	EPA 6020A	ICP-MS	Antimony
Aqueous/Solid	EPA 6020A	ICP-MS	Arsenic
Aqueous/Solid	EPA 6020A	ICP-MS	Barium
Aqueous/Solid	EPA 6020A	ICP-MS	Beryllium
Aqueous/Solid	EPA 6020A	ICP-MS	Cadmium
Aqueous/Solid	EPA 6020A	ICP-MS	Chromium
Aqueous/Solid	EPA 6020A	ICP-MS	Cobalt
Aqueous/Solid	EPA 6020A	ICP-MS	Copper
Aqueous/Solid	EPA 6020A	ICP-MS	Lead
Aqueous/Solid	EPA 6020A	ICP-MS	Manganese
Aqueous/Solid	EPA 6020A	ICP-MS	Molybdenum
Aqueous/Solid	EPA 6020A	ICP-MS	Nickel
Aqueous/Solid	EPA 6020A	ICP-MS	Selenium
Aqueous/Solid	EPA 6020A	ICP-MS	Silver
Aqueous/Solid	EPA 6020A	ICP-MS	Strontium
Aqueous/Solid	EPA 6020A	ICP-MS	Thallium
Aqueous/Solid	EPA 6020A	ICP-MS	Tin
Aqueous/Solid	EPA 6020A	ICP-MS	Titanium
Aqueous/Solid	EPA 6020A	ICP-MS	Vanadium
Aqueous/Solid	EPA 6020A	ICP-MS	Zinc
Aqueous/Solid	EPA 8015C /MADEP-VPH	GC/FID	Gasoline Range Organics (GRO) –
Aqueous/Solid	EPA 8015C/ MADEP-EPH	GC/FID	Diesel Range Organics (DRO)
Aqueous/Solid	EPA 8015C	GC/FID	2-ethoxyethanol
Aqueous/Solid	EPA 8015C	GC/FID	Diesel Range Organics (DRO)
Aqueous/Solid	EPA 8015C	GC/FID	Ethanol
Aqueous/Solid	EPA 8015C	GC/FID	Ethylene Glycol
Aqueous/Solid	EPA 8015C	GC/FID	Gasoline Range Organics (GRO)
Aqueous/Solid	EPA 8015C	GC/FID	Isobutyl alcohol

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8015C	GC/FID	Isopropyl Alcohol
Aqueous/Solid	EPA 8015C	GC/FID	Methanol
Aqueous/Solid	EPA 8015C	GC/FID	n-Butyl alcohol
Aqueous/Solid	EPA 8015C	GC/FID	n-Propanol
Aqueous/Solid	EPA 8015C	GC/FID	ORO (Oil Range Organics C20-C35)
Aqueous/Solid	EPA 8015C	GC/FID	Propylene Glycol
Aqueous/Solid	EPA 8015C	GC/FID	RRO (Residual Range Organics C25-C36)
Aqueous/Solid	EPA 8081B	GC/ECD	4,4'-DDD
Aqueous/Solid	EPA 8081B	GC/ECD	4,4'-DDE
Aqueous/Solid	EPA 8081B	GC/ECD	4,4'-DDT
Aqueous/Solid	EPA 8081B	GC/ECD	Aldrin
Aqueous/Solid	EPA 8081B	GC/ECD	alpha-BHC
Aqueous/Solid	EPA 8081B	GC/ECD	Alpha-Chlordane
Aqueous/Solid	EPA 8081B	GC/ECD	beta-BHC
Aqueous/Solid	EPA 8081B	GC/ECD	Chlordane (Tech)
Aqueous/Solid	EPA 8081B	GC/ECD	delta-BHC
Aqueous/Solid	EPA 8081B	GC/ECD	Dieldrin
Aqueous/Solid	EPA 8081B	GC/ECD	Endosulfan I
Aqueous/Solid	EPA 8081B	GC/ECD	Endosulfan II
Aqueous/Solid	EPA 8081B	GC/ECD	Endosulfan Sulfate
Aqueous/Solid	EPA 8081B	GC/ECD	Endrin
Aqueous/Solid	EPA 8081B	GC/ECD	Endrin Aldehyde
Aqueous/Solid	EPA 8081B	GC/ECD	Endrin Ketone
Aqueous/Solid	EPA 8081B	GC/ECD	gamma-BHC (Lindane)
Aqueous/Solid	EPA 8081B	GC/ECD	Gamma-Chlordane
Aqueous/Solid	EPA 8081B	GC/ECD	Heptachlor
Aqueous/Solid	EPA 8081B	GC/ECD	Heptachlor Epoxide
Aqueous/Solid	EPA 8081B	GC/ECD	Methoxychlor
Aqueous/Solid	EPA 8081B	GC/ECD	Toxaphene
Aqueous/Solid	EPA 8082A	GC/ECD	Aroclor 1016
Aqueous/Solid	EPA 8082A	GC/ECD	Aroclor 1221
Aqueous/Solid	EPA 8082A	GC/ECD	Aroclor 1232
Aqueous/Solid	EPA 8082A	GC/ECD	Aroclor 1242
Aqueous/Solid	EPA 8082A	GC/ECD	Aroclor 1248
Aqueous/Solid	EPA 8082A	GC/ECD	Aroclor 1254
Aqueous/Solid	EPA 8082A	GC/ECD	Aroclor 1260

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Advanced Environmental Laboratories, Inc.
6681 Southpoint Parkway, Jacksonville, FL 32216
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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8082A	GC/ECD	Aroclor 1262
Aqueous/Solid	EPA 8082A	GC/ECD	Aroclor 1268
Aqueous/Solid	EPA 8141B	GC/NPD	Atrazine
Aqueous/Solid	EPA 8141B	GC/NPD	Azinphos-methyl (Gunthion)
Aqueous/Solid	EPA 8141B	GC/NPD	Chloropyrifos
Aqueous/Solid	EPA 8141B	GC/NPD	Chlorpyrifos Methyl
Aqueous/Solid	EPA 8141B	GC/NPD	Dementon total
Aqueous/Solid	EPA 8141B	GC/NPD	Demeton-o
Aqueous/Solid	EPA 8141B	GC/NPD	Demeton-s
Aqueous/Solid	EPA 8141B	GC/NPD	Diazinon
Aqueous/Solid	EPA 8141B	GC/NPD	Dimethoate
Aqueous/Solid	EPA 8141B	GC/NPD	Disulfoton
Aqueous/Solid	EPA 8141B	GC/NPD	Ethion
Aqueous/Solid	EPA 8141B	GC/NPD	Ethoprop
Aqueous/Solid	EPA 8141B	GC/NPD	Ethyl Parathion
Aqueous/Solid	EPA 8141B	GC/NPD	Famphur
Aqueous/Solid	EPA 8141B	GC/NPD	Fensulfothion
Aqueous/Solid	EPA 8141B	GC/NPD	Fonophos
Aqueous/Solid	EPA 8141B	GC/NPD	Malathion
Aqueous/Solid	EPA 8141B	GC/NPD	Merphos
Aqueous/Solid	EPA 8141B	GC/NPD	Methyl parathion
Aqueous/Solid	EPA 8141B	GC/NPD	Mevinphos
Aqueous/Solid	EPA 8141B	GC/NPD	Phorate
Aqueous/Solid	EPA 8141B	GC/NPD	Phosmet
Aqueous/Solid	EPA 8141B	GC/NPD	Ronnel
Aqueous/Solid	EPA 8141B	GC/NPD	Simazine
Aqueous/Solid	EPA 8141B	GC/NPD	Sulfotep
Aqueous/Solid	EPA 8151A	GC/ECD	2,4,5-T
Aqueous/Solid	EPA 8151A	GC/ECD	2,4,5-TP (Silvex)
Aqueous/Solid	EPA 8151A	GC/ECD	2,4-D
Aqueous/Solid	EPA 8151A	GC/ECD	2,4-DB
Aqueous/Solid	EPA 8151A	GC/ECD	Dalapon
Aqueous/Solid	EPA 8151A	GC/ECD	Dicamba
Aqueous/Solid	EPA 8151A	GC/ECD	Dichloroprop
Aqueous/Solid	EPA 8151A	GC/ECD	Dinoseb
Aqueous/Solid	EPA 8151A	GC/ECD	Pentachlorophenol

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8260C, D	GC/MS	1,1 Dichloroethene
Aqueous/Solid	EPA 8260C, D	GC/MS	1,1 Dichloropropene
Aqueous/Solid	EPA 8260C, D	GC/MS	1,1,1,2-Tetrachloroethane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,1,1-Trichloroethane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,1,2,2-Tetrachloroethane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,1,2-Trichloro-1,2,2-trifluoroethane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,1,2-Trichloroethane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,1-Dichloroethane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,2 Dibromo-3-chloropropane (DBCP)
Aqueous/Solid	EPA 8260C, D	GC/MS	1,2 Dibromoethane (EDB)
Aqueous/Solid	EPA 8260C, D	GC/MS	1,2 Dichlorobenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	1,2 Dichloropropane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,2,3 Trichlorobenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	1,2,3 Trichloropropane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,2,4 Trichlorobenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	1,2,4 Trimethylbenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	1,2-Dichloroethane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,3,5 Trimethylbenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	1,3-Dichlorobenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	1,3-Dichlorpropane
Aqueous/Solid	EPA 8260C, D	GC/MS	1,4-Dichlorobenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	1,4-Dioxane
Aqueous/Solid	EPA 8260C, D	GC/MS	2 Hexanone
Aqueous/Solid	EPA 8260C, D	GC/MS	2,2-Dichlorpropane
Aqueous/Solid	EPA 8260C, D	GC/MS	2-Chloroethyl vinyl ether
Aqueous/Solid	EPA 8260C, D	GC/MS	2-Chlorotoluene
Aqueous/Solid	EPA 8260C, D	GC/MS	2-Nitropropane
Aqueous/Solid	EPA 8260C, D	GC/MS	4-Chlorotoluene
Aqueous/Solid	EPA 8260C, D	GC/MS	4-Methyl-2-pentanone (MIBK)
Aqueous/Solid	EPA 8260C, D	GC/MS	Acetone
Aqueous/Solid	EPA 8260C, D	GC/MS	Acetonitrile
Aqueous/Solid	EPA 8260C, D	GC/MS	Acrolein
Aqueous/Solid	EPA 8260C, D	GC/MS	Acrylonitrile
Aqueous/Solid	EPA 8260C, D	GC/MS	Allyl Chloride(3-Chloropropene)
Aqueous/Solid	EPA 8260C, D	GC/MS	Benzene
Aqueous/Solid	EPA 8260C, D	GC/MS	Bromobenzene

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8260C, D	GC/MS	Bromochloromethane
Aqueous/Solid	EPA 8260C, D	GC/MS	Bromodichloromethane
Aqueous/Solid	EPA 8260C, D	GC/MS	Bromoform
Aqueous/Solid	EPA 8260C, D	GC/MS	Bromomethane (Methyl Bromide)
Aqueous/Solid	EPA 8260C, D	GC/MS	Carbon Disulfide
Aqueous/Solid	EPA 8260C, D	GC/MS	Carbon Tetrachloride
Aqueous/Solid	EPA 8260C, D	GC/MS	Chlorobenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	Chloroethane
Aqueous/Solid	EPA 8260C, D	GC/MS	Chloroform
Aqueous/Solid	EPA 8260C, D	GC/MS	Chloromethane (Methyl Chloride)
Aqueous/Solid	EPA 8260C, D	GC/MS	Chloroprene
Aqueous/Solid	EPA 8260C, D	GC/MS	cis-1,2-Dichloroethene
Aqueous/Solid	EPA 8260C, D	GC/MS	cis-1,3-Dichloropropene
Aqueous/Solid	EPA 8260C, D	GC/MS	cis-1,4-Dichloro-2-butene
Aqueous/Solid	EPA 8260C, D	GC/MS	Cyclohexane
Aqueous/Solid	EPA 8260C, D	GC/MS	Cyclohexanone
Aqueous/Solid	EPA 8260C, D	GC/MS	Dibromochloromethane
Aqueous/Solid	EPA 8260C, D	GC/MS	Dibromomethane
Aqueous/Solid	EPA 8260C, D	GC/MS	Dichlorodifluoromethane
Aqueous/Solid	EPA 8260C, D	GC/MS	Diethyl Ether
Aqueous/Solid	EPA 8260C, D	GC/MS	Diisopropyl Ether (DIIPE)
Aqueous/Solid	EPA 8260C, D	GC/MS	Ethanol
Aqueous/Solid	EPA 8260C, D	GC/MS	Ethyl Acetate
Aqueous/Solid	EPA 8260C, D	GC/MS	Ethyl Methacrylate
Aqueous/Solid	EPA 8260C, D	GC/MS	Ethyl tert-Butyl Ether (ETBE)
Aqueous/Solid	EPA 8260C, D	GC/MS	Ethylbenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	Hexachlorobutadiene
Aqueous/Solid	EPA 8260C, D	GC/MS	Iodomethane (Methyl Iodide)
Aqueous/Solid	EPA 8260C, D	GC/MS	Isobutyl Alcohol
Aqueous/Solid	EPA 8260C, D	GC/MS	Isopropyl Alcohol (IPA)
Aqueous/Solid	EPA 8260C, D	GC/MS	Isopropylbenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	m,p-xylenes
Aqueous/Solid	EPA 8260C, D	GC/MS	MEK (2-Butanone)
Aqueous/Solid	EPA 8260C, D	GC/MS	Methacrylonitrile
Aqueous/Solid	EPA 8260C, D	GC/MS	Methyl Acetate
Aqueous/Solid	EPA 8260C, D	GC/MS	Methyl Methacrylate

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck Jesse Shuck Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8260C, D	GC/MS	Methyl tert butyl ether (MTBE)
Aqueous/Solid	EPA 8260C, D	GC/MS	Methylcyclohexane
Aqueous/Solid	EPA 8260C, D	GC/MS	Methylene Chloride
Aqueous/Solid	EPA 8260C, D	GC/MS	Naphthalene
Aqueous/Solid	EPA 8260C, D	GC/MS	n-Butylbenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	n-Propylbenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	o-xylene
Aqueous/Solid	EPA 8260C, D	GC/MS	Pentachloroethane
Aqueous/Solid	EPA 8260C, D	GC/MS	p-Isopropyltoluene
Aqueous/Solid	EPA 8260C, D	GC/MS	Propionitrile
Aqueous/Solid	EPA 8260C, D	GC/MS	sec-Butylbenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	Styrene
Aqueous/Solid	EPA 8260C, D	GC/MS	tert-Amyl Methyl Ether (TAME)
Aqueous/Solid	EPA 8260C, D	GC/MS	tert-Butyl alcohol (TBA)
Aqueous/Solid	EPA 8260C, D	GC/MS	tert-Butylbenzene
Aqueous/Solid	EPA 8260C, D	GC/MS	Tetrachloroethylene
Aqueous/Solid	EPA 8260C, D	GCMS	Tetrahydrofuran
Aqueous/Solid	EPA 8260C, D	GC/MS	Toluene
Aqueous/Solid	EPA 8260C, D	GC/MS	trans-1,2-dichloroethene
Aqueous/Solid	EPA 8260C, D	GC/MS	trans-1,3-Dichloropropene
Aqueous/Solid	EPA 8260C, D	GC/MS	trans-1,4-Dichloro-2-butene
Aqueous/Solid	EPA 8260C, D	GC/MS	Trichloroethene
Aqueous/Solid	EPA 8260C, D	GC/MS	Trichlorofluoromethane
Aqueous/Solid	EPA 8260C, D	GC/MS	Vinyl Acetate
Aqueous/Solid	EPA 8260C, D	GC/MS	Vinyl Chloride
Aqueous/Solid	EPA 8260C, D	GC/MS	Xylenes, Total
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	1-Methylnaphthalene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	2-Methylnaphthalene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Acenaphthene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Acenaphthylene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Anthracene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Benzo(a)anthracene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Benzo(a)pyrene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Benzo(b)fluoranthene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Benzo(g,h,i)perylene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Benzo(k)fluoranthene

Certificate of Accreditation: Supplement

ISO/IEC 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck Jesse Shuck Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Carbazole
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Chrysene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Dibenzo(a,h)anthracene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Dibenzofuran
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Fluoranthene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Fluorene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Indeno(1,2,3, cd)pyrene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Kepone
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Naphthalene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Phenanthrene
Aqueous/Solid	EPA 8270D, E SIM	GC/MS	Pyrene
Aqueous/Solid	EPA 8270D, E	GC/MS	(cis/trans)-Diallate
Aqueous/Solid	EPA 8270D, E	GC/MS	1,2 Dichlorobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	1,2,4,5 Tetrachlorobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	1,2,4-Trichlorobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	1,2-Diphenylhydrazine
Aqueous/Solid	EPA 8270D, E	GC/MS	1,3 Dichlorobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	1,3-Dinitrobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	1,4 Dichlorobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	1-Chloronaphthalene
Aqueous/Solid	EPA 8270D, E	GC/MS	1-Methylnaphthalene
Aqueous/Solid	EPA 8270D, E	GC/MS	1-Naphthylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	2 Methylnapthalene
Aqueous/Solid	EPA 8270D, E	GC/MS	2,3,4,6 Tetrachlorophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2,4,5 Trichlorophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2,4,6-Trichlorophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2,4-Dichlorophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2,4-Dimethylphenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2,4-Dinitrophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2,4-Dinitrotoluene
Aqueous/Solid	EPA 8270D, E	GC/MS	2,6 Dichlorophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2,6-Dinitrotoluene
Aqueous/Solid	EPA 8270D, E	GC/MS	2-Acetyl aminofluorene
Aqueous/Solid	EPA 8270D, E	GC/MS	2-Chloronaphthalene
Aqueous/Solid	EPA 8270D, E	GC/MS	2-Chlorophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2-methyl phenol (o-cresol)

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ISO/IEC 17025:2017 and DoD-ELAP

Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck Jesse Shuck Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270D, E	GC/MS	2-Methyl-4,6-Dinitrophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2-Naphthylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	2-Nitroaniline
Aqueous/Solid	EPA 8270D, E	GC/MS	2-Nitrophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	2-Picoline
Aqueous/Solid	EPA 8270D, E	GC/MS	3,3'-Dichlorobenzidine
Aqueous/Solid	EPA 8270D, E	GC/MS	3,3'-Dimethylbenzidine
Aqueous/Solid	EPA 8270D, E	GC/MS	3+4-methyl phenol (MPcresol)
Aqueous/Solid	EPA 8270D, E	GC/MS	3-Methylcholanthrene
Aqueous/Solid	EPA 8270D, E	GC/MS	3-Nitroaniline
Aqueous/Solid	EPA 8270D, E	GC/MS	4-Aminobiphenyl
Aqueous/Solid	EPA 8270D, E	GC/MS	4-Bromophenyl-phenylether
Aqueous/Solid	EPA 8270D, E	GC/MS	4-Chloro-3-methylphenol
Aqueous/Solid	EPA 8270D, E	GC/MS	4-Chloroaniline
Aqueous/Solid	EPA 8270D, E	GC/MS	4-Chlorophenyl-phenylether
Aqueous/Solid	EPA 8270D, E	GC/MS	4-Dimethyl aminoazobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	4-Nitroaniline
Aqueous/Solid	EPA 8270D, E	GC/MS	4-Nitrophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	5-Nitro-o-Toluidine
Aqueous/Solid	EPA 8270D, E	GC/MS	7,12-Dimethylbenz(a)anthracene
Aqueous/Solid	EPA 8270D, E	GC/MS	a,a-Dimethylphenylethylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	Acenaphthene
Aqueous/Solid	EPA 8270D, E	GC/MS	Acenaphthylene
Aqueous/Solid	EPA 8270D, E	GC/MS	Acetophenone
Aqueous/Solid	EPA 8270D, E	GC/MS	Alachlor
Aqueous/Solid	EPA 8270D, E	GC/MS	Aniline
Aqueous/Solid	EPA 8270D, E	GC/MS	Anthracene
Aqueous/Solid	EPA 8270D, E	GC/MS	Aramite
Aqueous/Solid	EPA 8270D, E	GC/MS	Atrazine
Aqueous/Solid	EPA 8270D, E	GC/MS	Benzaldehyde
Aqueous/Solid	EPA 8270D, E	GC/MS	Benzidine
Aqueous/Solid	EPA 8270D, E	GC/MS	Benzo(a)anthracene
Aqueous/Solid	EPA 8270D, E	GC/MS	Benzo(a)pyrene
Aqueous/Solid	EPA 8270D, E	GC/MS	Benzo(b)fluoranthene
Aqueous/Solid	EPA 8270D, E	GC/MS	Benzo(g,h,i)perylene
Aqueous/Solid	EPA 8270D, E	GC/MS	Benzo(k)fluoranthene

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Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck Jesse Shuck Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270D, E	GC/MS	Benzoic Acid
Aqueous/Solid	EPA 8270D, E	GC/MS	Benzyl Alcohol
Aqueous/Solid	EPA 8270D, E	GC/MS	Biphenyl
Aqueous/Solid	EPA 8270D, E	GC/MS	bis(2-Chloroethoxy) methane
Aqueous/Solid	EPA 8270D, E	GC/MS	bis(2-Chloroethyl) ether
Aqueous/Solid	EPA 8270D, E	GC/MS	bis(2-Chloroiospropyl) ether
Aqueous/Solid	EPA 8270D, E	GC/MS	Bis(2-ethylhexyl) phthalate
Aqueous/Solid	EPA 8270D, E	GC/MS	Butyl Benzyl Phthalate
Aqueous/Solid	EPA 8270D, E	GC/MS	Caprolactum
Aqueous/Solid	EPA 8270D, E	GC/MS	Carbazole
Aqueous/Solid	EPA 8270D, E	GC/MS	Chlorobenzilate
Aqueous/Solid	EPA 8270D, E	GC/MS	Chrysene
Aqueous/Solid	EPA 8270D, E	GC/MS	Dibenzo(a,h)anthracene
Aqueous/Solid	EPA 8270D, E	GC/MS	Dibenzo(a,j)acridine
Aqueous/Solid	EPA 8270D, E	GC/MS	Dibenzofuran
Aqueous/Solid	EPA 8270D, E	GC/MS	Diethyl phthalate
Aqueous/Solid	EPA 8270D, E	GC/MS	Dimethoate
Aqueous/Solid	EPA 8270D, E	GC/MS	Dimethyl phthalate
Aqueous/Solid	EPA 8270D, E	GC/MS	Di-n-butylphthalate
Aqueous/Solid	EPA 8270D, E	GC/MS	Di-n-octylphthalate
Aqueous/Solid	EPA 8270D, E	GC/MS	Diphenylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	Disulfoton
Aqueous/Solid	EPA 8270D, E	GC/MS	Ethyl methanesulfonate
Aqueous/Solid	EPA 8270D, E	GC/MS	Fluoranthene
Aqueous/Solid	EPA 8270D, E	GC/MS	Fluorene
Aqueous/Solid	EPA 8270D, E	GC/MS	Hexachlorobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	Hexachlorobutadiene
Aqueous/Solid	EPA 8270D, E	GC/MS	Hexachlorocyclopentadiene
Aqueous/Solid	EPA 8270D, E	GC/MS	Hexachloroethane
Aqueous/Solid	EPA 8270D, E	GC/MS	Hexachloropropene
Aqueous/Solid	EPA 8270D, E	GC/MS	Indeno(1,2,3, cd)pyrene
Aqueous/Solid	EPA 8270D, E	GC/MS	Isodrin
Aqueous/Solid	EPA 8270D, E	GC/MS	Isophorone
Aqueous/Solid	EPA 8270D, E	GC/MS	Isosafrole
Aqueous/Solid	EPA 8270D, E	GC/MS	Kepone
Aqueous/Solid	EPA 8270D, E	GC/MS	Methyl methanesulfonate

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Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216

Contact Name: Brandon Beck Jesse Shuck Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270D, E	GC/MS	Methyl Parathion
Aqueous/Solid	EPA 8270D, E	GC/MS	Naphthalene
Aqueous/Solid	EPA 8270D, E	GC/MS	Nitrobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	N-Nitrosodiethylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	n-Nitrosodimethylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	N-Nitrosodi-n-butylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	n-Nitroso-di-n-propylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	n-Nitrosodiphenylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	n-Nitrosomethylethylamine
Aqueous/Solid	EPA 8270D, E	GC/MS	N-Nitrosomorpholine
Aqueous/Solid	EPA 8270D, E	GC/MS	N-Nitrosopiperidine
Aqueous/Solid	EPA 8270D, E	GC/MS	N-Nitrosopyrrolidine
Aqueous/Solid	EPA 8270D, E	GC/MS	o,o,o-Triethyl phosphorothioate
Aqueous/Solid	EPA 8270D, E	GC/MS	o-Toluidine
Aqueous/Solid	EPA 8270D, E	GC/MS	Parathion
Aqueous/Solid	EPA 8270D, E	GC/MS	Pentachlorobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	Pentachloroethane
Aqueous/Solid	EPA 8270D, E	GC/MS	Pentachloronitrobenzene
Aqueous/Solid	EPA 8270D, E	GC/MS	Pentachlorophenol
Aqueous/Solid	EPA 8270D, E	GC/MS	Phenacetin
Aqueous/Solid	EPA 8270D, E	GC/MS	Phenanthrene
Aqueous/Solid	EPA 8270D, E	GC/MS	Phenol
Aqueous/Solid	EPA 8270D, E	GC/MS	Phorate
Aqueous/Solid	EPA 8270D, E	GC/MS	Pronamide
Aqueous/Solid	EPA 8270D, E	GC/MS	Pyrene
Aqueous/Solid	EPA 8270D, E	GC/MS	Pyridine
Aqueous/Solid	EPA 8270D, E	GC/MS	Safrole
Aqueous/Solid	EPA 8270D, E	GC/MS	Simazine
Aqueous/Solid	EPA 8270D, E	GC/MS	Sulfotep
Aqueous/Solid	EPA 8270D, E	GC/MS	Thionazin
Aqueous/Solid	EPA 9040	Electrode	pH
Aqueous/Solid	FL-PRO	GC/FID	TPH
Aqueous/Solid	FL-PRO / MADEP-EPH	GC/FID	Diesel Range Organics (DRO)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11C1-PF3OUdS)

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Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216
Contact Name: Brandon Beck, Jesse Shuck, Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	1H, 1H, 2H, 2H-Perfluorodecane Sulfonate (8:2 Fluorotelomersulfonate, 8:2FTS)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	1H, 1H, 2H, 2H-Perfluorohexane Sulfonate (4:2 Fluorotelomersulfonate, 4:2FTS)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	1H, 1H, 2H, 2H-Perfluorooctane Sulfonate (6:2 Fluorotelomersulfonate, 6:2FTS)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	4,8-Dioxa-3H-perfluorononanoic acid (ADONA)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9C1-PF3ONS)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Hexafluoropropylene oxide dimer acid (HFPO-DA) – GenX or Propanoic acid (PFPrOPrA)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluoro-3-methoxypropanoic acid (PFMPA)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluoro-4-methoxybutanoic acid (PFMBA)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorobutane sulfonate (PFBS, perfluorobutane sulfonic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorobutanoate (PFBA, perfluorobutyric acid, Perfluorobutanoic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorodecanoate (PFDA, perfluorodecanoic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorododecanoate (PFDoA, perfluorododecanoic acid)

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Advanced Environmental Laboratories, Inc.

6681 Southpoint Parkway, Jacksonville, FL 32216

Contact Name: Brandon Beck, Jesse Shuck, Kelly Bortle Phone: 904-363-9350

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluoroheptane Sulfonate (PFHpS, perfluorosulfonic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluoroheptanoate (PFHpA, perfluoroheptanoic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorohexane sulfonate (PFHxS, perfluorohexane sulfonic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorohexanoate (PFHxA, perfluorohexanoic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorononanoate (PFNA, perfluorononanoic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorooctane sulfonic acid (PFOS)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorooctanoate (PFOA, perfluorooctanoic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluoropentane sulfonic acid (PFPeS)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluoropentanoate (PFPeA, perfluoropentanoic acid)
Aqueous/Drinking Water	533 for DW PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluoroundecanoate (PFUnA, perfluoroundecanoic acid)
Aqueous	PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	N-Ethylperfluorooctane sufonamido acetic acid (NEtFOSAA)
Aqueous	PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	N-Methylperfluorooctane sulfonamido acetic acid (NMeFOSAA)
Aqueous	PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorodecane sulfonate (PFDS, perfluorodecane sulfonic acid)
Aqueous	PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorononanesulfonate (PFNS, Perfluorononane sulfonic acid)
Aqueous	PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorooctane sulfonamide (PFOSA)
Aqueous	PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorotetradecanoate (PFTeDA, perfluorotetradecanoic acid)
Aqueous	PFAS by LCMSMS Compliant w/ QSM 5.3 Table B-15	LCMSMS	Perfluorotridecanoate (PFTriA, perfluorotridecanoic acid)

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Accreditation is granted to the facility to perform the following testing:

Aqueous	EPA 3510C	Separatory Funnel	Extraction Prep Methods
Aqueous	EPA 5030B	Purge and trap	Volatile Prep Methods
Aqueous/Solid	EPA 1311	Leaching	Toxicity Characteristic Leaching Procedure
Aqueous/Solid	EPA 1312	Leaching	Synthetic Precipitation Leaching Procedure
Aqueous/Solid	EPA 3005A	Acid Digestion	Metals Digestion Prep Methods
Aqueous/Solid	EPA 3010A	Acid Digestion	Metals Digestion Prep Methods
Aqueous/Solid	EPA 3020A	Acid Digestion	Metals Digestion Prep Methods
Aqueous/Solid	EPA 3050B	Acid Digestion	Metals Digestion Prep Methods
Aqueous/Solid	EPA 3550C	Ultrasonic Extraction	Extraction Prep Methods
Aqueous/Solid	EPA 3580A	Waste Dilution Extraction	Extraction Prep Methods
Aqueous/Solid	EPA 3620B	Florisil Clean Up	Extraction Clean up
Aqueous/Solid	EPA 3630C	Silica Gel Clean Up	Extraction Clean up
Aqueous/Solid	EPA 3660B	Sulfur Clean Up	Extraction Clean up
Aqueous/Solid	EPA 3665A	Sulfuric Acid Clean Up	Extraction Clean up
Aqueous/Solid	EPA 5035A	Purge and Trap	Volatiles Prep Methods