DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

NATIONAL GUARD BUREAU
111 SOUTH GEORGE MASON DRIVE
ARLINGTON, VA 22204-1373

October 15, 2020

Wisconsin Department of Natural Resources
Attn: Mr. Riley Neumann
2300 N. Drive Martin Luther King Drive
Milwaukee, Wisconsin 53212

Dear Mr. Neumann:

This transmits the Final Site Inspection Uniform Federal Policy-Quality Assurance Project Plan Addendum for West Bend Army Aviation Support Facility, West Bend, Wisconsin. This report is a product of the Army National Guard program Perfluorooctane Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) Impacted Sites, Army National Guard Installations, Nationwide.

The point of contact for this transmittal is Mrs. Amanda Sullivan, who may be reached at 304-642-6000 or amanda.d.sullivan7.ctr@mail.mil. Please reach out to Mrs. Sullivan if there are any questions or concerns. We look forward to working with you.

Sincerely,

David M. Connolly, REM
PFAS Program Manager, Cleanup Branch,
Army National Guard

Enclosures

FINAL
Site Inspection Quality Assurance Project Plan Addendum West Bend Army Aviation Support Facility #1 West Bend, Wisconsin

Perfluorooctanesulfonic Acid (PFOS) and
Perfluorooctanoic Acid (PFOA) Impacted Sites
ARNG Installations, Nationwide

October 2020

Prepared for:

Army National Guard Bureau
111 S. George Mason Drive
Arlington, VA 22204

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Acronyms and Abbreviations

˚C	degrees Celsius
˚F	degrees Fahrenheit
µg/kg	micrograms per kilogram
µS/cm	micro Siemens per centimeter
AASF	Army Aviation Support Facility
ACSIM	Assistant Chief of Staff for Installation Management
AECOM	AECOM Technical Services, Inc.
AFFF	aqueous film forming foam
AOI	area of interest
APP	Accident Prevention Plan
ARAR	applicable or relevant and appropriate requirement
ARNG	Army National Guard
ASTM	American Society for Testing and Materials
bgs	below ground surface
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CoC	chain of custody
CPR	cardiopulmonary resuscitation
CSM	conceptual site model
DASA ESOH	Deputy Assistant Secretary of the Army for Environment, Safety and Occupational Health
DL	detection limit
DO	dissolved oxygen
DoD	Department of Defense
DPT	direct-push technology
DQI	data quality indicators
DQO	data quality objectives
DUA	Data Usability Assessment
ELAP	Environmental Laboratory Accreditation Program
ERB	equipment rinsate blank
FRB	field reagent blank
GCAL	Gulf Coast Analytical Laboratories, LLC
GPS	global positioning system
HA	Health Advisory
HAZWOPER	hazardous waste operations and emergency response
HDPE	high-density polyethylene
IDQTF	Intergovernmental Data Quality Task Force
IDW	investigation-derived waste
IED	Installations and Environment Division
ISC	instrument sensitivity check
LC/MS/MS	liquid chromatography tandem mass spectrometry

LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LOD	limit of detection
LOQ	limit of quantitation
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MPC	measurement performance criteria
MS/MSD	matrix spike/ matrix spike duplicate
ND	non-detect
NELAP	National Environmental Laboratory Accreditation Program
ng/L	nanograms per liter
ORP	oxidation-reduction potential
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PID	photoionization detector
PPE	personal protective equipment
ppm	parts per million
PQAPP	Programmatic UFP-QAPP
PVC	poly-vinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
QSM	Quality Systems Manual
RI	Remedial Investigation
ROE	Right of Entry
RPD	relative percent difference
RSL	regional screening level
SDG	sample delivery group
SI	Site Inspection
SL	screening level
SOP	standard operating procedure
SSHP	Site Safety and Health Plan
TCRA	Time Critical Removal Action
TO	Task Order
TOC	total organic carbon
TPP	Technical Project Planning

TSA	technical system audit
UCL	upper confidence limit
UCMR 3	Third Unregulated Contaminant Monitoring Rule
UFP	Uniform Federal Policy
US	United States
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VSI	visual site inspection
WIARNG	Wisconsin Army National Guard
WIDMA	Wisconsin Department of Military Affairs
WIDNR	Wisconsin Department of Natural Resources

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1. Introduction

1.1 Project Authorization

This is the Installation-Specific Addendum to the Army National Guard (ARNG) Site Inspection (SI) Programmatic Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP). This SI UFP-QAPP Addendum addresses specific SI activities to be completed at West Bend Army Aviation Support Facility (AASF) #1 in West Bend, Wisconsin.

The ARNG G9 is the lead agency in performing *Preliminary Assessments (PAs) and Site Inspections (SIs) for Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA) at Impacted Sites at ARNG Facilities Nationwide*. This work is supported by the United States (US) Army Corps of Engineers (USACE) Baltimore District and their contractor AECOM Technical Services, Inc. (AECOM) under Contract Number W912DR-12-D-0014, Task Order W912DR17F0192, issued 11 August 2017. Programmatically, the ARNG is assessing the potential environmental impacts primarily from aqueous film forming foam (AFFF) and similar chemical releases suspected at their properties related to processes that used per- and polyfluoroalkyl substances (PFAS) (e.g., fire training, firefighting, and metal plating).The SI project elements will be performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; United States Environmental Protection Agency [USEPA], 1980), as amended, the National Oil and Hazardous Substances Pollution Contingency Plan (40 Code of Federal Regulations [CFR] Part 300; USEPA, 1994), and in compliance with Army requirements and guidance for field investigations, including specific requirements for sampling for PFOA, PFOS, and perfluorobutanesulfonic acid (PFBS), and the group of related compounds known in the industry as PFAS. The term PFAS will be used throughout this plan to encompass all PFAS chemicals being evaluated, including PFOA, PFOS, and PFBS, which are the key components of the suspected releases being evaluated in the TO. This UFP-QAPP Addendum focuses on the SI phase of work specific to West Bend AASF #1 (also referred to as the “Site”) in West Bend, Wisconsin.

1.2 SI Purpose

The objective of this SI effort is to identify whether there has been a release to the environment from the Areas of Interest (AOIs) identified in the PA and determine the presence or absence of PFOA, PFOS, and PFBS at or above screening levels (SLs) at the facility.

As stated in the *Federal Facilities Remedial Site Inspection Summary Guide* (USEPA, 2005), an SI has five goals:

1) Develop information to potentially eliminate a release from further consideration because it is determined that it poses no significant threat to human health or the environment.
2) Determine the potential need for a removal action (i.e., Time Critical Removal Action [TCRA]; applies to drinking water only).
3) Collect or develop data to evaluate the release.
4) Collect additional data to develop the conceptual site model (CSM) in preparation for an effective Remedial Investigation (RI), if needed.
5) Collect data to determine whether the release is more than likely the result of activities associated with the Department of Defense (DoD).

In addition to the USEPA identified goals of an SI, the ARNG SI effort will also aim to evaluate whether the concentrations can be attributed to on-facility or off-facility sources that were identified within 4 miles of the installation as part of the PA (e.g., fire stations, major manufacturers, other DoD facilities).QAPP Addendum Organization

Elements of every ARNG PFAS SI are addressed in the SI Programmatic UFP-QAPP (PQAPP) (AECOM, 2018). The PQAPP is comprehensive and is consistent with the USEPA's intent that the UFP-QAPP be the primary planning document for an entire project (Intergovernmental Data Quality Task Force [IDQTF], 2005a-c). This QAPP Addendum, in combination with the PQAPP elements, meets the requirements set forth in the UFP for QAPPs (IDQTF, 2005a-c) *and USEPA Requirements for Quality Assurance Project Plans* (USEPA, 2001).

This QAPP Addendum was prepared to include the detailed information specific to the SI at West Bend AASF #1. For ease of review, material from the PQAPP is included in this deliverable alongside the West Bend AASF #1-specific worksheets. **Table 1-1** below describes the components that are covered under the PQAPP, and those that are covered under this UFP-QAPP Addendum:

Table 1-1: Comparison of PQAPP to QAPP Addendum

QAPP Addendum Worksheets	Applicable Document
Worksheets #1 and #2- Title and Approval Page and QAPP Identifying Information	**Programmatic/Site-Specific**
Worksheets #3 and #5- Project Organization and QAPP Distribution	**Programmatic/Site-Specific**
Worksheets #4, #7, #8- Personnel Qualifications and Sign-off Sheet	**Programmatic/Site-Specific**
Worksheet #6- Communication Pathways	**Programmatic/Site-Specific**
Worksheet #9- Technical Project Planning Session Summary	**Site-Specific**
Worksheet #10- Conceptual Site Model	**Site-Specific**
Worksheet #11- Project/ Data Quality Objectives	**Site-Specific**
Worksheet #12- Measurement Performance Criteria	**Programmatic**
Worksheet #13- Secondary Data Uses and Limitations	**Programmatic**
Worksheets #14 and #16- Project Tasks and Schedule	**Site-Specific**
Worksheet #15- Screening Limits and Laboratory- Specific Detection/ Quantitation Limits	**Programmatic**
Worksheet #17- Sampling Design and Rationale	**Site-Specific**
Worksheet #18- Sampling Locations and Methods	**Site-Specific**
Worksheets #19 and #30- Sample Containers, Preservation and Hold Times	**Programmatic**
Worksheet #20- Field Quality Control Summary	**Programmatic/Site-Specific**
Worksheet #21- Field Standard Operating Procedures	**Programmatic**
Worksheet #22- Field Equipment Calibration, Maintenance, Testing and Inspection	**Programmatic**

QAPP Addendum Worksheets	Applicable Document
Worksheet #23- Analytical Standard Operating Procedures	**Programmatic**
Worksheet #24- Analytical Instrument Calibration	**Programmatic**
Worksheet #25- Analytical Instrument and Equipment Maintenance, Testing and Inspection	**Programmatic**
Worksheets #26 and #27- Sample Handling, Custody and Disposal	**Programmatic**
Worksheet #28- Analytical Quality Control and Corrective Actions	**Programmatic**
Worksheet #29- Project Documents and Records	**Programmatic**
Worksheets #31, #32 and #33- Assessments and Corrective Action	**Programmatic**
Worksheet #34- Data Verification and Validation Inputs	**Programmatic**
Worksheet #35- Data Verification Procedures	**Programmatic**
Worksheet #36- Data Validation Procedures	**Programmatic**
Worksheet #37- Data Usability Assessment	**Programmatic**

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QAPP Worksheets #1 & #2: Title and Approval Page and QAPP Identifying Information

Site Name/Project Name: Army National Guard / MAES Delivery Order 00014/ Preliminary Assessments (PA) and Site Inspections (SI) for Perfluorooctanesulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) Impacted Sites, ARNG Installations, Nationwide

Installation: West Bend AASF #1, West Bend, Wisconsin

Contract Work Assignment Number: USACE Contract No. W912DR-12-D-0014;
Delivery Order No. W912DR17F0192

Relevant Plans and Reports from Previous Investigations: Relevant plans and reports from previous investigations are identified in the references cited in the introductory text that precedes these worksheets and in subsequent worksheets, as appropriate.

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Reason: I am approving this document
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Investigative Organization Project Manager	Signature / Date
Printed Name / Organization	Rosa Gwinn / AECOM Project Manager

Gettier, Sarah
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Date: 2020.09.11 10:52:47 -04'00'

Investigative Organization Quality Manager	Signature / Date
Printed Name / Organization	Sarah Gettier / AECOM Project QC Officer

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Date: 2020.09.14 12:02:11 -04'00'

Army National Guard	Signature / Date
Printed Name / Organization	David Connolly / ARNG Program Manager

Brendon Manglos
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Reason: I am the author of this document
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Date: 2020-09-14 13:48:53
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Wisconsin Army National Guard	Signature/Date
Printed Name / Organization	Brendon Manglos / Environmental Branch Chief

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Contract Organization Project Manager	Signature / Date
Printed Name / Organization	Timothy Peck / USACE, Baltimore District

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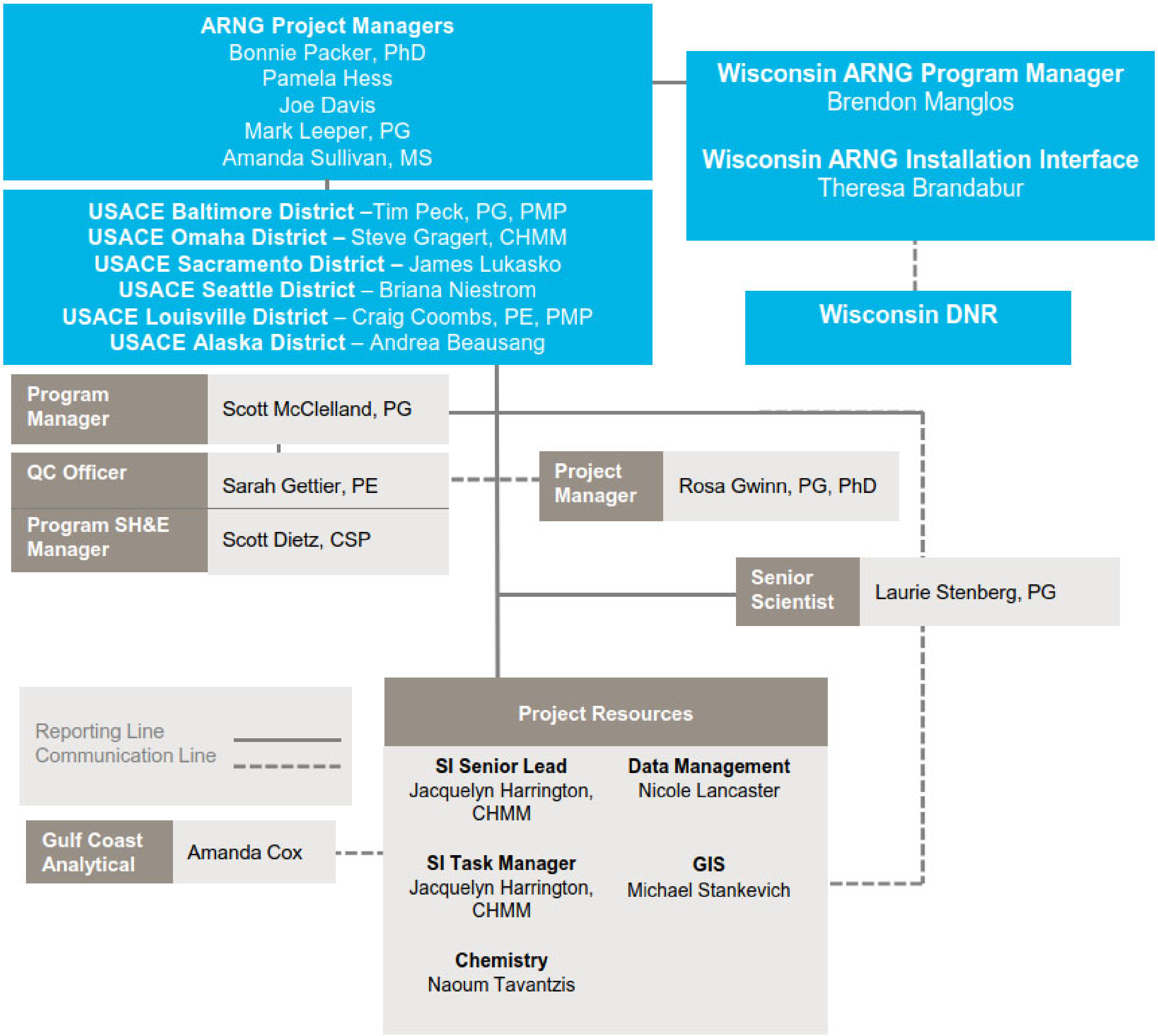
QAPP Worksheets #3 & #5: Project Organization and QAPP Distribution

The organization chart in **Figure 3-1** identifies key project personnel, as well as lines of authority and lines of communication among the ARNG, USACE, and prime contractor (AECOM). The QAPP Addendum will be distributed to all parties noted in the figure below. This organization chart is consistent with the PQAPP with the exception of the state regulatory personnel.

Figure 3-1 Project Organizational Chart



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QAPP Worksheets #4, #7 & #8: Personnel Qualifications and Sign-off Sheet

This worksheet contains a list of the key project personnel who are identified as performing the tasks that are defined in this QAPP Addendum for West Bend AASF #1 and includes the personnel's organization, project role, education/experience, and specialized training/certifications. The personnel have signed and dated the worksheet to signify that they agree with the information in this QAPP Addendum and agree to implement it.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Scott McClelland, PG	AECOM	Program Manager	Education: BA, Geology MS, Geology Experience. 30+ years; executing and managing environmental investigation and remediation projects including program management of USACE Baltimore contracts.	Professional Geologist, KY AECOM Certified PM	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Rosa Gwinn, PG, PhD	AECOM	PM	Education: BA, Geology MS, Geology PhD, Geology Experience: 33+ years; managed 4 ORA Phase II TOs of similar scope, complexity, and duration for USACE and ARNG; experience with PFAS investigations.	Professional Geologist, WA, UT AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher AECOM PFAS Sampling Training	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Laurie Stenberg, PG	AECOM	Senior Scientist	Education: BA, Geology Experience: 27 years; served as senior scientist for ORA Phase II TOs; experience with PFAS investigations.	Professional Geologist, PA AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher AECOM PFAS Sampling Training	Signature available upon request.
Jacquelyn Harrington, CHMM	AECOM	Senior Scientist, SI Senior Lead, SI Task Manger	Education: BA, Biology Experience: 27+ years; served as senior scientist for ORA Phase II TOs; MMRP RIs, experience with PFAS investigations.	CHMM AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher OSHA 8hr Supervisor First Aid/CPR AECOM PFAS Sampling Training	Signature available upon request.
Sarah Gettier	AECOM	QC Officer	Education: BS, Civil Engineering, MS Environmental Engineering Experience: 15+ years direct experience developing QAPPs and other environmental planning documents as a technical leader.	OSHA 40hr HAZWOPER OSHA 8hr Supervisor OSHA 8hr Refresher First Aid/CPR AECOM PFAS Sampling Training	Signature available upon request.
Scott Dietz, CSP, STSC	AECOM	Health and Safety Officer	Education: BS, OSHA Experience: 20+ years; OSHA.	CSP STSC	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Claire Mitchell, PE, PMP	AECOM	SI Team Manager	Education: BS, Civil Engineering Experience: 9+ years of environmental engineering experience including task management for PFAS investigations for DoD clients.	Professional Engineer, MO PMP Certification AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher First Aid/ CPR AECOM PFAS Sampling Training	Signature available upon request.
Robert Kennedy	AECOM	Senior Chemist	Education: BA, Chemistry Experience: 27+ years; served as senior scientist for ORA Phase II TOs; experience with PFAS investigations.	Auditing/Data Review training	Signature available upon request.
Naoum Tavantzis	AECOM	Project Chemist	Education: BA, Environmental Science Masters of Business Administration Experience: 9+ years; project chemist for ORA Phase II TOs; PFAS investigations, data validation, laboratory coordination.	OSHA 40hr HAZWOPER OSHA 8hr Refresher OSHA 8hr Supervisor AECOM PFAS Sampling Training	Signature available upon request.
Michael Stankevich	AECOM	GIS Specialist	Education: BA, Environmental Studies Experience: 9+ years; completed SDSFIE submittals for multiple ARNG installations.	ArcGIS Training	Signature available upon request.
Nicole Lancaster	AECOM	Data Management	Education: BS, Marine Biology, MS Chemistry Experience: 10+ years, experience with data validation, data management, laboratory coordination, and field sampling.	OSHA 40hr HAZWOPER OSHA 8hr Refresher First Aid/CPRAECOM PFAS Sampling Training	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Gretchen Welshofer	AECOM	Regulatory Specialist	Education: BA, Communication MS, Environmental Science Experience: 17+ years; performing human health risk assessments; expertise in evaluating potential risks and hazards to human health posed by MC emanating from small arms and large caliber ranges; expertise in evaluating contaminant fate and transport for validity of exposure pathways.	NA	Signature available upon request.
Sarah Stinger, PG	AECOM	Technical Quality	Education: BS, Geology MS, Geology Experience: 33+ years; performing CERCLA investigations; served as task leader and in QA role for ORA Phase II TOs at multiple ARNG installations.	Professional Geologist, VA, PA, LA AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher	Signature available upon request.
Amanda Martin, MS	AECOM	Technical Quality	Education: BS, Environmental Science; MS, Environmental Science and Engineering Experience: 7+ years; experience with QAPP development and PFAS investigations for DoD clients, including PAs and SIs for the ARNG; SIs and RIs on USACE Baltimore and New England contracts.	OSHA 40hr HAZWOPER OSHA 30hr Construction OSHA 8hr Refresher OSHA 8hr Supervisor First Aid/CPR AECOM PFAS Sampling Training	Signature available upon request.
Joe Witte	AECOM	Project Coordinator	Education: BS, Environmental Science and Policy Experience: 4+ years with 2 years direct experience working on ARNG and Army investigations under MMRP and ORA and developing QAPPs.	OSHA 40hr HAZWOPER OSHA 8hr Refresher First Aid/CPR AECOM PFAS Sampling Training	Signature available upon request.
Amanda Cox	Pace Gulf Coast (Formerly GCAL)	Laboratory Project Manager	Education: BS, Biology Experience: 3+ years as Project Manager.	NA	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
William Perry	Pace Gulf Coast	Laboratory Quality Assurance Specialist	Education: BS, Chemistry American Chemistry Society Program Experience: 30+ years including QAPP development, data validation, laboratory auditing and procurement, laboratory and sampling management, organic analysis and sample preparation management.	Statistics and 17025/TNI/QSM standards	Signature available upon request.

Notes:

AECOM = AECOM Technical Services, Inc.
ARNG = Army National Guard
BA = Bachelor of Arts
BS = Bachelor of Science
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CHMM = Certified Hazardous Materials Manager
CPR = cardiopulmonary resuscitation
CSP = Certified Safety Professional
DoD = Department of Defense
GCAL = Gulf Coast Analytical Laboratories, LLC.
GIS = Geographic Information System
HAZWOPER = Hazardous Waste Operations and Emergency Response
hr = hour
ITRC= Interstate Technology and Regulatory Council
KY = Kentucky
LA = Louisiana
MC = munitions constituents
MMRP = Military Munitions Response Program
MO = Missouri
MS = Master of Science
NA = not applicable
NH = New Hampshire
OSHA = Occupational Safety and Health Administration
PA = Pennsylvania
PE = Professional Engineer
PFAS = per- and polyfluoroalkyl substances
PG = Professional Geologist
PhD = Doctor of Philosophy
PM = Project Manager
PMP = Project Management Professional
QA = quality assurance
QAPP = Quality Assurance Project Plan
QC = quality control
QSM = Quality Systems Manual
RI = Remedial Investigation
SDSFIE = Spatial Data Standards for Facilities Infrastructure and Environment
SI = Site Inspection
STSC = Safety Trained Supervisor Construction
TNI = The NELAC Institute
TO = Task Order
USACE = United States Army Corps of Engineers
UT = Utah
VA = Virginia
WA = Washington

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QAPP Worksheet #6: Communication Pathways

Worksheet #6 documents the issues (communication drivers) that trigger the need to communicate with other project personnel or stakeholders. The purpose of **Worksheet #6** is to ensure there are procedures in place for providing the appropriate notifications and generating the appropriate documentation when handling important communications, including those involving regulatory interfaces, unexpected events, emergencies, non-conformances, and stop-work orders.

Communication Driver	Organization	Name	Contact Information	Procedure (Timing, Pathway, Documentation)
Program Manager decisions and modification	USACE, Baltimore District Project Manager USACE, Omaha District Project Manager USACE, Sacramento District Project Manager USACE, Seattle District Project Manager USACE, Seattle District Project Manager USACE, Louisville District Project Manager USACE, Alaska District Project Manager	Tim Peck, PG, PMP Steve Gragert, CHMM James Lukasko Karah Haskins Briana Niestrom Craig Coombs, PE, PMP Andrea Beausang	410-962-3416 timothy.j.peck@usace.army.mil 402-995-2743 steve.p.gragert@usace.army.mil 916-557-5392 james.i.lukasko@usace.army.mil 206-764-6964 karah.A.haskins@usace.army.mil 206-764-3498 Briana.c.niestrom@usace.army.mil 502-315-6324 Craig.A.Coombs@usace.army.mil 907-753-2557 Andrea.L.Beausang@usace.army.mil	Initiate award of work and options. Track project progress through monthly reporting and daily field reporting. Stop work for quality or performance concerns.

Communication Driver	Organization	Name	Contact Information	Procedure (Timing, Pathway, Documentation)
Program Technical Review	ARNG	Bonnie Packer, PhD Pamela Hess Joe Davis Mark Leeper, PG Amanda Sullivan, MS	703-607-7977 bonnie.m.packer.ctr@mail.mil 703-601-6818 pamela.s.hess.mil@mail.mil 615-791-1139 joe.b.davis36.ctr@mail.mil 804-516-3529 mark.s.leeper.ctr@mail.mil 304-642-6000 Amanda.d.sullivan7.ctr@mail.mil	The AECOM PM will obtain ARNG technical review and concurrence of the QAPP and project documents and any field modifications/QAPP changes as necessary. All approved modifications will be included in QAPP revisions (prior to field work). ARNG technical review and comments will be incorporated into the QAPP and project documents and a record of ARNG comments saved in project files for documentation.
Installation interface	Wisconsin Department of Military Affairs (WIDMA)	Brendon Manglos Theresa Brandabur	608-242-3361 Brendon.manglos@wisconsin.gov 608-242-3653 theresa.brandabur@wisconsin.gov	Communicate project scope/schedule and coordinate logistics between project team and installation personnel on an as-needed basis, documented via phone records and emails.
Regulatory agency interface (Wisconsin Department of Natural Resources)				Communicate technical approaches and decisions directly to regulatory agencies' representative(s) on an as-needed basis, documented via phone records and emails.
Community/ media interface				Communicate information directly to communities or media on an as-needed basis.

Communication Driver	Organization	Name	Contact Information	Procedure (Timing, Pathway, Documentation)
Manage all project phases Field progress reports Field modifications/QAPP changes	AECOM PM	Rosa Gwinn, PhD, PG	301-944-1468 rosa.gwinn@aecom.com	All materials and information about the project will be forwarded from the AECOM PM to ARNG/ USACE. Any field or laboratory changes will be coordinated with Karah Haskins (USACE), Briana Niestrom (USACE), Amanda Sullivan (ARNG), and Theresa Brandabur (WIDMA). The AECOM PM will obtain ARNG/ USACE approval/ concurrence for field modifications/ QAPP changes as necessary. All approved modifications will be included in QAPP revisions (prior to field work) or field change request forms (during field work), and resolution/ corrective action identified.
	AECOM SI Senior Lead	Jacquelyn Harrington, CHMM	402-952-2533 jacquelyn.harrington@aecom.com	Support AECOM PM in implementing SI tasks/procedures. Disseminate programmatic information from PM to SI Task Managers. Serve as lead verifier for SI documents.
	AECOM SI Task Manager			Responsible for overseeing preparation of SI QAPP and SI Report. Oversee daily activities and site-related communications. Communicate directly with SH&E manager.
	AECOM QC Officer	Sarah Gettier	301-944-0159 sarah.gettier@aecom.com	Oversee/conduct quality audits to assure field program performed in accordance with approved protocols. Support AECOM PM, Technical Task Manager, and Team Leaders to assure quality reviews are completed on project deliverables, including consistency and conformance with applicable regulatory and DoD guidance and with industry practices. Work with Project Chemist to resolve performance problems with contracted analytical laboratory.
Analytical laboratory modifications and performance problems	AECOM Project Chemist / Data Validator	Naoum Tavantzis	301-267-8761 naoum.tavantzis@aecom.com	Notify AECOM PM and QC Officer in a timely manner of performance problems encountered by the contracted analytical laboratory. PM will secure approval for modifications to the QAPP as necessary from ARNG/ USACE. All approved modifications will be included in Nonconformance and Corrective Action Report.

Communication Driver	Organization	Name	Contact Information	Procedure (Timing, Pathway, Documentation)
Data verification issues (e.g., incomplete records) and data validation issues (e.g., non-compliance with procedures)	AECOM Project Chemist / Data Validator	Naoum Tavantzis	301-267-8761 naoum.tavantzis@aecom.com	Verify/validate all analytical chemistry sample results from analytical laboratories with criteria developed in this QAPP and deliver to the PM and the Project QA Managers.
Data review corrective actions	AECOM Project Chemist / Data Validator	Naoum Tavantzis	301-267-8761 naoum.tavantzis@aecom.com	Notify Laboratory PMs to identify resolution/corrective actions.
Sample receipt variances	Pace Gulf Coast	Amanda Cox	225-214-7047 amanda.cox@pacelabs.com	Report all project non-conformances and problems to the AECOM Project Chemist.
Laboratory QC variances				Report all project non-conformances and problems to the AECOM Project Chemist.
Analytical corrective actions				Report all project non-conformances and problems to the AECOM Project Chemist.
Laboratory modifications and performance problems				Report all project non-conformances and problems to the Pace Gulf Coast PM. Pace Gulf Coast PM will report to AECOM Project Chemist.

Notes:

AECOM = AECOM Technical Services, Inc.
ARNG = Army National Guard
DoD = Department of Defense
SH&E = Safety, Health, and Environment
PM = Project Manager
QA = quality assurance
QAPP = Quality Assurance Project Plan
QC= quality control
SI = Site Inspection
USACE = United States Army Corps of Engineers
WIARNG = Wisconsin Army National Guard
WIDMA = Wisconsin Department of Military Affairs

QAPP Worksheet #9: Technical Project Planning Session Summary

This worksheet serves as a record of future Technical Project Planning (TPP) sessions. The intent is to provide a concise record of participants, key decisions or agreements reached, and action items. Minutes will be approved by all participants prior to being implemented into the QAPP Addendum (TPP Meeting Minutes, **Appendix A**).

AECOM will implement the TPP process as listed in Engineer Manual 200-1-2 (USACE, 2016) including facility meetings in a professional and organized manner to obtain consensus on specific Data Quality Objectives (DQOs) for SI work. Three meetings will be held (in person and/ or teleconference) per the Performance Work Statement as described below:

- TPP Meeting 1 - Discuss DQOs (pre-work plan) and CSM
- TPP Meeting 2 - Finalize work plan technical approach
- TPP Meeting 3 - Verify all data gaps have been filled and finalize SI Report

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QAPP Worksheet #10: Conceptual Site Model

The information presented in this section was gathered during the PA at West Bend AASF #1. The PA process included the following tasks:

- Reviewed data resources to obtain information relevant to suspected PFAS releases;
- Conducted a site visit on 8 May 2019;
- Interviewed current Wisconsin ARNG (WIARNG) personnel, WIARNG environmental managers, and operations staff;
- Completed visual site inspections (VSI) at known or suspected PFAS release locations and documented with photographs;
- Developed CSM(s) to outline the potential release and pathway of PFAS for the Area(s) of Interest (AOIs) and the ARNG facility.

The findings of the PA are summarized in this worksheet. The text within this worksheet was taken directly from the PA report. Additional details about West Bend AASF #1 can be found in the PA Report (AECOM, 2019).

Facility Location and Description

The West Bend AASF #1 is in Washington County, Wisconsin, approximately 2 miles east of West Bend, 30 miles northwest of Milwaukee, and 75 miles northeast of Madison (**Figure 10-1**). The facility is accessible from East Washington Street by Chopper Drive and Trenton Road.

The West Bend AASF #1 was constructed in 2004 on a parcel of land, approximately 35-acres, owned by the City of West Bend, and leased to the WIARNG. The current lease agreement expires September 2075. The current West Bend AASF #1 facilities include administrative offices, classrooms, and hangars for the operation, maintenance, and repair of WIARNG rotary-winged aircraft.

Facility Environmental Setting

The West Bend AASF #1 lies within the Milwaukee River Basin, which encompasses several land tributaries to the Milwaukee River. The topography of the area is comprised of rolling hills and numerous drumlins. The elevation of the facility is approximately 896 feet above mean sea level. The surrounding area is covered by cropland, grasslands, wooded area, and wetlands (Wisconsin Department of Natural Resources [WIDNR, 2001]).

Geology

The West Bend AASF #1 is situated in the Southeast Glacial Plains, as defined by the WIDNR Ecological Classification System. The Southeast Glacial Plains are characterized for having a rolling topography with silt loam soils, an outstanding array of glacial landforms, and numerous wetlands (WIDNR, 2015). Bedrock in the area consists of layers of dolomite and shale that range in thickness from 200 feet to greater than 400 feet. The bedrock ranges in age from Cambrian sandstone to Silurian Age, including the Maquoketa. The bedrock is underlain by sedimentary rock formed by volcanism from the Precambrian Age to the Middle Proterozoic Age. During the Pleistocene Age, glaciers invaded Wisconsin from the north and modified the land surface by caving and gouging out soft bedrock and depositing hills and ridges of sand and gravel, as well as flat lake beds of sand, silt, and clay (Wisconsin Geological and Natural History Survey, 2005).

Hydrogeology

The West Bend AASF #1 is within the Eastern Dolomite Aquifer, also known as the Silurian or Niagaran Aquifer. The aquifer lies above a fine-grained layer of shale and produces water from interconnected cracks and pores. The Eastern Dolomite Aquifer is thickest along the east side of Wisconsin and thins to the west. Below the Eastern Dolomite Aquifer lies the Cambrian or Cambrian-Ordovician Aquifer. This aquifer has sandstone and dolomite that yields water from the spaces or pores between the sand grains or from cracks and fractures (Wisconsin Geological and Natural History Survey, 2019). The West Bend AASF #1 is within the Milwaukee River Basin, which includes six watersheds.

Groundwater is drawn from sand and gravel aquifers and from deeper fractured and weathered bedrock or sedimentary rock. Depth to groundwater in the area is approximately 10 feet below ground surface. The shallow groundwater on the west and east side of the facility is likely to flow towards Wingate Creek. Groundwater in the bedrock aquifers is expected to flow generally east towards Lake Michigan. Aquifer recharge is predominantly through infiltration of precipitation, although some recharge occurs from open water sources (Stantec Consulting Services, Inc., 2018).

No potable water wells are located within the boundary of the West Bend AASF #1; however, unknown well types exist within 4 miles of the site (**Figure 10-2**). These wells are primarily upgradient of the West Bend AASF #1 and are not likely to be impacted by potential PFAS releases. Drinking water for the West Bend AASF #1 is supplied by the City of West Bend, which uses the Lake Michigan and the bedrock aquifers as its drinking water source (WIDNR, 2001).

The Third Unregulated Contaminant Monitoring Rule (UCMR 3) sampling program was an addition to the 1996 Safe Drinking Water Act which requires USEPA to, every five years, issue a new list of no more than 30 unregulated contaminants to be monitored by public water systems. Six PFAS compounds are currently included as part of the UCMR 3 list. The UCMR 3 dataset was evaluated to determine which public water systems were sampled for PFAS within a 20-mile radius of a site. The City of West Bend public drinking water was sampled; results for the six PFAS compounds sampled were non-detect. No other public water system was sampled within 20 miles of the facility (USEPA, 2017a).

Hydrology

The West Bend AASF #1 is located between the Silver Creek-Milwaukee River Watershed and the Village of Newburg-Milwaukee Watershed (**Figure 10-3**). The tributary that runs between the West Bend AASF #1 and the Armory is Wingate Creek, which discharges to the Milwaukee River. The WIARNG armory is located on the east side of the West Bend AASF #1. The site is currently connected to the City of West Bend sanitary sewer system. On the west side of the facility, the surface water flows to the south and east towards the stormwater basin. On the east side of the facility, surface water flows northwest and southwest to Wingate Creek, then to the Milwaukee River.

Climate

The climate of West Bend consists of warm summers, and winters with freezing, dry, and windy months. Seasonally, temperatures vary from summer highs of 81.5 degrees Fahrenheit (°F) to winter lows of 9.1°F. The average temperature is 45.5°F. Average precipitation is 31.2 inches of rain, and the average snowfall is 43.3 inches (World Climate, 2019). The area is subject to severe storms in the winter.

Current and Future Land Use

West Bend AASF #1 is a controlled access facility with public roads and is adjacent to the West Bend Municipal Airport. The facility consists of a storage hangar, repair hangar, shops, and a two-story office area. Exterior features are vehicle parking areas, roads, aircraft parking, taxiways, and a 90-feet clear-span bridge. The West Bend Municipal Airport is owned and operated by the City of West Bend and provides private, commercial, corporate, cargo, and military air service. Future infrastructure improvements, land acquisitions, and land use controls are not anticipated to change.

Areas of Interest and Conceptual Site Models

PFAS were potentially released to soil and groundwater within the boundary of West Bend AASF #1 through a fire training exercise and hangar fire suppression system. Two AOIs were identified based on preliminary data and assumed groundwater flow directions. These AOIs are described below and presented on **Figure 10-4**.

In general, the potential PFAS exposure pathways are ingestion and inhalation. Human exposure via the dermal contact pathway may occur, and current risk practice suggests it is an insignificant pathway compared to ingestion; however, exposure data for dermal pathways are sparse and continue to be the subject of PFAS toxicological study.

AOI 1 is the Fire Suppression System Release area where 20-40 gallons of 3 percent AFFF were dispensed annually onto the grass behind the building. The main hangar fire suppression system is supplied by two 500-gallon tanks filled with 3 percent AFFF. The AFFF tanks, pumps, and four bulk 55-gallon drums of AFFF that supply the fire suppression system are housed in a building connected to the hangar.

Ground-disturbing activities to surface soil at AOI 1 could result in site worker, construction worker, and trespasser exposure to potential PFAS contamination. Therefore, the exposure pathways for inhalation of soil particles and ingestion of soil are potentially complete for these receptors. Ground-disturbing activities to subsurface soil could result in construction worker exposure via inhalation of soil particles and ingestion of subsurface soil. Therefore, the inhalation and ingestion pathways for these receptors are considered potentially complete.

The stormwater drain within AOI 1 flows through the stormwater system to the south, where it discharges to a stormwater basin on the south side of the property. Additionally, if there is flooding at the stormwater basin, surface water can overflow to the Milwaukee River, which is to the south; therefore, the exposure pathway for surface water and sediment via ingestion is potentially complete for site workers, construction workers, trespassers, and off-facility recreational users.

AOI 1 is located side-gradient to two unknown well types and downgradient of one unknown well type. These wells could be potentially impacted by PFAS releases at AOI 1; therefore, the exposure pathway for ingestion via groundwater for construction workers and off-facility residents is potentially complete.

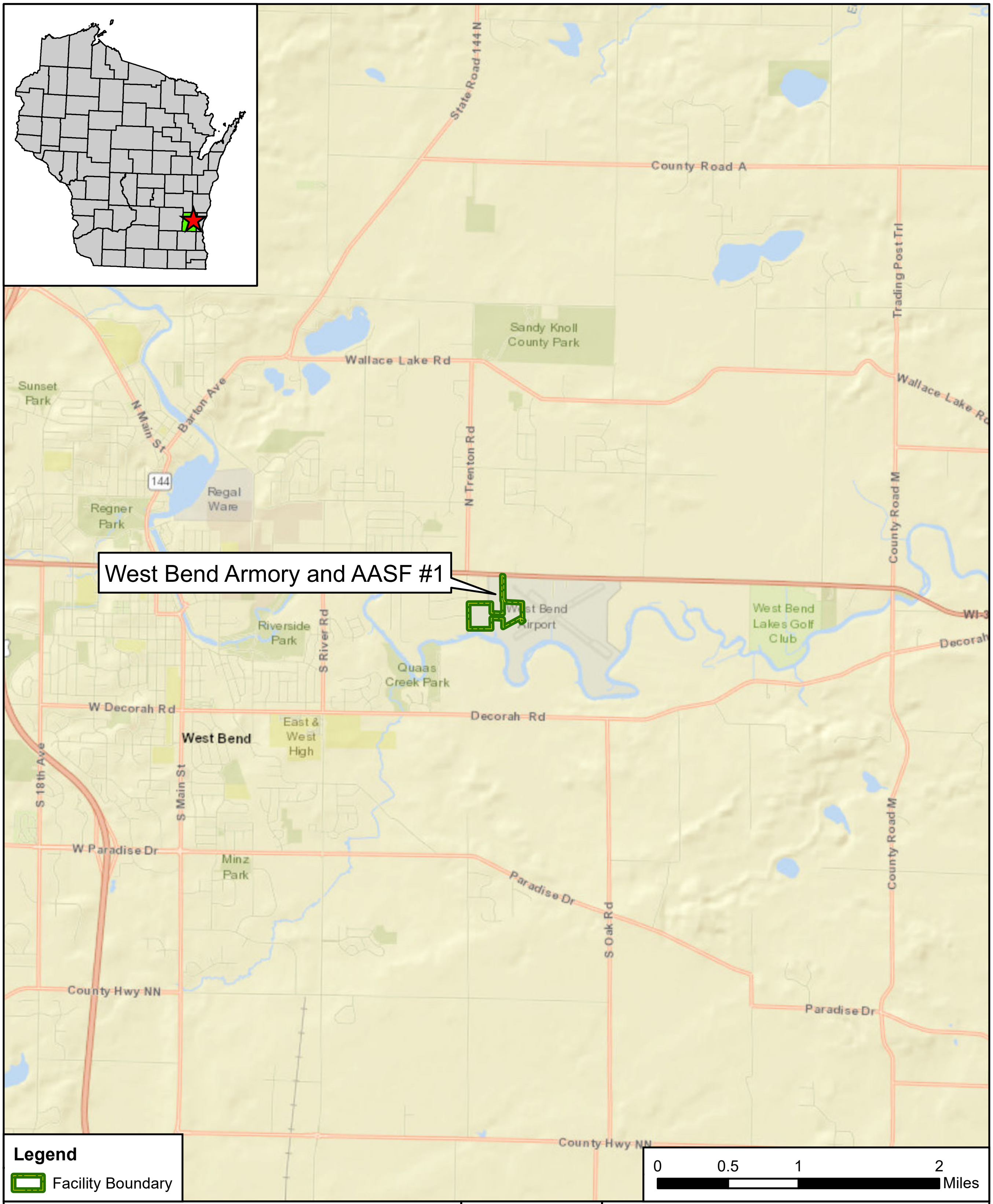
AOI 2 Tri-Max™ Release

AOI 2 is the Tri-Max™ Release area, where a one-time training event with one Tri-Max™ fire extinguisher occurred in a grassy area located on the east side of the Armory. The exact date, amount, and concentration of AFFF used are unknown.

Ground-disturbing activities to surface soil at AOI 2 could result in site worker, construction worker, and trespasser exposure to potential PFAS contamination. Therefore, the exposure pathways for inhalation of soil particles and ingestion of soil are potentially complete for these receptors. Ground-disturbing activities to subsurface soil could result in construction worker exposure via inhalation of soil particles and ingestion of subsurface soil. Therefore, the inhalation and ingestion pathways for this receptor are considered potentially complete.

The surface water flows northwest and southwest toward Wingate Creek, and ultimately to the Milwaukee River. Based on the overlying surface water flow at AOI 2, exposure pathways for ingestion via surface water/sediment for site workers, construction workers, and off-facility recreational users are potentially complete.

AOI 2 is located side-gradient to two unknown well types and downgradient of one unknown well type. These wells could be potentially impacted by PFAS releases at AOI 2; therefore, the exposure pathway for ingestion via groundwater for construction workers and off-facility residents is potentially complete.



CLIENT	ARNG			
Site Inspection for PFAS at West Bend Armory and AASF #1, WI				
REVISED	1/30/2020	GIS BY	MS	1/30/2020
SCALE	1:63,360	CHK BY	SI	1/30/2020
Base Map: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI,		PM	RG	1/30/2020

N

Facility Location

AECOM

12420 Milestone Center Drive
Germantown, MD 20876

Figure 10-1

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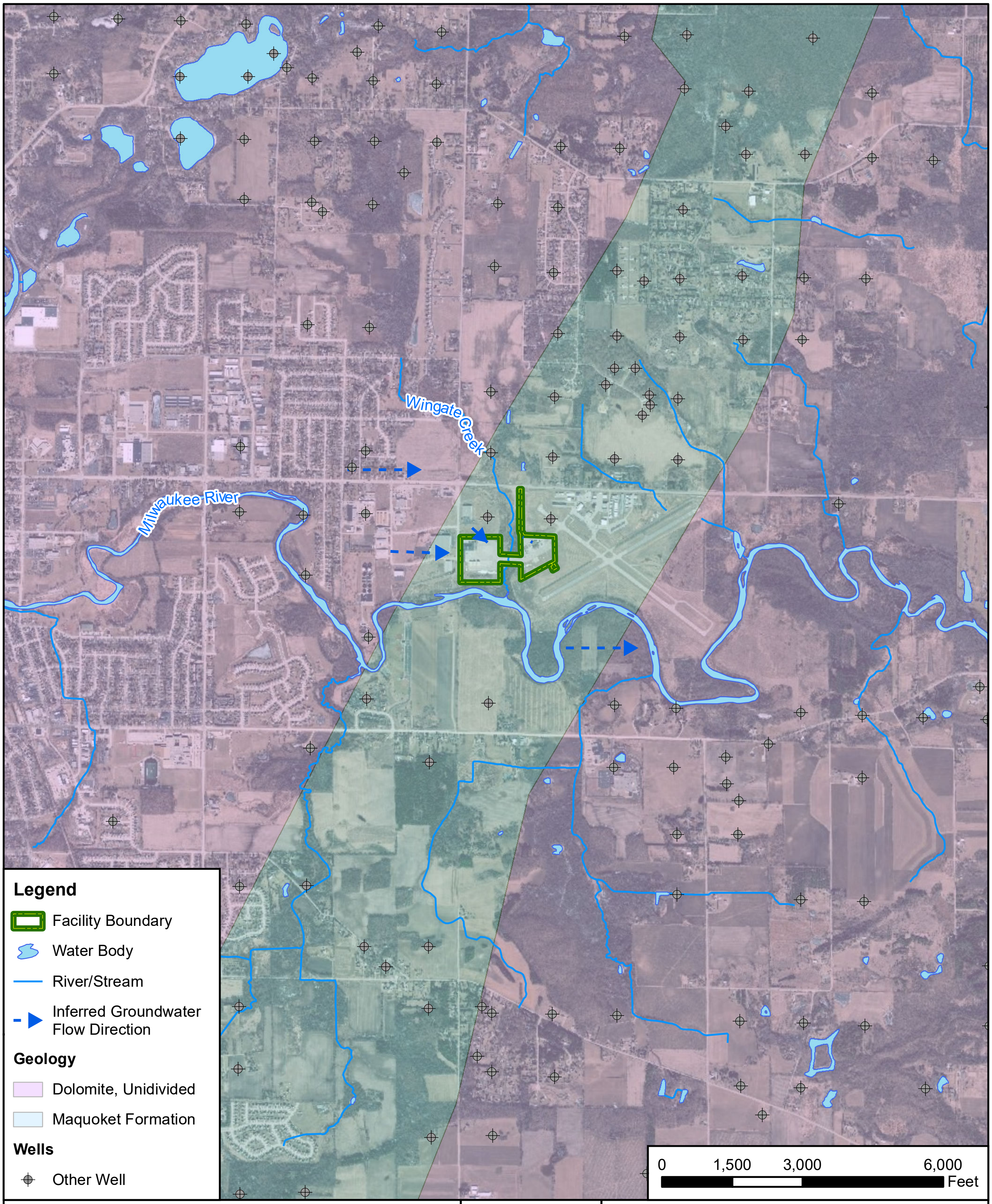


CLIENT ARNG			
Site Inspection for PFAS at West Bend, WI			
REVISED 3/31/2020	GIS BY	MS	3/31/2020
SCALE 1:36,000	CHK BY	SI	3/31/2020
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,	PM	RG	3/31/2020

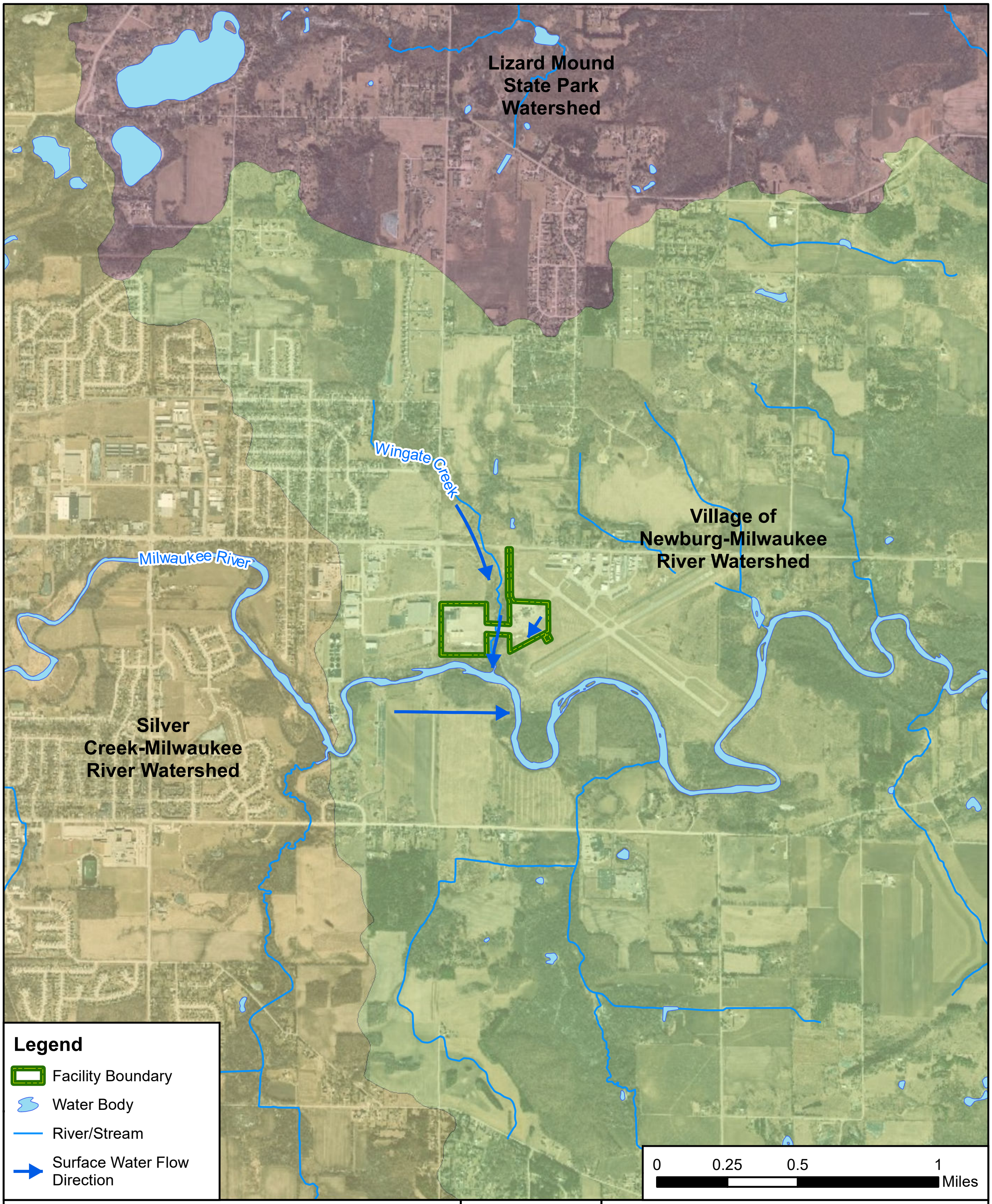
N

Groundwater Features

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 10-2

C:\Users\grace.canham\AECOM Directory\Stankevich, Michael - ARNG_PFAS_GIS_60552172\MXDs\WI\West_Bend_Figures\West_Bend_SI_Figures\Fig_10-2_West_Bend_Groundwater.mxd



CLIENT	ARNG			
Site Inspection for PFAS at West Bend, WI				
REVISED	1/30/2020	GIS BY	MS	1/30/2020
SCALE	1:31,680	CHK BY	SI	1/30/2020
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	1/30/2020

N

Surface Water Features

AECOM

12420 Milestone Center Drive
Germantown, MD 20876

Figure 10-3

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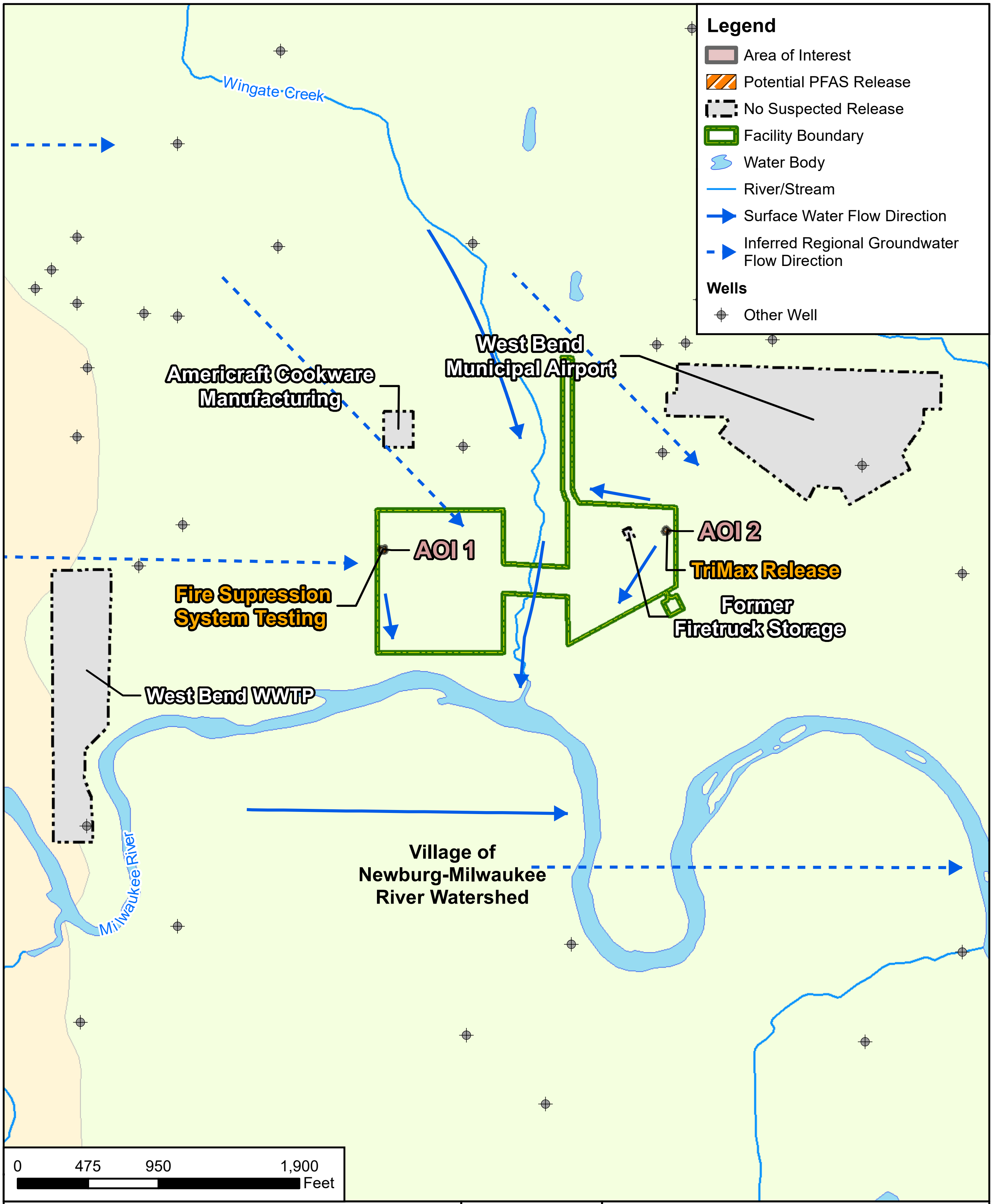

CLIENT	ARNG			
Site Inspection for PFAS at West Bend, WI				
REVISED	9/14/2020	GIS BY	MS	9/14/2020
SCALE	1:11,400	CHK BY	SI	9/14/2020
Base Map:		PM	RG	9/14/2020

N

Areas of Interest

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 10-4

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QAPP Worksheet #11: Project/ Data Quality Objectives

DQOs specify the level of data required to support the decision-making process for a project. Specific DQOs will be established for each site and will be described in this UFP-QAPP Addendum. These DQOs will follow the USEPA's seven-step iterative process for DQO development. DQOs are influenced by the ongoing project planning discussions with stakeholders and will be updated if new consensus decisions materialize.

The development of DQOs will follow the seven steps of USEPA's DQO process:

1. State the Problem

The presence of PFAS, which may pose a risk to human health or the environment, in environmental media at the facility is currently unknown. PFAS are classified as emerging environmental contaminants that are garnering increasing regulatory interest due to their potential risks to human health and the environment. The regulatory framework for managing PFAS at both the federal and state level continues to evolve. The DoD has adopted a policy to retain facilities in the CERCLA process based on risk-based screening levels (SLs) for soil and groundwater, as described in a memorandum from the Office of the Secretary of Defense (OSD) dated 15 October 2019 (Assistant Secretary of Defense, 2019). The ARNG program under which this SI will be performed follows this DoD policy. Should the maximum site concentration for sampled media exceed the SLs established in the OSD memorandum, the site will proceed to the next phase under CERCLA. The SLs established in the OSD memorandum apply to three compounds: PFOS, PFOA, and PFBS. Additionally, the USEPA issued drinking water lifetime Health Advisories (HAs) for PFOA and PFOS in May 2016 (USEPA 2016a; USEPA, 2016b). The USEPA HAs may also be used as SLs for groundwater samples collected at the facility boundary where off-facility drinking water wells are present downgradient. This determination will be based on localized groundwater flow direction established during the SI. The SLs are presented in **Worksheet #15** of this QAPP Addendum.

The following quotes from Army policy documents form the basis for this project:

- "The Army will research and identify locations where PFOS and/or PFOA containing products, such as AFFF, are known or suspected to have been used. Installations shall coordinate with installation/facility fire response or training offices to identify AFFF use or storage locations. The Army will consider fire training areas, AFFF storage locations, hangars/buildings with AFFF suppression systems, fire equipment maintenance areas, and areas where emergency response operations required AFFF use as possible source areas. In addition, metal plating operations, which used certain PFOS-containing mist suppressants, shall be considered possible source areas."
- "Based on a review of site records…determine whether a CERCLA PA is appropriate for identifying PFOS/PFOA release sites. If the PA determines a PFOS/PFOA release may have occurred, a CERCLA SI shall be conducted to determine presence/absence of contamination."
- "Identify sites where perfluorinated compounds are known or suspected to have been released, with the priority being those sites within 20 miles of the public systems that tested above USEPA HA levels." (USEPA, 2016a; USEPA, 2016b).

2. *Identify the Goals of the Study*

The goals of the SI include the following:

1. Determine the presence or absence of PFOA, PFOS, and PFBS at or above SLs at West Bend AASF #1.
2. Develop information to potentially eliminate a release from further consideration because it is determined that it poses no significant threat to human health or the environment.
3. Determine the potential need for a TCRA (applies to drinking water only). The primary actions that will be considered include provision of alternative water supplies or wellhead treatment.
4. Collect or develop data to evaluate the release.
5. Collect data to better characterize the release for more effective and rapid initiation of an RI (if determined necessary).
6. If PFAS are determined to be present, aim to evaluate whether the concentrations can be attributed to on-facility or off-facility sources that were identified within 4 miles of the installation as part of the PA (e.g., fire stations, major manufacturers, other DoD facilities).

3. *Identify Information Inputs*

Primary information inputs include:

- The PA Report for West Bend AASF #1;
- Analytical data collected during other environmental sampling efforts at the West Bend AASF #1;
- Groundwater, surface water, soil, and/or sediment sample data collected (if applicable) in accordance with this QAPP Addendum; and
- Field data collected including groundwater elevation and water quality parameters measured using a multi-parameter water quality meter.

4. *Define the Boundaries of the Study*

The scope of the SI is horizontally bounded by the property limits of West Bend AASF #1. Off-facility sampling is not included in the scope of this SI; however, if future off-facility sampling is required, the proper stakeholders will be notified, and necessary rights of entry will be obtained by ARNG with the property owner(s). The scope of the SI is vertically bounded as follows: groundwater (5 - 10 feet below ground surface [bgs]), soil from direct-push technology (DPT) borings (10 feet bgs), and surface soil (0 to 2 feet bgs). The temporal boundaries of the study are limited by seasonal conditions; the field work for the scope will be performed Summer 2020.

5. *Develop the Analytic Approach*

All samples will be analyzed by a DoD Environmental Laboratory Accreditation Program (ELAP) and National Environmental Laboratory Accreditation Program (NELAP) certified laboratory [i.e., Pace Gulf Coast (formerly Gulf Coast Analytical Laboratory [GCAL])]. Data will be compared to SLs (**Worksheet #15**) and decision rules as defined in the PQAPP will be applied concerning actions to be taken based on any SL exceedances. Decision rules have been developed for groundwater and soil that will apply to all data collected. These rules will govern response actions based on the results of the SI sampling effort.

The decision rules described in the tables at the end of this section (**Tables 11-1** and **11-2**) identify actions based on the following:

<u>Groundwater/Surface Water</u>:

1. Is there a human receptor within 4-miles of the facility?
2. What is the concentration of PFOA, PFOS, and PFBS at the potential source area?
3. What is the concentration of PFOA, PFOS, and PFBS at the boundary?
4. What does the CSM suggest in terms of source, pathway, and receptor?

<u>Soil/Sediment:</u>

1. What is the concentration of PFOA, PFOS, and PFBS in shallow surface soil or sediment (0-2 feet bgs)?
2. What is the concentration of PFOA, PFOS, and PFBS in soil (i.e., capillary fringe) (10 feet bgs)?
3. What does the CSM suggest in terms of source, pathway, and receptor?

Soil and groundwater will be collected (if applicable) from potential source areas identified in the PA. Based on previous investigations, groundwater is expected to be encountered within the shallow perched aquifer no deeper than 30 feet bgs. Proposed SI sample locations and depths are defined in **Worksheet #17**.

6. *Specify Performance/Acceptance Criteria*

See **Worksheet #37**.

7. *Develop the Detailed Plan for Obtaining Data*

See **Worksheet #17** and **#18**.

Table 11-1: Groundwater/Surface Water Decision Rules

Scenario	PFAS Concentration Range	Response Action (Off-facility human receptor within 4 miles)	Response Action (No off-facility human receptor within 4 miles)
Scenario 1	ND	No further action required during SI phase.	No further action required during SI phase.
Scenario 2	> ND (any positive detection) and < SLs	1.) Assess CSM including: - Data reliability and bias - Migration via groundwater flow (i.e., groundwater flow towards potential receptors) - Flow to surface water bodies, drinking water intakes - Distance from boundary to receptor - Aquifer where drinking water well(s) are screened - Estimated timeframe of release(s) 2.) No further action during SI Phase at this time. ARNG may consider need for additional evaluation in the future for groundwater.	1.) Assess CSM as described. 2.) No further action during SI Phase at this time. ARNG may consider need for additional evaluation in the future for groundwater.
Scenario 3	> SLs	1.) Assess CSM as described above and: - Potential off-facility alternative PFAS sources 2.) If exceedance of SLs is near facility boundary and the assessment of the CSM implies unacceptable risk to human health caused by a PFAS release attributable to ARNG activities, ARNG may initiate off-facility sampling protocol. 3.) Proceed to RI.	1.) Assess CSM as described. 2.) Proceed to RI.

Notes:

Notes:

a) Surface water samples are only applicable at facilities where the CSM indicates surface water is used for drinking water or where the facility may discharge to surface water used for drinking water.

< = less than
> = greater than
ARNG = Army National Guard
CSM = conceptual site model
ND = non-detect
PFAS = per- and polyfluoroalkyl substances
RI = Remedial Investigation
SI = Site Inspection
SL = screening level

Table 11-2: Soil Data Decision Rules

Scenario	PFAS Concentration Range	Response Action
Scenario 1	ND	No further action during SI Phase.
Scenario 2	> ND (any positive detection) and < SLs	1. Assess CSM including: - Potential for particulate runoff (i.e., transport via surface water) - Nearby receptors and land use (residential or industrial/commercial worker) at the source location (i.e., potential for incidental ingestion) - Depth to groundwater; distance to nearby surface water body - Comparison of soil concentrations to groundwater concentrations at the source or nearby surface water body - Data reliability and bias 2. No further action for soil during SI Phase at this time. ARNG may consider need for additional evaluation in the future.
Scenario 3	> SLs	1. Assess CSM as above and: - Comparison of soil concentrations to groundwater concentrations at the source and downgradient at the boundary - Comparison of soil concentrations to surface water concentrations at or near the source and downgradient at the boundary 2. Proceed to RI.

Notes:
> = greater than
ARNG = Army National Guard
CSM = conceptual site model
ND = non-detect
OSD= Office of the Secretary of Defense
PFAS = per- and polyfluoroalkyl substances
SI = Site Inspection
SL = screening level

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Final PQAPP Worksheet #12: Measurement Performance Criteria

Matrix	Groundwater and Surface Water
Analytical Group	PFAS
Concentration	Low

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for S, A or Both (S&A)
Accuracy/Bias	LCS/LCSD and MS/MSD shall be spiked with all analytes. Analyte recovery limits per Worksheet #15	LCS/LCSD, MS/MSD	A
Precision	Laboratory duplicates analysis should have an RPD <30%	LCS/LCSD, MS/MSD	A
Precision	Values > 5X LOQ: RPD must be ≤30% Values ≤ 5X LOQ: Absolute difference ≤ 2x the LOQ	Field Duplicates	S
Accuracy/ Contamination	No analytes detected > 1/2 LOQ or >1/10 the amount measured in any sample	Method Blank, Field Reagent Blanks, Equipment Rinsate Blanks	A
Sensitivity	Detection limits ≤ to acceptance criteria Instrument Sensitivity Check concentrations must be within ±30% of their true values.	Detection Limits, Instrument Sensitivity Check	A
Completeness	Completeness criteria will be considered met if 100% of all planned sample data (as requested on CoC in lab reports and EDD; including requested reanalyses) are collected	Reported Sample Data	S & A
Comparability	Based on accuracy and media comparison	Use of standardized SOPs in field and laboratory	S & A
Comparability	Serial dilution preparation (allowed due to known high concentrations of PFAS, notation of 'foamed' on CoC is considered documented approval)	Field shake test	S & A

Notes:

% = percent
A= analytical
CoC = chain of custody
EDD = electronic data deliverable
LCS/LCSD = laboratory control sample/ laboratory control sample duplicate
LOQ = limit of quantitation
MS/MSD = matrix spike/ matrix spike duplicate
QC = quality control
RPD = relative percent difference
S = sampling
SOP = standard operating procedure

< = less than
> = greater than
≤ = less than or equal to

Matrix Drinking Water
Analytical Group PFAS
Concentration Low

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for S, A or Both (S&A)
Accuracy/Bias	LCS/LCSD and MS/MSD shall be spiked with all analytes. Analyte recovery limits per Worksheet #15	LCS, LCSD, MS, MSD	A
Precision	Laboratory duplicates analysis should have a RPD <30%	LCS/LCSD, MS/MSD	A
Precision	Values > 5X LOQ: RPD must be ≤30% Values ≤ 5X LOQ: Absolute difference ≤ 2x the LOQ	Field Duplicates	S
Accuracy/ Contamination	No analytes detected > 1/2 LOQ or >1/10 the amount measured in any sample	Method Blank, Field Reagent Blanks, Equipment Rinsate Blanks	A
Sensitivity	Detection limits ≤ to acceptance criteria Instrument Sensitivity Check concentrations must be within ±30% of their true values.	Detection Limits, Instrument Sensitivity Check	A
Completeness	Completeness criteria will be considered met if 100% of all planned sample data (as requested on CoC in lab reports and EDD; including requested reanalyses) are collected	Reported Sample Data	S & A
Comparability	Based on accuracy and media comparison	Use of standardized SOPs in field and laboratory	S & A

Notes:
< = less than
> = greater than
≤ = less than or equal to
A= analytical
CoC = chain of custody
EDD = electronic data deliverable
LCS/LCSD = laboratory control sample/ laboratory control sample duplicate
LOQ = limit of quantitation
MS/MSD = matrix spike/ matrix spike duplicate
QC = quality control
RPD = relative percent difference
S = sampling
SOP = standard operating procedure

Matrix Soil and Sediment
Analytical Group PFAS
Concentration Low

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy/Bias	LCS/LCSD and MS/MSD shall be spiked with all analytes. Analyte recovery limits 70-130%	LCS, LCSD, MS, MSD	A
Precision	Laboratory duplicates analysis should have a RPD <30%	LCS/LCSD, MS/MSD	A
Precision	Values > 5X LOQ: RPD must be ≤30% Values ≤ 5X LOQ: Absolute difference ≤ 2x the LOQ	Field Duplicates	S
Accuracy/ Contamination	No analytes detected > 1/2 LOQ or >1/10 the amount measured in any sample	Method Blank, Field Reagent Blanks, Equipment Rinsate Blanks	A
Sensitivity	Detection limits ≤ to acceptance criteria Instrument Sensitivity Check concentrations must be within ±30% of their true values.	Detection Limits, Instrument Sensitivity Check	A
Completeness	Completeness criteria will be considered met if 100% of all planned sample data (as requested on CoC in lab reports and EDD; including requested reanalyses) are collected	Reported Sample Data	S & A
Comparability	Based on accuracy and media comparison	Use of standardized SOPs in field and laboratory	S & A

Notes:
< = less than
> = greater than
≤ = less than or equal to
A= analytical
CoC = chain of custody
EDD = electronic data deliverable
LCS/LCSD = laboratory control sample/ laboratory control sample duplicate
LOQ = limit of quantitation
MS/MSD = matrix spike/ matrix spike duplicate
QC = quality control
RPD = relative percent difference
S = sampling
SOP = standard operating procedure

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Final PQAPP Worksheet #13: Secondary Data Uses and Limitations

Secondary data sources, uses, and limitations are tabulated below. Original source documents were reviewed for uncertainty discussions that may identify additional or more subtle data limitations.

Data Type	Source	Data Uses Relative to Current Project	Factors Affecting Reliability of Data and Limitations on Data Use
Meteorological	National Weather Service	Estimates of seasonal fluctuations in precipitation.	Meteorological data is generally for a regional area. Actual site conditions may vary.
Topographic	USGS	Inferred surface water and wash flow pathways based on local topography at each site. Groundwater flow maps will ultimately rely upon groundwater measurements from monitoring wells.	Topography of some sites may have been altered by building or grading activities.
Soil and groundwater chemistry, groundwater monitoring data, and data gaps identification	Historical site reports	Applicable to the evaluation of historical site conditions in soil and groundwater to supplement data being collected under this delivery order.	The data may not represent current conditions because of the age of some of the data. Reliability of second- or third-party data quality.
Historical site records (i.e., material inventories)	Purchase records, site inventories, onsite records, safety data sheets	Applicable to the evaluation of potential constituents of concern and source areas.	Records may be incomplete or inaccurate.
Periodicals (i.e., news articles)	Local newspapers, magazines or other periodicals	Applicable to the evaluation of the use of potential constituents of concern at off-facility locations or mutual use/ aid agreements with local fire department or other entities.	Records may be incomplete or inaccurate.

Notes:
USGS = United States Geological Survey

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QAPP Worksheet #14 & #16: Project Tasks and Schedule

The following table describes the main tasks and schedule for the SI:

Task	Start Date	End Date
Pre-mobilization	September 2020	September 2020
Mobilization	October 2020	October 2020
Field Work	October 2020	October 2020
Demobilization	October 2020	October 2020
Data Review/ Validation	November 2020	December 2020
Reporting	December 2020	December 2020

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Final PQAPP Worksheet #15: Screening Limits and Laboratory-Specific Detection/ Quantitation Limits

Matrix: Groundwater/ Surface Water
Analyte Group: PFAS
Method: PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15

Analyte	CAS Number	Laboratory Control Spike Lower Control Limit (%)	Laboratory Control Spike Upper Control Limit (%)	Achievable Laboratory Limits		
				DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	65	140	1.70	4.0	10
Perfluoroheptanoic acid (PFHpA)	375-85-9	72	130	1.85	4.0	10
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	68	131	1.64	4.0	10
Perfluorononanoic acid (PFNA)	375-95-1	69	130	1.68	4.0	10
Perfluorooctanoic acid (PFOA)	335-67-1	71	133	1.80	4.0	10
Perfluorobutanesulfonic acid (PFBS)	375-73-5	72	130	1.47	4.0	10
Perfluorobutanoic acid (PFBA)	375-22-4	73	129	2.13	4.0	10
Perfluoropentanoic acid (PFPA)	2706-90-3	72	129	2.35	4.0	10
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	61	135	5.38	8.0	10
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	65	136	4.60	8.0	10
Perfluorodecanoic acid (PFDA)	335-76-2	71	129	1.65	4.0	10
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	71	132	2.76	4.0	10
Perfluorododecanoic acid (PFDoA)	307-55-1	72	134	2.45	4.0	10
Perfluorohexanoic acid (PFHxA)	307-24-4	72	129	1.94	4.0	10
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	65	144	2.56	4.0	10
Perfluoroundecanoic acid (PFUdA)	2058-94-8	69	133	1.86	4.0	10
6:2 Fluorotelomer sulfonate (6:2 FTS)	27619-97-2	64	140	1.79	4.0	10
8:2 Fluorotelomer sulfonate (8:2 FTS)	39108-34-4	67	138	1.63	4.0	10

Notes:
% = percent
CAS = Chemical Abstracts Service
DL= detection limit
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantitation
ng/L = nanograms per liter
PFAS = per- and polyfluoroalkyl substances
QSM =Quality Systems Manual
USEPA = United States Environmental Protection Agency

Matrix: Drinking Water
Analyte Group: PFAS
Method: USEPA Method 537.1

Analyte	CAS Number	Laboratory Control Spike Lower Control Limit (%)	Laboratory Control Spike Upper Control Limit (%)	Achievable Laboratory Limits		
				DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	70	130	5.38	8.0	10
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	70	130	4.60	8.0	10
Perfluorobutanesulfonic acid (PFBS)	375-73-5	70	130	1.47	4.0	10
Perfluorodecanoic acid (PFDA)	335-76-2	70	130	1.65	4.0	10
Perfluorododecanoic acid (PFDoA)	307-55-1	70	130	2.45	4.0	10
Perfluoroheptanoic acid (PFHpA)	375-85-9	70	130	1.85	4.0	10
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	70	130	1.64	4.0	10
Perfluorohexanoic acid (PFHxA)	307-24-4	70	130	1.94	4.0	10
Perfluorononanoic acid (PFNA)	375-95-1	70	130	1.68	4.0	10
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	70	130	1.70	4.0	10
Perfluorooctanoic acid (PFOA)	335-67-1	70	130	1.80	4.0	10
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	70	130	2.76	4.0	10
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	70	130	2.56	4.0	10
Perfluoroundecanoic acid (PFUnA)	2058-94-8	70	130	1.86	4.0	10

Notes:
% = percent
CAS = Chemical Abstracts Service
DL= detection limit
LOD = limit of detection
LOQ = limit of quantitation
ng/L = nanograms per liter
PFAS = per- and polyfluoroalkyl substances
QSM =Quality Systems Manual
USEPA = United States Environmental Protection Agency

Matrix: Soil/ Sediment
Analyte Group: PFAS
Method: PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15

Analyte	CAS Number	Laboratory Control Spike Lower Control Limit (%)	Laboratory Control Spike Upper Control Limit (%)	Achievable Laboratory Limits		
				DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	68	136	0.18	0.40	1.0
Perfluoroheptanoic acid (PFHpA)	375-85-9	71	132	0.13	0.40	1.0
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	67	130	0.14	0.40	1.0
Perfluorononanoic acid (PFNA)	375-95-1	72	129	0.090	0.40	1.0
Perfluorooctanoic acid (PFOA)	335-67-1	69	133	0.15	0.40	1.0
Perfluorobutanesulfonic acid (PFBS)	375-73-5	72	128	0.12	0.40	1.0
Perfluorobutanoic acid (PFBA)	375-22-4	71	135	0.13	0.40	1.0
Perfluoropentanoic acid (PFPA)	2706-90-3	69	132	0.15	0.40	1.0
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	61	139	0.19	0.40	1.0
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	63	144	0.28	0.40	1.0
Perfluorodecanoic acid (PFDA)	335-76-2	69	133	0.12	0.40	1.0
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	69	133	0.16	0.40	1.0
Perfluorododecanoic acid (PFDoA)	307-55-1	69	135	0.20	0.40	1.0
Perfluorohexanoic acid (PFHxA)	307-24-4	70	132	0.15	0.40	1.0
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	66	139	0.22	0.40	1.0
Perfluoroundecanoic acid (PFUdA)	2058-94-8	64	136	0.14	0.40	1.0
6:2 Fluorotelomer sulfonate (6:2 FTS)	27619-97-2	64	140	0.17	0.40	1.0
8:2 Fluorotelomer sulfonate (8:2 FTS)	39108-34-4	65	137	0.26	0.40	1.0

Notes:
% = percent
µg/kg = micrograms per kilogram
CAS = Chemical Abstracts Service
DL= detection limit
LC/MS/MS = liquid chromatography with tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantitation
PFAS = per- and polyfluoroalkyl substances
QSM =Quality Systems Manual
USEPA = United States Environmental Protection Agency

Matrix: Soil
Analyte Group: Wet Chemistry

Analyte	Method	Laboratory Control Spike Lower Control Limit (%)	Laboratory Control Spike Upper Control Limit (%)	Achievable Laboratory Limits		
				DL (mg/kg)	LOD (mg/kg)	LOQ (mg/kg)
Total Organic Carbon	9060A	90	110	150	200	250

Notes:
% = percent
DL= detection limit
LOD = limit of detection
LOQ = limit of quantitation
mg/kg = milligrams per kilogram
NA = not applicable

SLs for Soil and Groundwater

The DoD has adopted a policy to retain facilities in the CERCLA process based on conservative SLs for soil and groundwater, as described in a memorandum from the OSD dated 15 October 2019 (Assistant Secretary of Defense, 2019). The ARNG program under which this SI will be performed follows this DoD policy and should the maximum site concentration for sampled media exceed the SLs established in the OSD memorandum, the site will proceed to the next phase under CERCLA. The SLs established in the OSD memorandum apply to three compounds: PFOS, PFOA, and PFBS. Additionally, the USEPA issued drinking water lifetime Health Advisories (HAs) for PFOA and PFOS in May 2016 (USEPA 2016a; USEPA, 2016b). The USEPA HAs may also be used as SLs for groundwater samples collected at the facility boundary where off-facility drinking water wells are present downgradient. This determination will be based on localized groundwater flow direction established during the SI.

Analyte	CAS Number	Residential (Soil) (μg/kg)[a,b] 0-2 feet bgs	Industrial/ Commercial Composite Worker (Soil) (μg/kg)[a,b]	Tap Water (Groundwater) (ng/L)[a,b]	USEPA HA (Groundwater representative of Drinking Water) (ng/L)[d,e]
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	130	1,600	40	70[d]
Perfluoroheptanoic acid (PFHpA)	375-85-9	-	-	-	-
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	-	-	-	-
Perfluorononanoic acid (PFNA)	375-95-1	-	-	-	-
Perfluorooctanoic acid (PFOA)	335-67-1	130	1,600	40	70[d]
Perfluorobutanesulfonic acid (PFBS)	375-73-5	130,000	1,600,000	40,000	-
Perfluorobutanoic acid (PFBA)	375-22-4	-	-	-	-
Perfluoropentanoic acid (PFPA)	2706-90-3	-	-	-	-
N-ethyl perfluorooctanesulfonamidoacetic acid	2991-50-6	-	-	-	-
N-methyl perfluorooctanesulfonamidoacetic acid	2355-31-9	-	-	-	-
Perfluorodecanoic acid (PFDA)	335-76-2	-	-	-	-
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	-	-	-	-
Perfluorododecanoic acid (PFDoA)	307-55-1	-	-	-	-
Perfluorohexanoic acid (PFHxA)	307-24-4	-	-	-	-
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	-	-	-	-
Perfluoroundecanoic acid (PFUdA)	2058-94-8	-	-	-	-
6:2 Fluorotelomer sulfonate (6:2 FTS)	27619-97-2	-	-	-	-
8:2 Fluorotelomer sulfonate (8:2 FTS)	39108-34-4	-	-	-	-

Notes:

a.) Assistant Secretary of Defense, 2019. Risk Based Screening Levels Calculated for PFOS, PFOA, PFBS in Groundwater and Soil using USEPA's Regional Screening Level Calculator. HQ=0.1. 15 October 2019.

b.) The SL for surface soil (0 to 2 feet bgs) is based on incidental ingestion of soil (residential scenario); the SL for subsurface soil (industrial/commercial worker scenarios) and therefore will only be applied to the soil intervals reasonably anticipated to be encountered in these scenarios (2 to 15 feet bgs).

c.) If only one PFAS is present, a Hazard Quotient (HQ) of 1 applies and the values presented would increase by a factor of x10.

d.) USEPA. 2016a. Drinking Water HA for Perfluorooctanoic Acid (PFOA). Office of Water (4304T). Health and Ecological Criteria Division, Washington, DC 20460. USEPA Document Number: 822-R-16-005. May 2016. / USEPA. 2016b. Drinking Water HA for Perfluorooctane Sulfonate (PFOS). Office of Water (4304T). Health and Ecological Criteria Division, Washington, DC 20460. USEPA Document Number: 822-R-16-004. May 2016.

e.) USEPA HAs apply to the PFOS and PFOA concentrations individually or combined.

bgs = below ground surface
CAS = Chemical Abstracts Service
ng/L = nanograms per liter
HA = Health Advisory
OSD= Office of the Secretary of Defense
µg/kg = micrograms per kilogram

QAPP Worksheet #17: Sampling Design and Rationale

Worksheet #17a-f describes the sampling design, basis for its selection and field investigation details. Field activities will be completed per the Standard Operating Procedures (SOPs) in **Appendix B**.

The objectives for the SI are to determine presence or absence of PFAS in soil and groundwater (if present) at each AOI and assess if PFAS constituents are migrating off-facility by sampling relevant media at the boundary. As discussed in **Worksheet #10**, two potential source areas were identified at West Bend AASF #1. Bedrock aquifer groundwater flow at the West Bend AASF #1 is predominantly to the east; however, a shallow aquifer exists and flows towards Wingate Creek from the west and east side of the Site.

- AOI 1: The main hangar is equipped with a fire suppression system that is supplied by two 500-gallon tanks filled with 3 percent AFFF. The AFFF tanks, pumps, and four bulk 55-gallon drums of AFFF that supply the fire suppression system are housed in a building connected to the hangar. The fire suppression system is tested annually by dispensing 20-40 gallons of 3 percent AFFF. On numerous occasions, the AFFF was dispensed onto the grassy area behind the building.
- AOI 2: There was a one-time training event with one Tri-Max™ fire extinguisher that occurred in a grassy area located on the east side of the Armory. The exact date, amount, and concentration of AFFF used are unknown.

Environmental media samples will be collected from the AOIs in accordance with the applicable CSM, as summarized in **Table 17-1**. Temporary monitoring wells will be installed where PFAS were potentially released and downgradient of the potential source areas.

In instances where deviations from this sampling design and rationale are made due to unforeseen Site conditions, a Field Change Request Form will be generated to document the change and request feedback from the AECOM Task and Project Managers, USACE, and ARNG.

Sampling Tasks

The field program will include tasks as detailed in the following Worksheet elements:

- **Worksheet #17a** - Mobilization
- **Worksheet #17b** - Direct Push Boring Installation and Soil Sampling
- **Worksheet #17c** - Temporary Groundwater Monitoring Well Installation and Grab Groundwater Samples
- **Worksheet #17d** - Synoptic Water Level Measurements
- **Worksheet #17e** - Surveying
- **Worksheet #17f** - Investigation-Derived Waste Management

Table 17-1: Site Inspection Sample Count

AOI	Potential PFAS Release Area	# of DPT Borings	# of HA Boring Locations	Approximate Depth (feet bgs)	Groundwater Samples	Soil Samples
1	Fire Suppression System Testing	4	0	10	4	12
2	TriMax^{TM} Release	5	6	10	5	21
Total (not including QC)		9	6	--	9	33

Notes:

1) All samples will be analyzed for PFAS.
2) One soil sample per AOI will be analyzed for pH and TOC from a location in the source area. Grain size analysis will be performed in up to one soil sample per AOI where extensive horizontal and vertical clay units are identified by the field geologist, if these conditions are encountered in the field.

AASF = Army Aviation Support Facility
AOI = area of interest
bgs = below ground surface
DPT = direct push technology
HA = hand auger
NA = not applicable

QAPP Worksheet #17a
Sampling Design and Rationale
Mobilization

Site Preparation

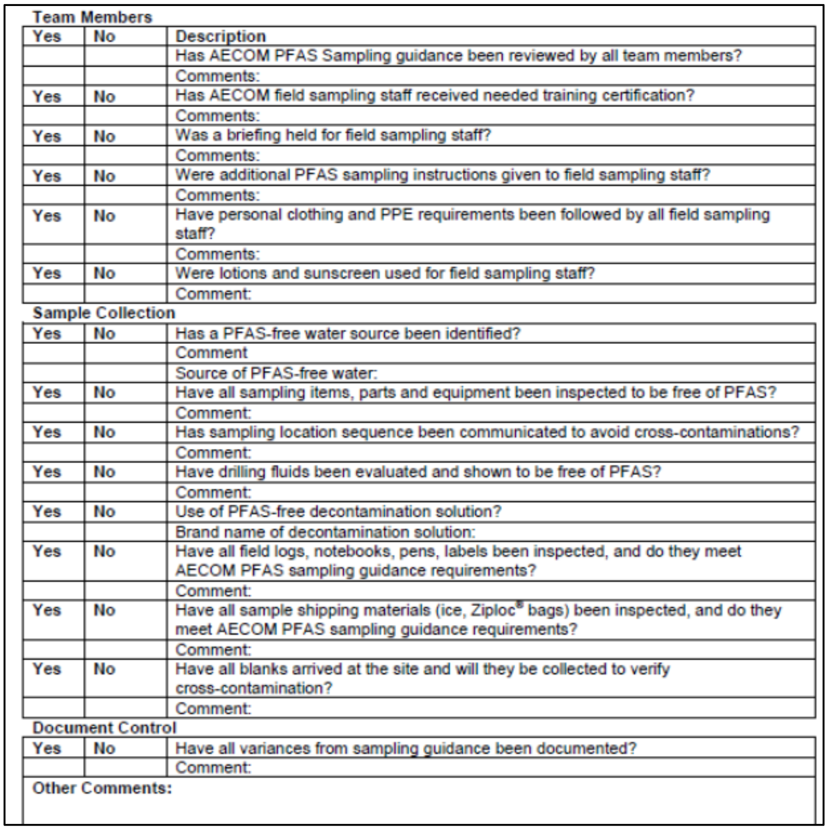
The site preparation activities for the SI field investigation operations include mobilization of field team personnel and equipment. No vegetation clearance is planned during field investigation activities.

PFAS Site Water Supply Sampling and Sampling Equipment Acceptability

A sample from the potable water source will be collected prior to mobilization to confirm that the water is PFAS free for use during field activities (i.e., equipment decontamination). If the water is not PFAS- free, totes of water will be brought onsite from another source determined to be PFAS-free.

All materials being purchased or rented for field work will be confirmed as acceptable for use in the PFAS sampling environment. A summary of acceptability of materials for use in the PFAS sampling environment is provided in SOP 3-41 (**Appendix B**). As an additional layer of control, prior to the start of field work each day, a PFAS Sampling Checklist will be completed (SOP 3-41, **Appendix B**). The checklist will serve as a reminder to each field team member regarding the allowable materials within the sampling environment. An example of the checklist is provided below.

Example PFAS Daily Sampling Checklist



Team Members		
Yes	**No**	**Description**
		Has AECOM PFAS Sampling guidance been reviewed by all team members?
		Comments:
Yes	**No**	Has AECOM field sampling staff received needed training certification?
		Comments:
Yes	**No**	Was a briefing held for field sampling staff?
		Comments:
Yes	**No**	Were additional PFAS sampling instructions given to field sampling staff?
		Comments:
Yes	**No**	Have personal clothing and PPE requirements been followed by all field sampling staff?
		Comments:
Yes	**No**	Were lotions and sunscreen used for field sampling staff?
		Comment:
Sample Collection		
Yes	**No**	Has a PFAS-free water source been identified?
		Comment
		Source of PFAS-free water:
Yes	**No**	Have all sampling items, parts and equipment been inspected to be free of PFAS?
		Comment:
Yes	**No**	Has sampling location sequence been communicated to avoid cross-contaminations?
		Comment:
Yes	**No**	Have drilling fluids been evaluated and shown to be free of PFAS?
		Comment:
Yes	**No**	Use of PFAS-free decontamination solution?
		Brand name of decontamination solution:
Yes	**No**	Have all field logs, notebooks, pens, labels been inspected, and do they meet AECOM PFAS sampling guidance requirements?
		Comment:
Yes	**No**	Have all sample shipping materials (ice, Ziploc® bags) been inspected, and do they meet AECOM PFAS sampling guidance requirements?
		Comment:
Yes	**No**	Have all blanks arrived at the site and will they be collected to verify cross-contamination?
		Comment:
Document Control		
Yes	**No**	Have all variances from sampling guidance been documented?
		Comment:
Other Comments:		

Personnel Qualifications

All personnel mobilized to the site will meet applicable Occupational Safety and Health Administration (OSHA) training requirements including hazardous waste operations and emergency response (HAZWOPER) training and medical surveillance requirements as specified in the Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP). Personnel will be required to complete the DoD's *Operations Security Awareness for Military Members, DoD Employees, and Contractors* and *Level 1 Antiterrorism Awareness Training*. Additionally, all AECOM employees that will be performing field work will take an internal PFAS sampling guidance training.

Permits and Notifications

Utility clearance will be conducted by WIARNG with input from the AECOM field team. A minimum of two weeks to coordinate the clearance will be required. The Diggers Hotline, one-call utility clearance contractor will be notified prior to intrusive work, in accordance with state and local requirements. However, because West Bend AASF #1 is a private facility, Diggers Hotline contractors do not enter the facility. Therefore, AECOM will contract a private utility location service to perform utility clearance at the Site.

AECOM and the drilling subcontractor will participate in a West Bend AASF #1 orientation prior to initiating work, if required. The determination of the orientation requirement will be made after final intrusive investigation locations are determined. AECOM will also contact the ARNG Environmental Manager at least five business days prior to the scheduled start of the field activities. A site walk will be scheduled with the appropriate ARNG personnel to mark out locations of the subsurface utilities. As a precaution, the first 5 feet of each boring will be pre-cleared using hand tools (e.g., post-hole diggers, augers, etc.) or air knifing methods. All field work will be coordinated with the ARNG Environmental Manager and/or his/her designee.

Health and Safety Requirements

Health and safety requirements for SI field activities are provided in the APP. Field personnel will wear PFAS-free Level D personal protective equipment (PPE). Detailed Activity Hazard Analyses identifying the physical, chemical, and biological hazards that may be encountered at the site and the associated mitigation methods are presented in the SSHP.

All onsite personnel who may be exposed to hazardous conditions will be required to meet training requirements identified in Federal Regulation 29 CFR 1910.120 (HAZWOPER). At least two personnel trained in first aid and cardiopulmonary resuscitation (CPR) will be onsite during field activities. Training certificates for personnel (HAZWOPER 40-hour training; current HAZWOPER 8-hour refresher training; and first aid/CPR) will be maintained onsite by the Site Supervisor.

Personnel and visitors who enter the site will be required to review the APP and SSHP and sign the acknowledgement form. Site workers will be required to sign the daily tailgate safety meeting form and fill out daily Activity Hazard Analysis forms. Safety issues that arise during implementation of field activities will be addressed during tailgate safety meetings held daily before the workday and will be documented in the daily tailgate safety meeting form.

QAPP Worksheet #17b
Sampling Design and Rationale
Direct-Push Boring Installation and Soil Sampling

Soil samples will be collected via hand auger and DPT (SOP 3-17). Hand augers will be used at locations designated for collection of surface soil samples (0 to 2 feet bgs) only. Borings will be advanced using DPT at locations designated for subsurface soil sample collection; however, hand augers will be used to clear the top 5 feet of the boring in accordance with AECOM utility clearance protocols. A GeoProbe® DT45 or DT60 dual-tube sampling system (or equivalent) will be used to collect continuous soil cores to the target depth. The target depth of the borings is to the soil-groundwater interface. Groundwater is anticipated to be encountered at both AOIs at approximately 10 feet bgs. If groundwater is not encountered, DPT borings will be advanced to a maximum of 30 feet bgs.

DPT will be used to collect three soil samples per boring, if possible: one surface soil sample (0 to 2 feet bgs), one subsurface soil sample approximately 1 foot above the groundwater table, and one subsurface soil sample at the mid-point between the surface and the groundwater table. If refusal is encountered before the desired depth of sample location, one additional attempt will be made adjacent to the original location (within 10 feet of the original boring) to collect a soil sample at the desired depth. If refusal is encountered at 6 feet bgs or shallower, only two samples will be collected per boring: one surface soil sample (0 to 2 feet bgs) and one sample approximately 1 foot above refusal. All drilling materials will be PFAS-free.

The proposed sample locations are shown on **Figures 17-1** and described in **Worksheet #18**. The soil sample rationale and target depths for the borings are provided in **Table 17-2** below.

Table 17-2: Soil Sample Rationale and Target Depths for Borings

Area of Interest	Number of Borings	Sample Collection Method	Target Depth (feet bgs)	Rationale
AOI 1	4	DPT	10	Four borings proposed, one upgradient, two downgradient of release area, and one within suspected release area. Target depth of boring was determined by the likelihood of encountering the shallow aquifer.
AOI 2	5	DPT	10	Five borings proposed, one upgradient, three downgradient of release area, and one within suspected release area. Target depth of boring was determined by the likelihood of encountering the shallow aquifer. Six locations within suspected release area proposed for hand auger samples due to ensure exact release point is sampled.
	6	Hand Auger	2	

Notes:
AOI = area of interest
bgs = below ground surface
DPT = direct push technology

The soil cores will be continuously logged for lithological descriptions by a field geologist using the Unified Soil Classification System (USCS) per SOP 3-16. A photoionization detector (PID) will be used to screen the breathing zone during boring activities. Observations and measurements will be recorded on field forms and in a non-treated field logbook. Photographs of the boring cores will also be taken. At a minimum, depth interval, recovery thickness, PID concentrations, moisture, relative density, color (using a Munsell soil color chart), and texture (using the USCS) will be recorded. Additional observations to be recorded may include groundwater or perched water depth, organic material, or cultural debris. If a clay layer is observed in a boring with a thickness in excess of 3 feet, boring activities will be terminated in order to avoid completely penetrating a competent clay layer.

It is anticipated that all boring will be advanced in areas without surface cover; however, if a boring is required in asphalt, it will be abandoned by backfilling with bentonite chips to approximately 6 inches bgs, and the remainder of the borehole will be patched with an asphalt cold patch. Borings into concrete will be avoided, if possible; however, if borings are advanced into concrete, the borings will be abandoned by backfilling with bentonite chips to approximately 6 inches bgs, and the remainder of the borehole will be filled with concrete to provide as flush a surface as possible. The surface at each location will be restored to match the surrounding area.

Quality Control (QC) samples will be collected in accordance with **Worksheet #20**. Field duplicate samples will be collected at a rate of 10 percent and analyzed for the same parameters as the accompanying samples. Matrix spikes/ matrix spike duplicates (MS/MSDs) will be collected at the rate of 5 percent and analyzed for the same parameters as the accompanying samples. One Field Reagent Blank (FRB) will be collected per sampling event and will be analyzed for PFAS. Equipment rinsate blanks (ERBs) will not be prepared or analyzed unless a deviation from this plan requires sample handling using non-dedicated equipment. If non-dedicated sampling equipment is used, ERBs will be collected and will be analyzed for the same analytes as the associated samples. A temperature blank will be placed in each cooler to ensure that samples are preserved at or below 4 degrees Celsius (˚C) during shipment.

Each sample will be collected into laboratory-supplied bottleware and submitted to the laboratory for analysis of selected parameters. Samples will be analyzed for PFAS by liquid chromatography tandem mass spectrometry (LC/MS/MS) compliant with Quality Systems Manual (QSM) 5.1 Table B-15. Additionally, one soil sample per AOI from a location in the source area will be analyzed for total organic carbon (TOC) (USEPA Method 9060A) and pH (USEPA Method 9045D). Additionally, up to one soil sample per AOI will be submitted for grain size analysis with sieve and hydrometer (American Society for Testing and Materials [ASTM] D-422) (i.e., clay content). The grain size analysis will be performed where extensive horizontal and vertical clay units are identified by the field geologist, if these conditions are encountered in the field. All sample containers will be PFAS free. The laboratory method detection limits (DLs) for these analytes are presented in **Worksheet #15**. Samples will be packaged on ice and transported daily via overnight commercial carrier under standard chain of custody (CoC) procedures to the laboratory (see SOP 3-04).

QAPP Worksheet #17c
Sampling Design and Rationale
Temporary Groundwater Monitoring Well Installation and Grab Groundwater Samples

Boreholes for temporary wells will be created using a Geoprobe® DT45 or DT60 dual-tube sampling system (or equivalent). Once the borehole has been advanced to the specified depth, the temporary well will be constructed of a 5-foot section of 1-inch Schedule 40 poly-vinyl chloride (PVC) screen with sufficient casing to reach ground surface. New PVC pipe will be used for each sampling location. The target screen interval for each location will be the top of the groundwater table, which is expected to be encountered no deeper than 30 feet bgs. The target screen intervals and rationale for the sampling locations are described in **Table 17-3**.

Table 17-3: Groundwater Sample Rationale and Proposed Screen Intervals

Area of Interest	# Temporary wells	Target Screen Interval (feet bgs)	Rationale
AOI 1	4	Top of groundwater table, (est. 10 - 15)	Four temporary wells proposed, one upgradient, two downgradient of release area, and one within the suspected release area. Target depth of boring was determined by the likelihood of encountering the shallow aquifer.
AOI 2	5	Top of groundwater table, (est. 10 - 15)	Five temporary wells proposed, one upgradient, three downgradient of release area, and one within the suspected release area. Target depth of boring was determined by the likelihood of encountering the shallow aquifer.

Notes:
AASF = Army Aviation Support Facility
AOI = area of interest
bgs = below ground surface

A grab groundwater sample will be collected at each temporary well using a peristaltic pump with tubing that has been determined to be PFAS free (i.e. high-density polyethylene [HDPE] or other PFAS-free material). If the peristaltic pump cannot generate enough hydraulic lift to bring the groundwater to the surface, groundwater samples will be collected using a PFAS-free 0.85-inch Geotech Bladder pump or other sampling device.

In addition, a subsample of each groundwater sample will be collected in a separate container and undergo a shaker test to identify if there is any foaming. If foaming is observed, the observation will be noted on the CoC to notify the laboratory prior to analysis.

Any non-dedicated sampling materials will be decontaminated between boring locations. Water quality parameters (e.g., temperature, specific conductance, pH, dissolved oxygen [DO], oxidation-reduction potential [ORP]) will be measured and recorded on the field sampling form after the grab sample has been collected. Water quality parameters will be measured using a water quality meter and flow-through cell. See SOP 3-14: Monitoring Well Sampling and SOP 3-24: Water Quality Parameter Testing for more details.

Each sample will be collected into laboratory-supplied bottleware and submitted to the laboratory for analysis of selected parameters (PFAS by LC/MS/MS compliant with QSM 5.1 Table B-15) (DoD, 2018b) as per SOP 3-41. The laboratory method DLs for these analytes are presented in **Worksheet #15**. QC samples will be collected in accordance with **Worksheet #20**. All sample containers will be PFAS free and the aqueous samples will not be filtered. Samples will be packaged on ice and transported daily via overnight commercial carrier under standard CoC procedures to the laboratory (SOP 3-04).

Temporary wells will be abandoned using bentonite chips at the completion of sampling activities and surveying.

QAPP Worksheet #17d
Sampling Design and Rationale
Synoptic Water Level Measurements

Groundwater levels will be used to monitor site-wide groundwater elevations and assess groundwater flow. Synoptic water level elevation measurements will be collected from the newly-installed temporary monitoring wells. The wells will be surveyed, and the water level measurement will be taken from the survey mark on the northern side of the well casing.

QAPP Worksheet #17e
Sampling Design and Rationale
Surveying

A small notch will be cut on the northern side of the well casing of temporary monitoring wells, which will be surveyed by a state-licensed surveyor (see SOP 3-07). The top of casing and ground surface elevation will be surveyed for each newly installed well. Survey data will be collected in the applicable Universal Transverse Mercator zone projection with WGS84 datum (horizontal) and North American Vertical Datum 1988 (vertical).

QAPP Worksheet #17f
Sampling Design and Rationale
Investigation-Derived Waste Management

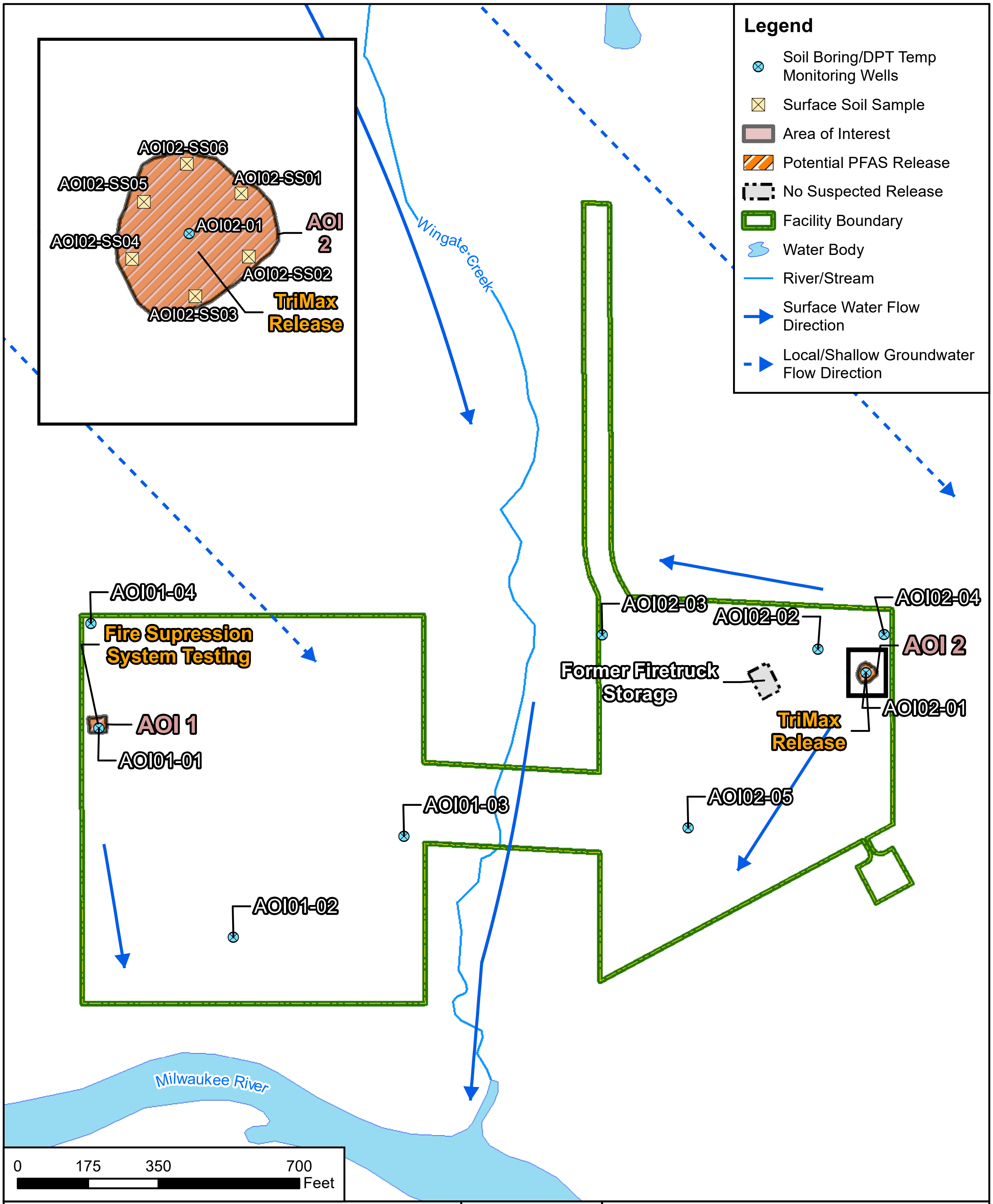
Currently, the disposal of PFAS investigation-derived waste (IDW) is not regulated. PFAS IDW is considered a non-hazardous waste and will be managed in accordance with USEPA Management of IDW, ARNG guidance, and applicable state regulations (USEPA, 2014).

Soil IDW generated will be containerized in properly labeled 55-gallon drums (See SOP 3-05). The IDW will be stored at a location designated by the West Bend AASF#1 Environmental Manager and WIARNG. This IDW will not be sampled and will assume the PFAS characteristics of the associated soil samples collected from that source location. ARNG will coordinate waste profiling, transportation, and disposal of the solid IDW.

Liquid IDW will be managed in accordance with the Army Guidance for Addressing Releases of PFAS, Q18. The IDW will be containerized in properly labeled 55-gallon drums (see SOP 3-05). The IDW will be stored on the facility at a location designated by the West Bend AASF #1 Environmental Manager and WIARNG. ARNG will coordinate transportation and disposal of the liquid IDW.

AECOM will collect global positioning system (GPS) points (i.e., polygons) around the location where the IDW was placed. The polygon will be included in the reporting phase for future use, if required.

Other solids such as spent PPE, plastic sheeting, tubing, rope, unused monitoring well construction materials, and other environmental media generated during the field activities will be disposed of at a licensed solid waste landfill.



CLIENT	ARNG				N
Site Inspection for PFAS at West Bend, WI					
REVISED	8/31/2020	GIS BY	MS	8/31/2020	
SCALE	1:4,200	CHK BY	SI	8/31/2020	
Base Map:		PM	RG	8/31/2020	

Site Inspection Sample Locations

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 17-1

C:\Users\stankevichm\OneDrive - AECOM Directory\ARNG_PFAS_GIS_60552172\MXDs\WI\West_Bend_Figures\West_Bend_SI_Figures\Fig_17-1_West_Bend_SI_Sample_Locations.mxd

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QAPP Worksheet #18: Sampling Locations and Methods

The table below describes the samples that will be collected during the West Bend AASF #1 SI. Sampling SOPs can be found in **Appendix B**.

AOI	Location Identifier	Sample Identifier	Matrix	Depth (feet bgs)	Type (Sampling Tool)	Analyte/Analytical Group	Sampling SOP
Soil Samples							
All	AOI01-01 AOI01-02 AOI01-03 AOI01-04 AOI02-01 AOI02-02 AOI02-03 AOI02-04 AOI02-05	AOI01-01-SB-[Depth] AOI01-02-SB-[Depth] AOI01-03-SB-[Depth] AOI01-04-SB-[Depth] AOI02-01-SB-[Depth] AOI02-02-SB-[Depth] AOI02-03-SB-[Depth] AOI02-04-SB-[Depth] AOI02-05-SB-[Depth]	Surface Soil	0-2	Geoprobe Dual-tube Sampling System	PFAS (LC/MS/MS compliant with QSM 5.1 Table B-15) Limited Sample Selection (one sample per AOI): TOC (USEPA Method 9060A) pH (USEPA Method 9045D) Limited Sample Selection (up to one sample per AOI): Grain Size/Clay Content (ASTM D-422)	3-21
All	AOI01-01 AOI01-02 AOI01-03 AOI01-04 AOI02-01 AOI02-02 AOI02-03 AOI02-04 AOI02-05	AOI01-01-SB-[Depth] AOI01-02-SB-[Depth] AOI01-03-SB-[Depth] AOI01-04-SB-[Depth] AOI02-01-SB-[Depth] AOI02-02-SB-[Depth] AOI02-03-SB-[Depth] AOI02-04-SB-[Depth] AOI02-05-SB-[Depth]	Subsurface Soil	mid-point	See Above	See Above	3-21
All	AOI01-01 AOI01-02 AOI01-03 AOI01-04 AOI02-01 AOI02-02 AOI02-03 AOI02-04 AOI02-05	AOI01-01-SB-[Depth] AOI01-02-SB-[Depth] AOI01-03-SB-[Depth] AOI01-04-SB-[Depth] AOI02-01-SB-[Depth] AOI02-02-SB-[Depth] AOI02-03-SB-[Depth] AOI02-04-SB-[Depth] AOI02-05-SB-[Depth]	Subsurface Soil	Above groundwater table	See Above	See Above	3-21

AOI	Location Identifier	Sample Identifier	Matrix	Depth (feet bgs)	Type (Sampling Tool)	Analyte/Analytical Group	Sampling SOP
AOI 2	AOI02	AOI02-SS01 AOI02-SS02 AOI02-SS03 AOI02-SS04 AOI02-SS05 AOI02-SS06	Surface Soil	0-2	Hand Auger or Towel	PFAS (LC/MS/MS compliant with QSM 5.1 Table B-15)	3-21
Groundwater Samples							
All	AOI01-01 AOI01-02 AOI01-03 AOI01-04 AOI02-01 AOI02-02 AOI02-03 AOI02-04 AOI02-04	AOI01-01-GW AOI01-02-GW AOI01-03-GW AOI01-04-GW AOI02-01-GW AOI02-02-GW AOI02-03-GW AOI02-04-GW AOI02-05-GW	Groundwater	Mid-screen	Peristaltic pump	PFAS (LC/MS/MS compliant with QSM 5.1 Table B-15)	3-14
QA/QC Samples							
NA	NA	WB-FRB-01	Water Quality	NA	NA (Pour laboratory-supplied PFAS-free water)	PFAS (LC/MS/MS compliant with QSM 5.1 Table B-15)	3-10
NA	NA	WB-ERB-01 WB-ERB-02	Water Quality	NA	NA (Pour laboratory-supplied PFAS-free water)	PFAS (LC/MS/MS compliant with QSM 5.1 Table B-15)	3-10
NA	NA	WB-PW-01	Decontamination Water Source	NA	NA (collect from tap or hose)	PFAS (LC/MS/MS compliant with QSM 5.1 Table B-15)	3-10

Notes:

AOI = area of interest
ASTM = American Society for Testing and Materials
ERB = equipment rinsate blank
GW = groundwater
LC/MS/MS = liquid chromatography-tandem mass spectrometry
PFAS = per- and polyfluoroalkyl substances
QC = quality control
SB = soil boring
TOC = total organic carbon
bgs = below ground surface
FRB = field regent blank
IDW = investigation-derived waste
NA = not applicable
QA = quality assurance
QSM = Quality Systems Manual
SOP = standard operating procedure
USEPA = United States Environmental Protection Agency
WB = West Bend AASF #1

Final PQAPP Worksheet #19 & #30: Sample Containers, Preservation, and Hold Times

Laboratory: Pace Gulf Coast
7979 Innovation Park Dr.
Baton Rouge, Louisiana 70820
(225) 769-4900
List any required accreditations/certifications: DoD/ELAP; applicable state certification
Back-up Laboratory: NA
Sample Delivery Method: FedEx

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround
PFAS	Aqueous	QSM 5.1 Table B-15/ SOP LCMS-011	ELAP-12/27/2020 NELAP-6/30/2021	HDPE w/ HDPE screw cap 2 x 125mL	Cool, 0-6°C	14 days from collection to extraction	28 days from extraction to analysis	28 days
PFAS	Drinking Water	USEPA 537/ SOP LCMS-010	ELAP-12/27/2020 NELAP-6/30/2021	HDPE w/ HDPE screw cap 2 x 250mL	Cool, 0-6°C; Trizma	14 days from collection to extraction	28 days from extraction to analysis	28 days
PFAS	Solid	QSM 5.1 Table B-15/ SOP LCMS-011	ELAP-12/27/2020 NELAP-6/30/2021	HDPE w/ HDPE screw cap 1 x 125 mL	Cool, 0-6°C	14 days from collection to extraction	28 days from extraction to analysis	28 days
Total Organic Carbon	Solid	USEPA 9060A, SM 5310 B-2011/WL-057	ELAP-12/27/2020 NELAP-6/30/2021	Polyethylene, Glass 1 x 2oz	Cool, 0-6ºC,	30 days to extraction	7 days from extraction to analysis	28 days
pH	Solid	USEPA 9045D/EXT-032	ELAP-12/27/2020 NELAP-6/30/2021	Polyethylene, Glass 1 x 2oz	None	NA	Immediate	28 days
Grain Size	Solid	ASTM D422 / CA-551	02/01/2022	Polyethylene, Glass 1 x 2oz	Cool, 0-6ºC	None	None	28 days

Notes:
1.)TOC and pH are important for evaluating transport through the soil medium.
2.)Trizma will be added to any groundwater samples collected from drinking water wells, even if the groundwater is not chlorinated.

°C = degrees Celsius
ASTM = American Society for Testing and Materials
DoD = Department of Defense
ELAP = Environmental Laboratory Accreditation Program
USEPA = United States Environmental Protection Agency

HDPE = high-density polyethylene
LCMS = liquid chromatography/ mass spectrometry
mL = milliliter
NA = not applicable
NELAP = National Environmental Laboratory Accreditation Program

oz = ounce
PFAS = per- and polyfluoroalkyl substances
QSM = Quality Systems Manual
SOP = standard operating procedure

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Final PQAPP Worksheet #20: Field Quality Control Summary

Matrix	Analytical Group	Field Samples	Field Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Reagent Blanks	Equipment Rinsate Blanks*	Total Samples
Groundwater	PFAS	9	1	1	1	1	1	14
Soil	PFAS	33	4	2	2	0	2**	43
	pH, TOC	2	1	1	1	0	0	5
	Grain Size	TBD***	0	0	0	0	0	TBD***
Decontamination Water	PFAS	1	0	0	0	0	0	1

Notes:
*Applies only if use of non-dedicated sampling equipment is necessary
** Equipment rinsate blanks for solid matrices are aqueous samples
*** Grain size analysis will be performed in up to one soil sample per AOI where extensive horizontal and vertical clay units are identified by the field geologist, if these conditions are encountered in the field.

PFAS = per- and polyfluoroalkyl substances

TBD = to be determined
TOC = total organic carbon

Measurement Performance Criteria Table — Field Quality Control Samples

QC Sample	Analytical Group	Frequency	Data Quality Indicators	MPC
Matrix: Groundwater and Surface Water				
Field Duplicate	PFAS	One per 10 field samples	Precision	Values > 5X LOQ: RPD must be ≤30% Values ≤ 5X LOQ: Absolute difference ≤ 2x the LOQ
Matrix Spike/Matrix Spike Duplicate	PFAS	One per 20 field samples[1]	Bias/Accuracy/Precision (lab)	RPD ≤ 30%; Refer to Worksheet #28 for recovery criteria
Equipment Rinsate Blank	PFAS	One per 20 field samples per type of reusable equipment used[2]	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank. Laboratory-certified PFAS-free water will be used to collect ERBs.
Reagent Blank	PFAS	One per sampling event[3]	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank
Cooler Temperature Blank	PFAS	One per cooler	Representativeness	Temperature must be above freezing and ≤ 6 °C
Matrix: Soils (Surface, Subsurface, and Sediment)				
Field Duplicate	PFAS, TOC	One per 10 field samples	Precision	Values > 5X LOQ: RPD must be ≤30% Values ≤ 5X LOQ: Absolute difference ≤ 2x the LOQ
Matrix Spike/Matrix Spike Duplicate	PFAS, TOC	One per 20 field samples[1]	Bias/Accuracy/Precision (lab)	RPD ≤ 30%; Refer to Worksheet #28 for recovery criteria
Reagent Blank	PFAS	One per sampling event[3]	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank
Equipment Rinsate Blank	PFAS, TOC	One per 20 field samples per type of reusable equipment used[2]	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank
Cooler Temperature Blank	PFAS	One per cooler	Representativeness	Temperature must be above freezing and ≤ 6°C

Measurement Performance Criteria Table — Field Quality Control Samples				
QC Sample	**Analytical Group**	**Frequency**	**Data Quality Indicators**	**MPC**
Matrix: Drinking Water				
Field Duplicate	PFAS	One per 10 field samples	Precision	Values > 5X LOQ: RPD must be ≤30% Values ≤ 5X LOQ: Absolute difference ≤ 2x the LOQ
Matrix Spike/Matrix Spike Duplicate	PFAS	One per 20 field samples[1]	Bias/Accuracy/Precision (lab)	RPD ≤ 30%; Refer to **Worksheet #28** for recovery criteria
Equipment Rinsate Blank	PFAS	One per 20 field samples per type of reusable equipment used[2]	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank
Field Reagent Blank	PFAS	One per day or one per 10 samples (whichever is more)	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank
Cooler Temperature Blank	PFAS	One per cooler	Representativeness	Temperature must be above freezing and ≤ 6°C

Notes:
1.) Analyzed more frequently than one per twenty samples or per sample delivery group.
2.) Only for re-usable equipment, not for disposable equipment/ supplies.
3.) Regardless of matrix.

% = percent
≤ = less than or equal to
≥ = greater than or equal to
°C = degrees Celsius
FRB = field reagent blank
LOQ = limit of quantitation
MPC = measurement performance criteria
PFAS = per- and polyfluoroalkyl substances
QC = quality control
RPD = relative percent difference
TOC = total organic carbon

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Final PQAPP Worksheet #21: Field Standard Operating Procedures

A summary of SOPs is provided in the table below, which can be found in **Appendix B**. All field staff will be trained through AECOM's internal PFAS Sampling Training prior to performing any sampling activities. A summary of the acceptability of certain materials for use in the PFAS sampling environment and a PFAS sampling checklist to be completed daily is provided in SOP 3-41.

Reference Number	Title, Revision Date, and/or Number	Originating Organization	Modified for Project Work?	Comments
3-01	*Utility Clearance*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-02	*Logbooks*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-03	*Recordkeeping, Sample Labeling and Chain of Custody*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-04	*Sample Handling, Storage, and Shipping*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-05	*Investigation-Derived Waste Management*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-06	*Equipment Decontamination*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-07	*Land Surveying*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-09	*Geophysics*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-10	*Surface Water Sampling*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-12	*Monitoring Well Installation*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-13	*Monitoring Well Development*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-14	*Monitoring Well Sampling*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures

Reference Number	Title, Revision Date, and/or Number	Originating Organization	Modified for Project Work?	Comments
3-15	*Monitoring Well and Borehole Abandonment*	AECOM	N	See SOP for detailed procedures
3-16	*Soil and Rock Classification*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-17	*Direct Push Sampling Techniques*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-20	*Operation and Calibration of Photoionization Detector*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-21	*Surface and Subsurface Soil Sampling Procedures*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-22	*Sediment Sampling*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-24	*Water Quality Parameter Testing for Groundwater Sampling*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-33	*Subsurface Soil Sampling by Split Spoon*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-35	*In-Situ Hydraulic Conductivity Testing via Rising or Falling Head Slug Testing*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-37	*Grab Groundwater Sampling Techniques*	AECOM	Y	Modified for PFAS sampling See SOP for detailed procedures
3-41	*Per- and Polyfluoroalkyl Substance Field Sampling Protocol*	AECOM	Y	See SOP for detailed procedures

Notes:
AECOM = AECOM Technical Services, Inc.
N = no
NA = not applicable
PFAS = per- and polyfluoroalkyl substances
SOP = standard operating procedure
Y = yes

Final PQAPP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection

Field Equipment	Calibration Activity	Maintenance Activity	SOP Reference	Testing Activity	Inspection Activity	Title or Position of Responsible Person	Frequency	Calibration Acceptance Criteria	Corrective Action
Horiba U-52 Water Quality Standards (pH, ORP, DO, Conductivity, Temperature, Turbidity)	Calibrate with standard solutions	Per page 8 of SOP C24	Field Equipment SOP C24	Operational equipment check and calibration	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	pH: ± 0.01 pH units Conductivity: ± 0.01 μS/cm Turbidity: ± 0.01 NTU DO: ± 0.01 mg/L Temp: ± 0.01 °C	Minor: Repair Major: Replace instrument
MiniRAE 2000 (PID)	Calibrate with fresh air and isobutylene calibration gas	Per page 4 of SOP C20	Field Equipment SOP C20	Operational equipment check and calibration	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	0-99 ppm ± 0.1 ppm 100-1,999 ppm ± 1.0 ppm 2000-10,000 ppm ± 10 ppm	Minor: Repair Major: Replace instrument
QED MP10 Controller (Bladder Pump Controller Box)	NA	--	Field Equipment SOP C14	Operational equipment check	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	NA	Minor: Repair Major: Replace instrument
QED SamplePro (Stainless Steel Submersible Bladder Pump)	NA	Per page 7 of SOP C14	Field Equipment SOP C14	Operational equipment check	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	NA	Minor: Repair Major: Replace instrument

Field Equipment	Calibration Activity	Maintenance Activity	SOP Reference	Testing Activity	Inspection Activity	Title or Position of Responsible Person	Frequency	Calibration Acceptance Criteria	Corrective Action
Solinst 101 (Water Level Meter)	NA	Per page 5 of SOP C14	Field Equipment SOP C14	Operational equipment check	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	NA	Minor: Repair Major: Replace instrument

Notes:
°C = degrees Celsius
DO = dissolved oxygen
mg/L = milligrams per liter
NA = not applicable
NTU = nephelometric turbidity unit
ORP = oxidation-reduction potential
PID = photoionization detector
ppm = parts per million
SOP = standard operating procedure
Temp = temperature
µS/cm = micro Siemens per centimeter

Final PQAPP Worksheet #23: Analytical Standard Operating Procedures

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
LCMS-011	*Analysis of PFAS, 10/12/17, Revision 02*	Definitive	Water/PFAS Solid/PFAS	Agilent 6460 Triple Quad LC/MS/MS	Pace Gulf Coast	N
LCMS-010	*SOP for Determination of Selected Perfluorinated Alkyl Acids (PFAA) in Drinking Water*	Definitive	Drinking Water/PFAS	Agilent 6460 Triple Quad LC/MS/MS	Pace Gulf Coast	N
WL-057	*SOP for TOC, 09/18/17, Revision 07.1*	Definitive	Solid/TOC	Shimadzu TOC-V CSH or TOC-V CPH analyzer	Pace Gulf Coast	N
EXT-032	*pH in Aqueous and Soil/Waste Samples, 10/26/17, Revision 18*	Definitive	Solid/pH	Orion 720A pH Meter, Combination Electrode	Pace Gulf Coast	N
CA-551	*Grain Size Analysis, 04/19, Revision 2.*	Definitive	Solid/Grain Size	Sieve	Katahdin	N

Notes:
LCMS = liquid chromatography/ mass spectrometry
LC/MS/MS = liquid chromatography-tandem mass spectrometry
N = no
PFAA = perfluorinated alkyl acids
PFAS = per- and polyfluoroalkyl substances
SOP = standard operating procedure
TOC = total organic carbon
Y = yes

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Final PQAPP Worksheet #24: Analytical Instrument Calibrations

Instrument/ Equipment	Calibration Procedure	Calibration Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person(s) Responsible for CA	SOP Reference
LC/MS/MS	Calibration Standards	NA	Prior to sample analysis	For analytes which have both linear and branched isomers and have standards available containing both linear and branched isomers, the analytes are calibrated and quantitated using a single continuous baseline to integrate all identifiable isomers.	NA	Analyst, Supervisor, QA Manager	LCMS-011
LC/MS/MS	Tune Check	NA	When the masses fall outside of the ±0.5 amu of the true value (as determined by the product ion formulas).	Mass assignments of tuning standard within 0.5 amu of true value.	Retune instrument and verify. If the tuning will not meet acceptance criteria, an instrument mass calibration must be performed and the tune check repeated.	Analyst, Supervisor, QA Manager	LCMS-011
LC/MS/MS	Minimum five-point initial calibration for all analytes (ICAL)	5.0 – 100 ppb on column	Initial calibration prior to sample analysis	For each calibration standard, each analyst must calculate to be within 70-130% of true value. RSD <20% or $r^2 \geq 0.99$ S/N Ratio: ≥ 10:1 for all ions used for quantitation. For analytes having a promulgated standard, (e.g., HA levels for PFOA and PFOS), the qualitative (confirmation) transition ion must have an S/N Ratio of ≥ 3:1.	Repeat calibration if criterion is not met	Analyst, Supervisor, QA Manager	LCMS-011
LC/MS/MS	Second source calibration verification	50 ppb on column	Once after each initial calibration	All analytes must calculate to be within 70-130% of true value and extracted internal standard must calculate to be within 50-150% of true value.	Remake standard, recalibrate if necessary	Analyst, Supervisor, QA Manager	LCMS-011
LC/MS/MS	Retention Time Windows	NA	Prior to sample analysis	Established with the first CCV of the day or the average of the ICAL on days when calibration is performed. See Table 3 of LCMS-011 for RT Windows.	Perform maintenance on pump or column. Recalibrate, if necessary, to re-establish retention times.	Analyst, Supervisor, QA Manager	LCMS-011

Instrument/ Equipment	Calibration Procedure	Calibration Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person(s) Responsible for CA	SOP Reference
LC/MS/MS	Tune check	Agilent ESI-L Low Concentration Tuning Mix	Daily, prior to sample analysis, only once per analytical batch. No time constraints.	Manufacturer recommended criteria which include delta and FWHM tolerance checks of 6 m/z's over the spectrum of the detector.	Retune instrument and repeat check tune. Maintenance may be required.	Analyst, Supervisor, QA Manager	LCMS-011
LC/MS/MS	LOD/LOQ verification	Various, see Table 3 of LCMS-010	Quarterly	LOD meets method qualitative requirements or is at least 3x higher than noise; LOQ is recovered within LCS criteria.	Perform instrument maintenance and repeat failed LOD or LOQ study passing two consecutive tests or perform new DL study.	Analyst, Supervisor, QA Manager	LCMS-011
LC/MS/MS	CCV	5ppb and 50ppb on column	Daily, before sample analysis, every 10 samples, and at end of batch. Alternating concentration between low and mid-range.	All targets spiked and within the QC limits included in Worksheet #15. Each extracted internal standard must be 50-150% of the true value.	Repeat initial calibration and reanalyze all samples analyzed since the last successful calibration verification. Alternatively, immediately analyze two consecutive CCVs for the failed analytes. If both pass, samples may be reported without reanalysis.	Analyst, Supervisor, QA Manager	LCMS-011
LC/MS/MS	Mass Spectral Acquisition Rate	NA.	Each analyte, Extracted Internal Standard Analyte, and Injection Internal Standard Analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	NA.	Analyst, Supervisor, QA Manager	LCMS-011

Instrument/ Equipment	Calibration Procedure	Calibration Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person(s) Responsible for CA	SOP Reference
LC/MS/MS	Calibration, Calibration Verification, and Spiking Standards	5ppb and 50ppb on column	All analytes.	Standards containing both branched and linear isomers must be used when commercially available. If not available, the total response of the analyte must be integrated (i.e., accounting for peaks that are identified as linear and branched isomers) and quantitated using a calibration curve which includes the linear isomer only for that analyte (e.g., PFOA).	NA.	Analyst, Supervisor, QA Manager	LCMS-011
LC/MS/MS	ISC	NA.	Prior to analysis and at least once every 12 hours.	Analyte concentrations must be at LOQ; concentrations must be within ±30% of their true values.	Correct problem, rerun ISC. If problem persists, repeat ICAL.	Analyst, Supervisor, QA Manager	LCMS-011
LC/MS/MS	Instrument Blanks	NA.	Immediately following the highest standard analyzed and daily prior to sample analysis.	Concentration of each analyte must be ≤ ½ the LOQ.	If acceptance criteria are not met after the highest calibration standard, calibration must be performed using a lower concentration for the highest standard until acceptance criteria is met. If acceptance criteria are not met after the highest standard that is not included in the calibration, the standard cannot be used to determine the highest concentration in samples at which carryover does not occur. If acceptance criteria are not met after sample, additional instrument blanks must be analyzed until acceptance criteria are met. Additional samples shall not be analyzed until acceptance criteria are met.	Analyst, Supervisor, QA Manager	LCMS-011

Instrument/ Equipment	Calibration Procedure	Calibration Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person(s) Responsible for CA	SOP Reference
Shimadzu TOC-V CSH or TOC-V CPH	ICAL	Various	Analyzed and evaluated before any result can be quantitated.	The correlation coefficient must be 0.995 or greater	Correct problem; recalibrate instrument, new calibration verified	Analyst, Supervisor, QA Manager	WL-057
Shimadzu TOC-V CSH or TOC-V CPH	ICV	10,000 µg & 20,000 µg	Immediately following the ICAL	±10% (90-110% of true value)	Instrument maintenance, reanalysis of ICV or initial calibration or re-preparation of the standards	Analyst, Supervisor, QA Manager	WL-057
Shimadzu TOC-V CSH or TOC-V CPH	CCV	10,000 µg	Each day that an ICAL is not performed a CCV must be performed before sample analysis. Also analyze every 10 samples ant at the end of analytical batch	±10 % (90-110% of true value)	Instrument maintenance, reanalysis of ICV or initial calibration or re-preparation of the standards	Analyst, Supervisor, QA Manager	WL-057
Shimadzu TOC-V CSH or TOC-V CPH	CCB	<250 mg/kg	Analyzed after every 10 samples or more frequently and at the end of analytical batch	Concentration must be less than the LOQ	Correct problem; recalibrate instrument	Analyst, Supervisor, QA Manager	WL-057
Shimadzu TOC-V CSH or TOC-V CPH	ICAL	Various	Analyzed and evaluated before any result can be quantitated.	The correlation coefficient must be 0.995 or greater	Correct problem; recalibrate instrument, new calibration verified	Analyst, Supervisor, QA Manager	WL-057
Orion 720 pH Meter	Calibrate meter	1.00-13.00	Daily before use	92-108%	Recalibrate meter	Analyst, Supervisor QA Manager	EXT-032

Instrument/ Equipment	Calibration Procedure	Calibration Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person(s) Responsible for CA	SOP Reference
Orion 720 pH Meter	QC Check Buffer	8.00	Immediately after calibration and with every 20 samples	0.05 pH units of the true value	Recalibrate meter	Analyst, Supervisor, QA Manager	EXT-032

Notes:
% = percent
µg = micrograms
amu = atomic mass unit
CCB = continuing calibration blank
CCV = continuing calibration verification
DL = detection limit
ESI = electrospray Ionization
ICAL = initial calibration
ICV = independent calibration verification
ISC = instrument sensitivity check
LCMS = liquid chromatography/ mass spectrometry
LC/MS/MS = liquid chromatography-tandem mass spectrometry
LCS = laboratory control spike
LOD = limit of detection
LOQ = limit of quantitation
mg/kg = milligram per kilogram
NA = not applicable
PFOA = perfluorooctanoic acid
PFOS = perfluorooctanesulfonic acid
ppb = parts per billion
QA = quality assurance
QC = quality control
RSD = relative standard deviation
SOP = standard operating procedure
S/N = signal to noise

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Final PQAPP Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing and Inspection

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
LC/MS/MS	Clean ESI Chamber	NA	NA	Weekly or as needed	NA	NA	Analyst	LCMS-011
LC/MS/MS	Backflush Analytical Column and Hold Column for Solvent Cleaning	NA	Peak Assymetry	As needed	NA	NA	Analyst	LCMS-011
Shimadzu TOC-V CSH or TOC-V CPH	Change injection needle, change catalyst	TOC	Monitor instrument performance via Continuing Calibration Verification	As needed or replace as necessary, loss of sensitivity or failing resolutions, erratic response	No maintenance is required as long as instrument QC meets criteria	Perform instrument maintenance, clean injection needle, change catalyst	Analyst, Supervisor, QA Manager	WL-057

Notes:

ESI = electrospray ionization
LCMS = liquid chromatography/ mass spectrometry
LC/MS/MS = liquid chromatography-tandem mass spectrometry
NA = not applicable
QC = quality control
SOP = standard operating procedure
TOC = total organic carbon

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Final PQAPP Worksheet #26 & #27: Sample Handling, Custody, and Disposal

Sampling Organization: AECOM
Laboratory: Pace Gulf Coast
Method of sample delivery (shipper/carrier): FedEx
Number of days from reporting until sample disposal: 60 Days

Activity	Organization and title or position of person responsible for the activity	SOP reference
Sample labeling	AECOM	SOP 3-03 *Recordkeeping, Sample Labeling and Chain of Custody*
CoC form completion	AECOM	
Packaging	AECOM	SOP 3-04 *Sample Handling, Storage, and Shipping*
Shipping coordination	AECOM	
Sample receipt, inspection, & log-in	Pace Gulf Coast	SAD-001 *Sample Receiving and LIMS Log-In*
Sample custody and storage	Pace Gulf Coast	SAD-002 *Sample Chain of Custody and Sample Integrity*
Sample disposal	Pace Gulf Coast	GEN-009 *Waste Collection, Storage, Disposal*

Notes:
AECOM = AECOM Technical Services, Inc.
CoC = chain of custody
LIMS = Laboratory Information Management System
SOP = Standard Operating Procedures

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Final PQAPP Worksheet #28: Analytical Quality Control and Corrective Actions

Matrix: Soil & Aqueous
Analytical Group: PFAS
Analytical Method: USEPA Method 537.1, PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15
SOP Reference: LCMS-010, LCMS-011
Certification Status: DoD/ELAP Certification

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Measurement Performance Criteria
Aqueous Sample Preparation	Each sample and associated batch QC samples.	SPE must be used unless samples are known to contain high PFAS concentrations (e.g., AFFF formulations). Inline SPE is acceptable. Samples of known high PFAS concentrations can be prepared by serial dilution instead of SPE, with documented project approval.	NA	NA	As per Table B-15
Soil & Sediment Sample Preparation	Each sample and associated batch QC samples.	Entire sample received by the laboratory must be homogenized prior to subsampling.	NA	NA	As per Table B-15
Method Blank	One per preparatory batch, maximum of 20 samples	No analytes detected > ½ LOQ or > 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.	Correct problem; reanalyze any sample associated with a blank that fails criteria, except when the sample analysis resulted in a non-detect.	Analyst, Supervisor, QA Manager	As per Table B-15
LCS	One per preparatory batch, maximum of 20 samples	Blank spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. 70-130% of True Value	Reanalyze and/or reprep all associated samples unless recoveries are high with no detection of analytes.	Analyst, Supervisor, QA Manager	As per Table B-15

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Measurement Performance Criteria
Matrix Spike	One per preparatory batch. Not required for aqueous samples prepared by serial dilution instead of SPE.	Sample spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. All targets spiked and within the QC limits included in Worksheet #15.	Evaluate the data to determine if the failed criteria are due to sample matrix or laboratory error. Re-prep if sufficient sample is available when lab error is suspected, otherwise, qualify data with narrative.	Analyst, Supervisor, QA Manager	As per Table B-15
MSD or MD	For MSD: One per preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE.	For MSD: Sample spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. For MSD: All targets spiked and within the QC limits included in Worksheet #15. RPD ≤ 30% (between MS and MSD or sample and MD).	The data shall be evaluated to determine the source of difference. For Sample/MD: RPD criteria only apply to analytes whose concentration in the sample is greater than or equal to the LOQ. The MD is a second aliquot of the field sample that has been prepared by serial dilution.	Analyst, Supervisor, QA Manager	As per Table B-15
Extracted Internal Standards	Every field sample, standard, blank, and QC sample.	Added to sample prior to extraction. For aqueous samples prepared by serial dilution instead of SPE, added to samples prior to analysis. Extracted Internal Standard Analyte recoveries must be within 50% to 150% of the true value.	If recoveries are acceptable for QC samples, but not field samples, the field samples must be re-prepped and reanalyzed (greater dilution may be needed). If recoveries are unacceptable for QC samples, correct problem, and reanalyze all associated failed field samples.	Analyst, Supervisor, QA Manager	As per Table B-15

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Measurement Performance Criteria
Instrument Internal Standard Analytes (Used for quantitation of drinking water results)	Every field sample, standard, blank, and QC sample.	Added to aliquot of sample dilutions, QC samples, and standards just prior to analysis. Peak areas must be within -50% to +50% of the area measured in the ICAL midpoint standard. On days when ICAL is not performed, the peak areas must be within -50% to +50% of the peak area measured in daily initial CCV.	If peak areas are unacceptable, analyze a second aliquot of the extract or sample if enough extract remains. If there is not enough extract, reanalyze the first aliquot. If second analysis meets acceptance criteria, report the second analysis. If it fails, either analysis may be reported with the appropriate flags.	Analyst, Supervisor, QA Manager	As per Table B-15
Post Spike Sample	Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of “<LOQ” for analyte(s).	Spike aliquot(s) of sample at the final dilution(s) reported for sample with all analytes that have reported value of “<LOQ” in the final dilution. The spike must be at the LOQ concentration to be reported with the sample (the “<LOQ” value). When analyte concentrations are calculated as “<LOQ”, the spike must recover within 70-130% of its true value.	When analyte concentrations are calculated as “<LOQ”, and the spike recovery does not meet the 70-130% acceptance criteria, the sample, sample duplicate, and post spike sample must be reanalyzed at consecutively higher dilutions until the criteria is met.	Analyst, Supervisor, QA Manager	As per Table B-15

Notes:

% = percent
< = less than
> = greater than
≤ = less than or equal to
≥ = greater than or equal to
AFFF = aqueous film forming foam
CCV = continuing calibration verification

ICAL = initial calibration
LC/MS/MS = liquid chromatography tandem mass spectrometry
LCS = laboratory control spike
LOD = limit of detection
LOQ = limit of quantitation
MD = matrix duplicate

MS/MSD = matrix spike/matrix spike duplicate
NA = not applicable
QA = quality assurance
QC = quality control
RPD = relative percent difference
SOP = standard operating procedure
SPE = solid phase extraction

Matrix: Soil
Analytical Group: Total Organic Carbon
Analytical Method: USEPA 9060A
SOP Reference: WL-057
Certification Status: DoD/ELAP Certification

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Measurement Performance Criteria
Method Blank	One per preparatory batch, maximum of 20 samples	Concentration shall not be > 1/2 the LOQ or 1/10 the amount of sample	The source of contamination should be investigated and samples should be reanalyzed. If, additional sample is not available, report with narrative.	Analyst, Supervisor, QA Manager	As per method
LCS	One per preparatory batch, maximum of 20 samples	90-110%	If LCS fails to meet lab criteria, the source of inaccuracy should be investigated and samples reanalyzed. If additional sample is not available, report in a narrative.	Analyst, Supervisor, QA Manager	As per method
MS	One pair per batch (assuming sufficient volume exists) or as specified by client request.	80-120%	If recovery is outside control limits and a lab error suspected, repeat the MS determination. If the LCS is within control limits and the matrix interference is indicated, analyze a post digestion spike and report results with a narrative.	Analyst, Supervisor, QA Manager	As per method
Duplicate/ MSD	One pair per batch (assuming sufficient volume exists) or as specified by client request.	RPD should be ≤20	Investigate the source of the precision error. A source of precision error in the duplicate /MSD may be the homogenous nature of the sample. If lab error is suspected, repeat analysis. If matrix issue is indicated, report with a narrative.	Analyst, Supervisor, QA Manager	As per method

Notes:
% = percent
< = less than
≤ = less than or equal to
DoD = Department of Defense
ELAP = Environmental Laboratory Accreditation Program
LCS = laboratory control spike
LOQ = limit of quantitation
MS/MSD = matrix spike/matrix spike duplicate
QA = quality assurance
QC = quality control
RPD = relative percent difference
SOP = standard operating procedure

Matrix: Soil
Analytical Group: pH
Analytical Method: USEPA 6045D
SOP Reference: EXT-032
Certification Status: DoD/ELAP Certification

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Measurement Performance Criteria
QC Check Buffer	Before sample analysis, after every 20 samples and at the end of analysis	Within ±0.05 pH of true value	Do not analyze samples without a daily LCS that meets criteria.	Analyst, Supervisor, QA Manager	As per method
Duplicate	One per batch, maximum of 20 samples	Within 0.1 pH unit	Repeat if sample volume allows or narrate results	Analyst, Supervisor, QA Manage	As per method

Notes:
% = percent
DoD = Department of Defense
ELAP = Environmental Laboratory Accreditation Program
LCS = laboratory control spike
QA = quality assurance
QC = quality control
SOP = standard operating procedure

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Final PQAPP Worksheet #29: Project Documents and Records

Sample Collection Documents and Records	Onsite Analysis Documents and Records	Offsite Analysis Documents and Records	Data Assessment Documents and Records	Other
Field Logbook	Field Logbook	Sample receipt, custody, and tracking records	Field sampling audit records	NA
CoC Records	Field Sampling Forms	Sample prep logs	Laboratory audit records	
Air Bills	Equipment Inspection Forms	Equipment calibration logs	Data validation reports	
Custody Seals	Boring Logs	Run logs	Data usability assessment reports	
Corrective Action Forms	Corrective Action Forms	Equipment maintenance test, and inspection logs	Corrective Action Forms	
Field Sampling Forms	Daily Tailgate SH&E Sign In Sheet	Corrective Action Forms	Field Change Request Form	
Sample location and depth data	APP/SSHP Acknowledgement	Reported analytical results		
Field equipment calibration logs	Dig Permits	Data package completeness checklists		
		Sample disposal records		
		Extraction/cleanup records		
		Raw data		
		EQuIS™		
		ROE Agreements		
		Photographic Logs		

Notes:
APP/SSHP = Accident Prevention Plan/ Site Safety and Health Plan
CoC = chain of custody
EQuIS = Environmental Quality Information System
SH&E = Safety, Health, and Environment
NA = not applicable
ROE = right of entry

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Final PQAPP Worksheet #31, #32 & #33: Assessments and Corrective Action

This worksheet is used to document responsibilities for conducting project assessments, responding to assessment findings, and implementing corrective action. Appropriately scheduled assessments allow management to implement corrective action in a timely manner, thereby correcting non-conformances and minimizing their impact on DQOs/Project Quality Objectives.

Assessments:

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Action	Person(s) Responsible for Monitoring Effectiveness of Corrective Action
Project Manager Review	Monthly (for field efforts that are longer than one month)	Internal	AECOM	Project Manager/ AECOM	Field Sampling Team Leader/ AECOM	Field Sampling Team Leader/ AECOM	Project Manager/ AECOM
Review of CoC forms	Daily	Internal	AECOM	Project Chemist/ AECOM	Field Sampling Team Leader/ AECOM	Field Sampling Team Leader/ AECOM	Project Chemist/ AECOM
Laboratory Data Assessment (validation)	Once	Internal	AECOM	Data Validator	Project Chemist/ AECOM	Data Validator	Project Chemist/ AECOM
Daily Quality Control Audits	Daily	Internal	AECOM	Field Sampling Team Leader/ AECOM	Field Sampling Team Leader/ AECOM	Field Sampling Team Leader/ AECOM	QA Officer/ AECOM
Field TSAs	Daily	Internal	AECOM	Field Sampling Team Leader/ AECOM	Field Sampling Team Leader/ AECOM	Field Sampling Team Leader/ AECOM	QA Officer/ AECOM
Field Performance Audits	Weekly	Internal	AECOM	Project Manager/ AECOM or representative	Field Sampling Team Leader/ AECOM	Field Sampling Team Leader/ AECOM	Project Manager/ AECOM

Assessment Response and Corrective Action:

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response	Timeframe for Response
Field Sampling Audit	Email	Field Sampling Team Leader/AECOM Project Manager	Immediate	Daily QC Report/ Email	Project Quality Manager/ Project Manager	24 hours after notification
Project Manager Review	Email	Field Sampling Team Leader/ AECOM	Immediate	Daily QC Report/ Email	AECOM Project Manager	24 hours after notification
Review of CoC forms	Email	Field Sampling Team Leader/AECOM Project Manager	Immediate	Daily QC Report/ Email	Project Chemist	24 hours after notification
Laboratory Data Assessment (validation)	Written Audit Report	Laboratory QA Manager; AECOM Project Chemist	Within 24 hours after audit	Email	Data Validator	Up to 1 week after notification
Daily Quality Control Audits	Email/ Daily QC Report	Field Sampling Team Leader/AECOM Project Manager	Immediate	Daily QC Report/ Email	AECOM Project Manager	24 hours after notification
Field TSAs	Email/ Daily QC Report	Field Sampling Team Leader/AECOM Project Manager	Immediate	Daily QC Report/ Email	AECOM Project Manager	24 hours after notification
Field Performance Audits	Email	Field Sampling Team Leader	Immediate	Daily QC Report/ Email	AECOM Project Manager	24 hours after notification

Laboratory Assessments: Pace Gulf Coast

Assessment Type	Responsible Party & Organization	Number/Frequency	Estimated Dates	Assessment Deliverable	Deliverable Due Date
DoD/ELAP Accreditation	PJLA	Every Two Years	NA	Certification	NA
PT samples	Laboratory QAM	Accreditation	Per Accrediting Authority	Per Accrediting Authority	Per Accrediting Authority
Data Review	Naoum Tavantzis, AECOM	Once	45 days after receipt of data	Validation Report	45 days after receipt of data
External Laboratory Audit	PJLA	Bi-annually	NA	Written Audit Report	NA
Internal Laboratory Audit	Pace Gulf Coast	Annually	NA	Written Audit Report	NA

Notes:
AECOM = AECOM Technical Services, Inc.
CoC = chain of custody
DoD = Department of Defense
ELAP = Environmental Laboratory Accreditation Program
NA = not applicable
PJLA = Perry Johnson Laboratories Accreditation
PT = proficiency testing
QA = quality assurance
QAM = Quality Assurance Manager
QC = quality control
TSA = technical system audit

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Final PQAPP Worksheet #34: Data Verification and Validation Inputs

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)
Planning Documents/Records			
1	Approved QAPP	X	
2	Contract	X	
4	Field SOPs	X	
5	Laboratory SOPs	X	
Field Records			
6	Field logbooks	X	
7	Equipment calibration records	X	
8	CoC Forms	X	X
9	Sampling diagrams/surveys	X	
10	Drilling logs	X	
11	Relevant correspondence	X	
12	Change orders/deviations	X	
13	Field audit reports	X	
14	Field change request forms	X	
Analytical Data Package			
16	Cover sheet (laboratory identifying information)	X	X
17	Case narrative	X	X
18	Internal laboratory CoC	X	X
19	Sample receipt records	X	X
20	Sample chronology (i.e., dates and times of receipt, preparation, and analysis)	X	X
21	Communication records	X	
22	LOD/LOQ establishment and verification	X	
23	Standards traceability	X	
24	Instrument calibration records	X	X
25	Definition of laboratory qualifiers	X	
26	Results reporting forms	X	X
27	QC sample results	X	X
28	Corrective action reports	X	X
29	Raw data	X	X
30	Electronic data deliverable	X	X

Notes:
CoC = chain of custody
LOD = limit of detection
LOQ = limit of quantitation
QAPP = Quality Assurance Project Plan
QC = quality control
SOP = standard operating procedure

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Final PQAPP Worksheet #35: Data Verification Procedure

This worksheet documents procedures that will be used to verify project data. The procedures apply to both field and laboratory records. Data verification is a completeness check to confirm that all required activities were conducted, all specified records are present, and the contents of the records are complete. As illustrated in the following example, verification often is performed at more than one step by more than one person.

Records Reviewed	Requirement Documents	Process Description	Responsible Person, Organization
Chain of custody forms and shipping forms	CoC, Shipping Documents	CoC 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 CoC should be initialled by the reviewer, a copy of the CoC retained in the site file, and the original and remaining copies taped inside the cooler for shipment.	Appropriate Field Sampling Team Leaders for the individual medias
Review of field logbooks	Field Logbooks	Review for completeness and accuracy.	Appropriate field Sampling Team Leaders
Field sampling TSAs	TSA Reports	Assessment of field sampling process prior to start of, or as close to the start of sampling as possible.	QA Manager or designee
Fixed laboratory analytical data review	Laboratory Data Package	Data controls are compared to this QAPP and DoD QSM v 5.1 (and PFAS analysis by USEPA Method 537, DoD QSM v5.1 Table B-15) in a Three-Tiered process using a minimum 100% peer review.	PM or QA Manager
Fixed laboratory TSAs	Laboratory Data Package	ELAP audit and internal quality audits.	QA Manager
Fixed laboratory data verification	Data Validation Reports	100% data verification/validation for water and soil.	AECOM Project Chemist
Fixed laboratory data validation	Data Validation Reports	Calculate and assess laboratory DQIs.	QA Manager, or designee

Notes:
AECOM = AECOM Technical Services, Inc.
CoC = chain of custody
DoD = Department of Defense
DQI = data quality indicator
ELAP = Environmental Laboratory Accreditation Program
PFAS = per- and polyfluoroalkyl substances
PM = Project Manager
QA = quality assurance
QAPP = Quality Assurance Project Plan
QSM = Quality Systems Manual
TSA = technical system audit
USEPA = United States Environmental Protection Agency

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Final PQAPP Worksheet #36: Data Validation Procedures

Data Validator: AECOM

Analytical Group/Method	All Analytical Data
Analytical specifications	WS#24, WS #28 & Laboratory SOPs
Measurement performance criteria	WS #12, WS#15, and WS#28
Percent of data packages to be validated	100%
Percent of raw data reviewed	100%
Percent of results to be recalculated	0%
Validation procedure and qualification	National Functional Guidelines for Organic Superfund Data Review, January 2017 (USEPA, 2017b); Department of Defense General Data Validation Guidelines, February 2018 (DoD, 2018a)
Validation code	S2bVEM/S2bVM
Electronic validation program/version	AECOM EarthSoft EQuIS™ Automated Validation Assistant

Notes:
% = percent
AECOM = AECOM Technical Services, Inc.
DoD = Department of Defense
EQuIS = Environmental Quality Information System
SOP = standard operating procedure
USEPA = United States Environmental Protection Agency
WS = worksheet

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Final PQAPP Worksheet #37: Data Usability Assessment

The Data Usability Assessment (DUA) is an evaluation at the conclusion of data collection activities that uses the results of both data verification and validation in the context of the overall project decisions or objectives. Using both quantitative and qualitative methods, the assessment will determine whether project execution and the resulting data the DQOs established in **Worksheet #11** were achieved. Both sampling and analytical activities will be considered with the ultimate goal to assess whether the final, qualified results support the decisions to be made with the data.

The following personnel are responsible for participating in the DUA:

AECOM Project Manager:	Rosa Gwinn
AECOM Project Chemist:	Naoum Tavantzis
AECOM SI Task Manager:	Jacquelyn Harrington

The DUA will be documented as a discussion within the SI report and refer to the Data Validation Report that will appear in an appendix of the SI reports. The Data Validation Report will follow the procedures given in **Worksheet #36**.

The following steps summarize the processes used to determine whether the collected data are of the right type, quality, and quantity to support the environmental decision-making for ARNG related to PFAS contamination at certain installations and describe how data quality issues will be addressed and how limitations on the use of the data will be handled.

Step 1	**Review the project's objectives and sampling design.** The key components established in the DQOs (**Worksheet #11**) will be reviewed to ensure that they are still applicable. Also, the sampling design and how it was implemented in the field will be reviewed for consistency with the stated objectives. For example, this step in the DUA will: • Reevaluate whether comparison criteria (i.e., SL; **Worksheet #15**) were updated since PQAPP generation and if laboratory quantitation limits (QLs) were sensitive enough for those changes (e.g., QLs remain lower than new criteria). It is important to note several states are in various stages of developing or finalizing limits for PFAS chemicals for different media; therefore, it is critical that SLs are regularly evaluated over the course of the project to ensure the SLs remain current. Additionally, project data must meet the measurement performance criteria (MPC) for sensitivity and project QLs specified in **Worksheets #15 & 28**. • Discuss the limitations and impact on the use of project data if validation reports indicate that project specific sensitivity goals or QLs were not achieved for a specific sampling or laboratory group, dataset or sample delivery group (SDG), matrix, analytical group, or concentration level.
Step 2	**Review the data verification and data validation outputs** Available Quality Assurance (QA) reports, including both field and laboratory generated forms, will be reviewed for deviations from planned activities identified in Step 1 (e.g., number and locations of samples, holding time exceedances, damaged samples, non-compliant proficiency testing sample results, and SOP deviations) and determine their impacts on the data usability. Validated data will be summarized and/or compiled to identify patterns, trends, and anomalies as they relate to the Data Quality Indicators (DQIs) precision, accuracy/bias, representativeness, comparability, completeness, and sensitivity. Descriptions of each DQI and examples of how each may be incorporated into the usability report follow.

Step 2 (cont.)	**Precision** Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as standard deviation, variance, percent difference, or range, in either absolute or relative terms. Quality Control (QC) measures for precision include field duplicates, laboratory duplicates, MSDs, analytical replicates, and surrogates. To meet the needs of the data users, SI project data must meet the MPC for precision specified in **Worksheet #12** of this QAPP. Precision errors may be the result of one or more of the following: PFAS cross-contamination, field instrument variation, analytical measurement variation, poor sampling technique, sample transport problems, or spatial variation (heterogeneous sample matrices). To identify the cause of imprecision, the field sampling design rationale and sampling techniques will be evaluated by the reviewer, and both field and analytical duplicate/replicate sample results will be compared. For example, if poor precision is indicated in both the field and analytical duplicates/replicates, then the laboratory may be the source of error. If poor precision is limited to the field duplicate/replicate results, then the sampling technique, PFAS contamination, field instrument variation, sample transport, medium inhomogeneity, or spatial variability may be the source of error. If data validation reports indicate that analytical imprecision exists for a particular dataset or SDG, then the impact of that imprecision on usability will be discussed in the usability report.
	Accuracy/Bias Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) due to sampling and analytical operations. Examples of QC measures for accuracy include Matrix Spikes, Laboratory Control Samples, and ERBs. A measurement is accurate when the reported value does not differ from the true value or known concentration of the spike or standard. To meet the needs of the data users, project data must meet the MPC for accuracy/bias specified in **Worksheet #12** of this QAPP. The usability report for each installation will: • Discuss and compare data on contamination and accuracy/bias (when bias is observable) for each matrix, analytical group, and concentration level. • Describe the limitations on the use of project data if extensive contamination, inaccuracy, or bias exists, or when inaccuracy is limited to a specific sampling or laboratory group, dataset or SDG, matrix, or concentration level. • Discuss the impact of any qualitative and quantitative trends in bias on the sample data.
	Representativeness Representativeness is the measure of the degree to which data accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition, and it is achieved through a well-designed sampling program and by using standardized sampling strategies, techniques, and analytical procedures. To meet the needs of the data users, project data must meet the MPC for sample representativeness specified in **Worksheet #12** of this QAPP. **Worksheet #28 & 35** discusses how the QA/QC activities (e.g., review of sampling design and SOPs, field sampling Technical System Audits (TSAs), and analysis audits) and QC sample data will be reviewed to assess sample representativeness. For example, if field duplicate precision checks indicate potential spatial variability, additional scoping meetings and subsequent resampling may be needed to collect data that are more representative of a nonhomogeneous site. The usability report for each installation will: • Discuss the impact of field duplicate imprecision on site representativeness. For example, when data variability is high among field duplicate datasets (i.e., high relative standard deviation), calculation of the 95% upper confidence limit (UCL) of the population mean is more likely to overestimate the true mean and therefore achieve better statistical coverage. • Discuss the impact of laboratory and field sampling methods on sampling results and how they reflect site conditions. • Discuss the effect of site heterogeneity on sampling results in light of sampling methods used.

	• Describe the limitations on the use of project data when sampling results are non-representative for all data or for a specific sampling, group, dataset or SDG, matrix, analytical group, or concentration level.
Step 2 (cont.)	**Comparability** Comparability is the degree to which different methods, datasets, and decisions agree or can be represented as similar. Comparability describes the confidence (expressed qualitatively or quantitatively) that two datasets can contribute to a common analysis and interpolation. The SI results will be used as benchmarks for determining comparability for data collected during any future sampling events at the various installations using the same or similar sampling and analytical SOPs. At this time, data will not be compared to other datasets or data using different sampling or analytical SOPs. To ensure future comparability of data generated for the installations, standard sample collection procedures and approved analytical methods will be used. Sample analyses will be performed by the laboratory using approved methods and procedures. Comparability criteria will be considered met for the project if, based on data reviewed, the sample collection and analytical procedures (such as use of alternate preparation if indicated by a positive field shake test) are determined to have been followed or defined to show that variations did not affect the values reported. Deviations to sampling scope will be documented in sampling nonconformance reports which may contain some of the discussion of comparability. The usability reports will describe the limitations on the use of project data when project-required data comparability is not achieved for the overall project or is limited to a specific sampling or laboratory group, dataset or SDG, matrix, analytical group, or concentration level.
	Completeness Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under correct, normal circumstances. To meet the needs of the data users, project data must meet the MPC for data completeness. Completeness criteria will be considered met if 100% of all planned sample data are collected. As applicable, the usability report may also: • Describe how the amount of valid data will be determined as a percentage of the number of valid measurements for each matrix, analytical group, and concentration level. • Describe how critical data were assessed for completeness when certain sample locations or analytes and matrices are more critical than others in making project decisions. • Evaluate the impact of missing information. Ensure that enough information was obtained for the data to be usable to meet the DQOs (**Worksheet #11**).
Step 2 (cont.)	**Sensitivity** Sensitivity is the capability of a test method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest. Examples of QC measures for determining sensitivity include laboratory fortified blanks, a DL study, Limit of Detection (LOD)/Limit of Quantitation (LOQ) Verifications, and Instrument Sensitivity Checks (ISC). To meet the needs of the data users, project data must meet the MPC for sensitivity and project QLs specified in **Worksheets #15 & 28** of this QAPP. If appropriate, the usability report may also: • Discuss and compare sensitivity and DL/LOD/LOQ from the datasets collected for the project for each matrix, analytical group, and concentration level. • Discuss the impact of a lack of sensitivity or higher DL/LOD/LOQ on data usability, if validation reports indicate that sensitivity goals or DL/LOD/LOQ goals were not achieved. Describe the limitations on the use of project data if project-required sensitivity goals and DL/LOD/LOQ are not achieved for all project data, or when sensitivity is limited to a specific sampling or laboratory group, dataset or SDG, matrix, analytical group, or concentration level

Step 3	**Verify the assumptions of the selected statistical method** The use of statistical methods for data assessment for this project will be limited to estimating a 95% UCL (or mean as appropriate for the analyte) for the assessment of risks.
Step 4	**Implement the statistical method** Where statistical methods are used, the underlying assumptions will be assessed during the DUA. The consequences of selecting the incorrect alternative will be discussed, and uncertainty tolerances will be considered.
Step 5	**Document data usability and draw conclusions** The DUA will determine and document whether the data can be used as intended given any deviations and corrective actions that may have occurred. Limitations on data use will be considered and discussed as appropriate, and the performance of the sampling design assessed. Conclusions will be drawn taking any data limitations into consideration and documented in the SI report.

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Appendix A – Technical Project Planning Meeting Minutes (TPP1 and TPP2)

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Meeting Minutes
West Bend AASF #1– Site Inspection (SI)
Technical Project Planning (TPP) – Meeting 1/Meeting 2
Preliminary Assessments and Site Inspections (PA/SIs) for Perfluorooctanesulfonic Acid (PFOS) and Perfluorooctanic Acid (PFOA) Impacted Sites
Contract No. W912DR-12-D-0014, DO W912DR17F0192
Thursday, 27 August 2020
1300 to 1415 hrs.

Participants			
Name	**Affiliation***	**Phone**	**E-Mail**
Trevor Nobile	WIDNR	414-852-5310	Trevor.Nobile@wisconsin.gov
Riley Neumann	WIDNR	414-750-7030	riley.neumann@wisconsin.gov
Timothy Alessi	WIDNR	414-881-1015	timothy.alessi@wisconsin.gov
Judy Fassbender	WIDNR	414-507-5571	Judy.Fassbender@Wisconsin.gov
Theresa Brandabur	WIDMA	608-333-6459	theresa.brandabur@wisconsin.gov
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Tim Peck	USACE – Baltimore	410-962-3416	Timothy.J.Peck@usace.army.mil
Amanda Sullivan	ARNG G9	304-642-6000	amanda.d.sullivan7.ctr@mail.mil
Jady Harrington	AECOM	402-350-3687	jacquelyn.harrington@aecom.com
Savannah Wolfe	AECOM	703-682-9063	Savannah.irving@aecom.com

**ARNG G9-Army National Guard; WIDMA-Wisconsin Department of Military Affairs; WIDNR-Wisconsin Department of Natural Resources; USACE-United States Army Corps of Engineers; and AECOM-AECOM Technical Services, Inc.*

Jady Harrington (JH) (SI Task Manager & Senior Lead, AECOM) welcomed participants and began the meeting with a roll call and introductions. The sign-in sheet is included as **Attachment A** to these meeting minutes. The meeting focused on per- and polyfluoroalkyl substance (PFAS) releases at West Bend Army Aviation Support Facility (AASF) #1 and the proposed Site Inspection (SI) sampling approach.

JH began the presentation; briefing slides are included here as **Attachment B**. Key points discussed during the presentation are provided below.

As a safety reminder, the SI will conform to requirements in United States Army Corps of Engineers (USACE) Engineering Manual (EM) 385-1-1. Site-specific safety procedures will be planned for and followed during SI field work, including establishing controlled work zones during field activities.

Programmatic Discussion:

- The Technical Project Planning (TPP) process is a USACE-established process with the main goal of engaging stakeholders in project planning and reporting. The Army National Guard (ARNG) has embraced a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) model for the PFAS Preliminary Assessment (PA) and SIs nationwide that will incorporate state-specific guidance as necessary. The TPP1 will also serve as the TPP2.
- This TPP1/TPP2 meeting will provide an opportunity for stakeholders to discuss the SI Work Plan; regulatory stakeholders will be afforded the opportunity to formally review and comment on the SI Work Plan. Sample rationale and locations will be reviewed later in the presentation.

- The TPP3 meeting presents the SI Report findings to all stakeholders; again, regulatory review and comment of the document will occur.
- The ARNG PFAS program is centrally contracted through USACE and managed by ARNG. Every ARNG facility nationwide responded to a questionnaire on potential PFAS releases. Facilities were prioritized by the likelihood of release and proximity to drinking water sources. The facility-wide PA for West Bend AASF #1 was completed in May 2019.
- There are nearly 200 facilities on the ARNG's nationwide PA list.

West Bend AASF #1 PA Findings:

- Savannah Wolfe (SW) (SI Field Manager, AECOM) provided a brief overview of the PA findings. During the PA, two potential source areas were identified. These locations are identified in the briefing slides, and more detail was provided during the SI Overview, but the potential PFAS releases were attributed to aqueous film forming foam (AFFF) fire suppression system releases, and fire extinguishers containing AFFF.
- The group discussed potential adjacent sources to the AASF.

West Bend AASF #1 SI Overview:

- The ARNG and Wisconsin Department of Military Affairs (WIDMA) investigations share the primary objective of protecting human health and the environment from potential PFAS exposure.
- During the SI planning phase, data quality objectives (DQOs) were established in order to collect the appropriate data to feed into the conceptual site model (CSM).
- The primary goal of the SI is to determine the presence/absence of a release from potential source areas.
- SW reviewed the two Area of Interests (AOIs):
    - AOI 1 Fire Suppression System Testing
    - AOI 2 TriMax^{TM} Fire Extinguisher
- Geologic and hydrogeological data will inform the CSM, specifically with respect to the direction and rate of groundwater flow. The ARNG PFAS program includes consideration of enhanced DQOs that assess PFAS at the point of exposure and at the West Bend AASF #1 boundary.

West Bend AASF #1 SI Proposed Activities:

- Continuous soil cores to target depth will be collected during the field work. Samples will be collected in shallow soil and above the water table in the potential source areas. Continuous logging of borings will support understanding lithologic controls of preferential pathways.
- Surface soil and subsurface soil will be collected at the potential source area.
- Temporary monitoring wells will be installed to a maximum depth of 30 ft below ground surface to sample groundwater. Target depth is 10 ft below ground surface.
- The group discussed Investigation Derived Waste (IDW) and agreed that it would be containerized in Department of Transportation (DOT)-approved steel 55-gallon drums with Pending Labels. The drums will be stored in a Hazardous Materials Storage shed located on-Site.

- Document Review and Distribution was determined as follows:
    - Wisconsin Department of Natural Resources (WIDNR): Document review and comments are pending financial arrangements
    - Documents will be sent electronically and via the WIDNR specified online portal for distribution by the WIDMA.

Questions and Open Discussion:

- Tim Peck (USACE) asked if surveying of the boring locations will take place and the group discussed that surveying will be conducted for each of the boring location ideally the same day as sampling.
- Judy Fassbender (JF) (WIDNR) asked how the temporary wells were installed. It was discussed that using direct push technology, a one-inch diameter polyvinyl chloride (PVC) temporary well will be installed with five feet intervals. Trevor Nobile (TN) (WIDNR) mentioned several Wisconsin Administration Codes (such as NR 141 and NR 712) to review and ensure the wells are installed in accordance with Wisconsin requirements.
- Regarding AOI 2, JF expressed concern for the one monitoring well at the source area. JH suggested adding surface soil samples with the source area. Additionally, the group discussed the piezometer (AOI02-PZ01) and decided to make the location a monitoring well.
- WIDMA and WIDNR discussed being present during the sample location stake out and utility locates.
- The PFAS analytical list was discussed. WIDNR asked if the Wisconsin 36-compound PFAS list would be used, and JH stated that it is a programmatic decision to use the 18-compound PFAS list for the SI. Additionally, SW discussed that the laboratory (Pace Gulf Coast) anticipates having their Environmental Laboratory Approval Program (ELAP) certification for Wisconsin in September 2020. The laboratory will gain certification on the Wisconsin 36 PFAS compound list.
- The group discussed document submittal to the WIDNR, the WIDMA will submit documents through the WIDNR online portal.
- WIDNR stated that IDW should be containerized into 55-gallon drums. WIDMA stated that it could be stored in a hazardous materials room at the AASF.
- JH gave closing remarks and thanked all participants for a productive discussion.

Visual Reconnaissance:

- Proposed sample locations were not visually inspected during this TPP due to travel restrictions. The proposed sample locations with be visually inspected concurrently with the utility clearance.

Action Items:

- AECOM will issue the Final Uniform Federal Policy for Quality Assurance Project Plan (UFP-QAPP) Addendum upon concurrence with responses to comments on the Draft Final UFP-QAPP Addendum.

Attachment A- TPP1/2 Sign-In Sheet

SIGN-IN SHEET
Technical Project Planning Meeting 1/2
Site Inspection, West Bend AASF #1, Wisconsin
Thursday, 27 August 2020

Name	Organization/Role	Phone	Email
Trevor Nobile*	WIDNR	414-852-5310	Trevor.Nobile@wisconsin.gov
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Theresa Brandabur*	WIDMA	608-333-6459	theresa.brandabur@wisconsin.gov
Brendon Manglos*	WIDMA	608-512-6097	brendon.manglos@wisconsin.gov
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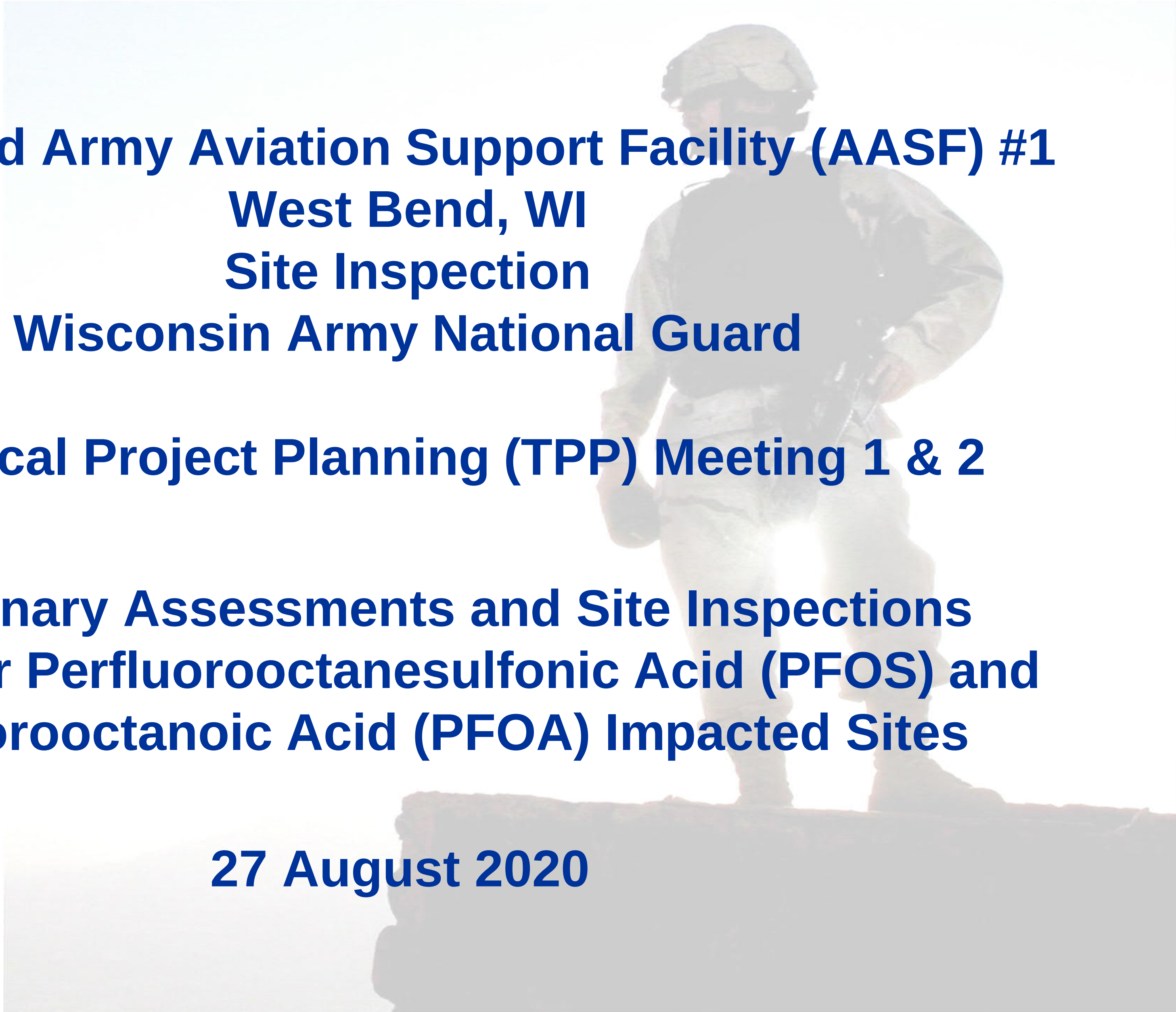
Alison Suess*	USACE - Seattle	-	Alison.m.suess@usace.army.mil
Kristin Addis*	USACE – Seattle	-	Kristin.l.addis@usace.army.mil
Tim Peck*	USACE – Baltimore	410-962-3416	Timothy.J.Peck@usace.army.mil
Amanda Sullivan*	ARNG G9	304-642-6000	amanda.d.sullivan7.ctr@mail.mil
Jady Harrington*	AECOM	402-350-3687	jacquelyn.harrington@aecom.com
Savannah Wolfe*	AECOM	703-682-9063	Savannah.irving@aecom.com
*participated by phone			

Attachment B- TPP1/2 Briefing Slides



West Bend Army Aviation Support Facility (AASF) #1
West Bend, WI
Site Inspection
Wisconsin Army National Guard

Technical Project Planning (TPP) Meeting 1 & 2

Preliminary Assessments and Site Inspections (PA/SI) for Perfluorooctanesulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) Impacted Sites

27 August 2020

Agenda

- Introductions
- Safety Moment
- TPP Meeting Goals
- Army National Guard (ARNG) PA/SI Overview
- West Bend AASF #1 ARNG PA Results
- West Bend AASF #1 SI Overview
- Stakeholder Involvement
- Questions and Open Discussion
  - Sample location refinement

Introductions

- ARNG G9, Cleanup Branch
  - David Connolly, Program Manager
  - Bonnie Packer, Nationwide Project Manager
  - Amanda Sullivan, SI Project Manager
- United States Army Corps of Engineers (USACE)
  - Tim Peck, Program Manager
  - Briana Niestrom, SI Project Manager
  - Alison Suess, Lead Chemist
  - Kristin Addis, Lead Geologist
- Wisconsin Department of Military Affairs (WIDMA)
  - Brendon Manglos, Interim Environmental Branch Chief
  - Theresa Brandabur, Water Resources and Training Manager
- Wisconsin Department of Natural Resources (WIDNR)
  - Trevor Nobile, P.G., CPG, Lead Project Manager
  - Steve Ales, Hydrogeologist Program Coordinator/Technical Expert
  - Riley Neumann, Hydrogeologist Project Manager
  - Tim Alessi, Regional Supervisor
  - Judy Fassbender, Chief, Policy and Technical Resources Section
- AECOM Technical Services, Inc.
  - Jacquelyn Harrington, SI Task Manager and SI Senior Lead
  - Savannah Wolfe, Field Task Manager

Safety Moment
Site Safety Procedures

- SI will follow USACE Engineering Manual (EM) 385-1-1 requirements:
  - Accident Prevention Plan addresses all component plans for EM 385-1-1, including Construction Support during drilling operations
  - Site Specific Health and Safety Plan addresses project participants, training, and hazard identification and mitigation
- Planning documents were prepared during SI Work Plan phase
- All Health and Safety documentation has been revised to incorporate COVID-19 updates and protective measures

TPP Meeting Goals

- TPP1:
  - Provide an overview of the ARNG PA/SI Program
    - Regulatory framework
  - Discuss PA Findings
  - Define objectives for SI data collection
  - Encourage stakeholder involvement
  - Review project schedule
  - Capture action items
- TPP2: Discuss proposed SI approach
- TPP3: Discuss SI findings
- Participants:
  - TPP1 and 2: ARNG, USACE, WIDMA, WIDNR
  - TPP3: ARNG, USACE, WIDMA, WIDNR, other local stakeholders

ARNG PA/SI Overview

Work Phases

Preliminary Assessment

***Site Inspection**

Remedial Investigation

Feasibility Study

Proposed Plan

Decision Document

Remedial Design

Remedial Action

Notes: *Current stage of activity

- Follows the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Process
- An interim removal action can be conducted or a No Further Action determination can be made at any phase

ARNG PA/SI Overview

- Activities centrally contracted through USACE and managed by ARNG G9
  - USACE Baltimore manages the contract, with technical project support from Louisville, Omaha, Sacramento, Seattle, and Alaska Districts
  - Project support: chemistry, geology, risk screening
- PA ranking (~200 facilities) - state ARNG input
  - Likelihood of release
  - Complete pathway to drinking water receptor
- Priority assigned to facilities with highest likelihood of release near drinking water intake
- PA – facility-wide; SI – areas of interest (AOIs)

ARNG PA/SI Overview

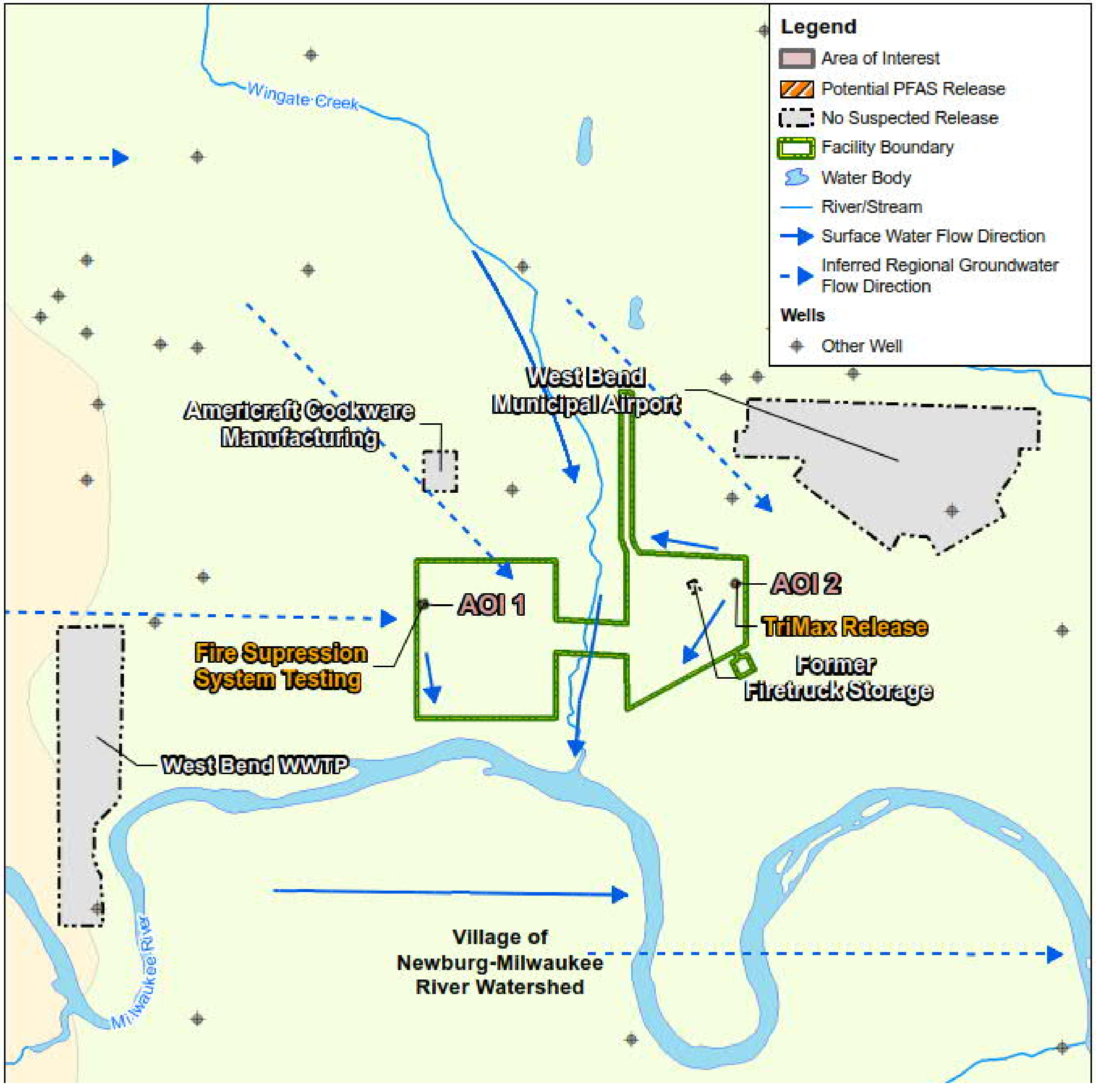
- ARNG / WIDMA
  - Identify potential per- and polyfluoroalkyl substances (PFAS) release locations
  - Provide facility access and points of contact
  - Gather and provide appropriate documents
  - Identify/schedule personnel to interview
  - Supply final PA to the regulatory agencies
- SI Regulatory Involvement
  - CERCLA SI conducted in conjunction with the appropriate regulatory agency

West Bend AASF #1
ARNG PA Results

- Potential PFAS release areas: Two Areas of Interest (AOIs) identified during the PA
- PFAS releases attributed to:
  - Fire Suppression System Release
    - Release of aqueous film forming foam (AFFF) to the grassy area west of the hangar annually from 2004 to present
  - Trimax^{TM} Fire Extinguisher
    - AFFF released from one TriMax^{TM} fire extinguisher during a fire training exercise
    - The concentration and exact date of release are unknown

West Bend AASF #1

Summary of Findings and AOIs



West Bend AASF #1 PA Findings

AOI 1 Fire Suppression System Testing

- The main hangar is equipped with a fire suppression system that is supplied by two 500 gallon tanks filled with 3% AFFF
- Since the main hangar was built in 2004, the fire suppression system has been tested annually by dispensing 20-40 gallons of AFFF through a piping system, and onto the gravel/grass
- The AFFF tanks are located in a room on the west side of the main hangar that is outfitted with floor drains that lead to an oil/water separator, then to the sanitary WWTP
- The stormwater drain within AOI 1 discharges to Wingate Creek, which then discharges to the Milwaukee River

West Bend AASF #1 PA Findings

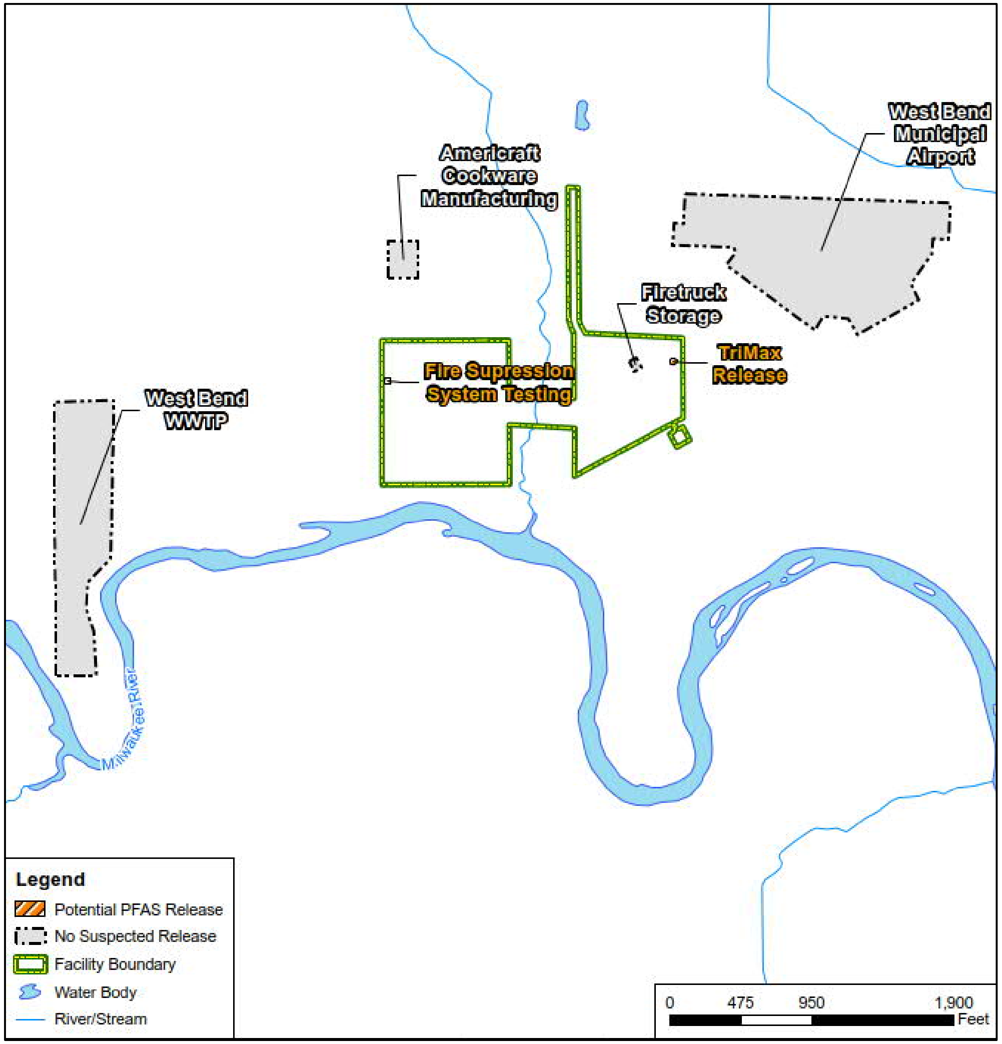
AOI 2 TriMax^{TM} Release

- One-time training event with one TriMax^{TM} fire extinguisher on the grassy area on the east side of the Armory
- The exact date, amount, and concentration of AFFF is unknown
- TriMax^{TM} fire extinguishers were removed from the AASF in 2010
- Surface water in the area flows northwest, towards the drain field, then discharges south to the Milwaukee River
- The drain field, located north of the Armory, was present from 1960 to 1998

West Bend AASF #1 PA Findings

Adjacent Sources

- West Bend Municipal Airport
    - Constructed in 1928
    - Located northeast of AASF
- Americraft Cookware Manufacturing
    - There is a potential for PFAS-containing materials used in the facility.
    - Building is located north of AASF
- West Bend Wastewater Treatment Plant
    - Constructed in 1928
    - Located southwest



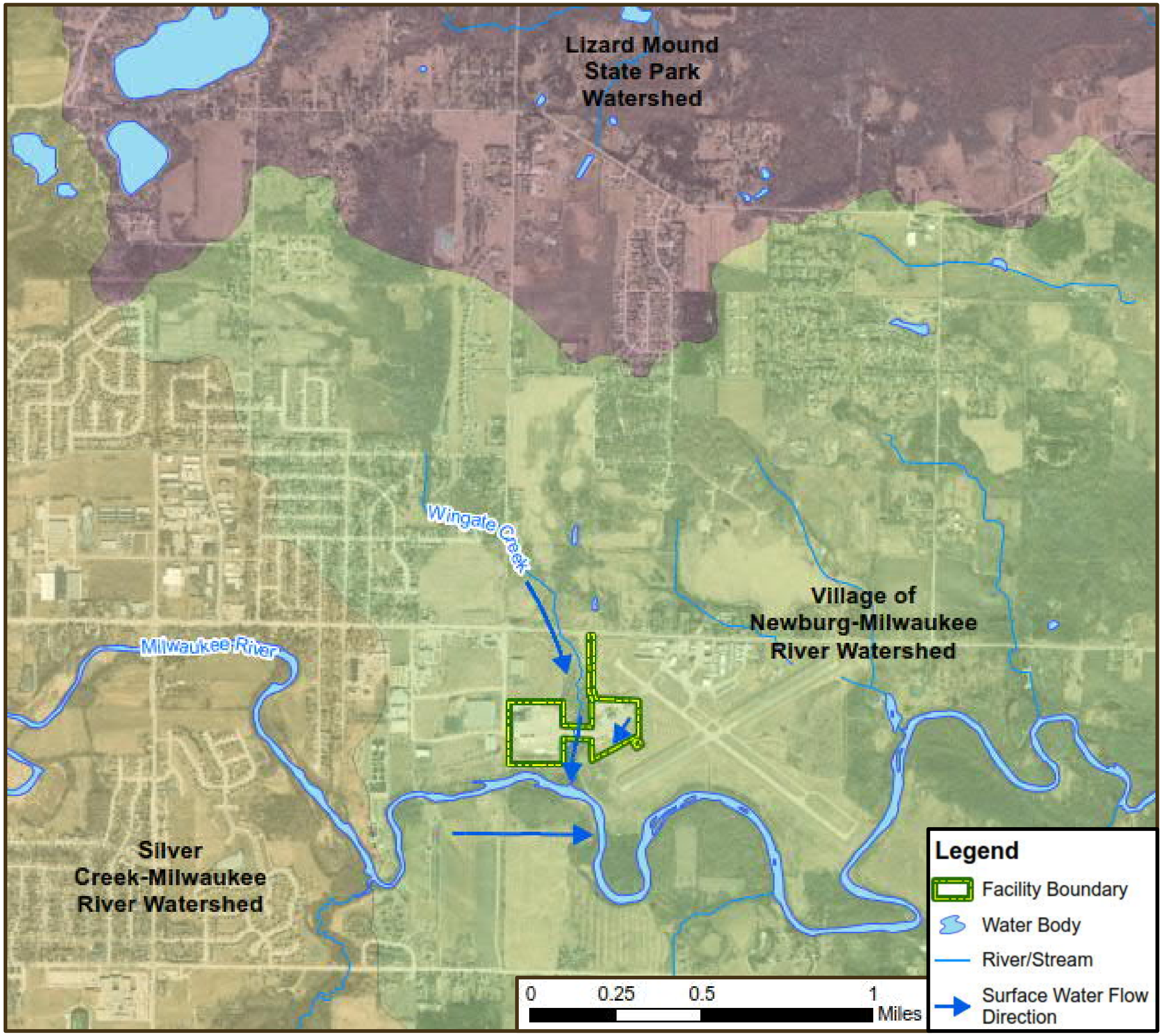
West Bend AASF #1
SI Overview
Data Quality Objectives (DQOs)

- Primary SI DQOs
  - Confirm the presence/absence of a release
  - Gather data for conceptual site model (CSM):

    Understanding of Source-Pathway-Receptor relationships required for establishing sampling strategy
- Extended SI DQOs
  - Determine the presence/absence at facility boundary
  - Check for alternate sources, up- or downgradient
  - Measure PFAS at/near receptor, if warranted

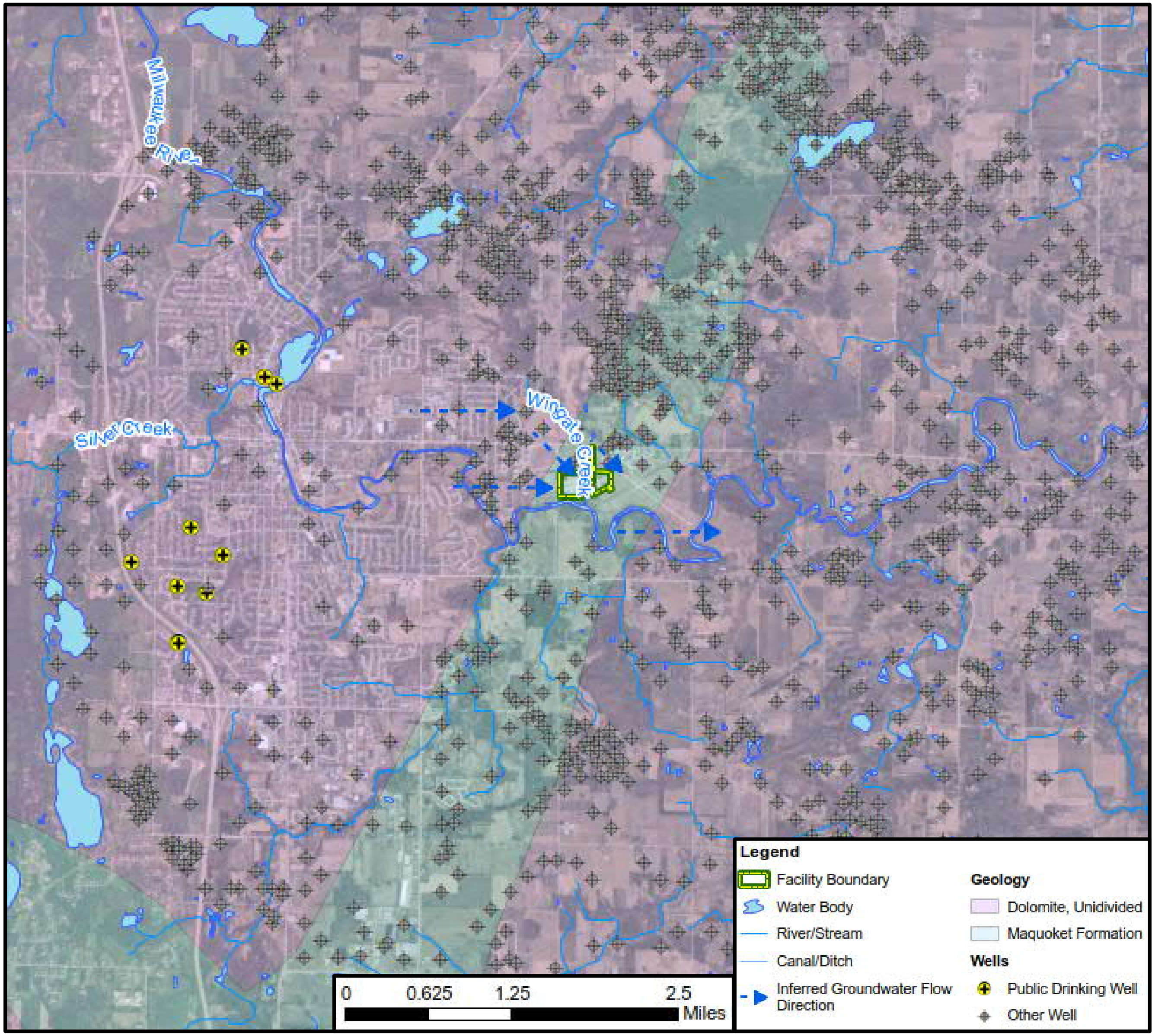
West Bend AASF #1 SI Overview

CSM – Surface Water Features

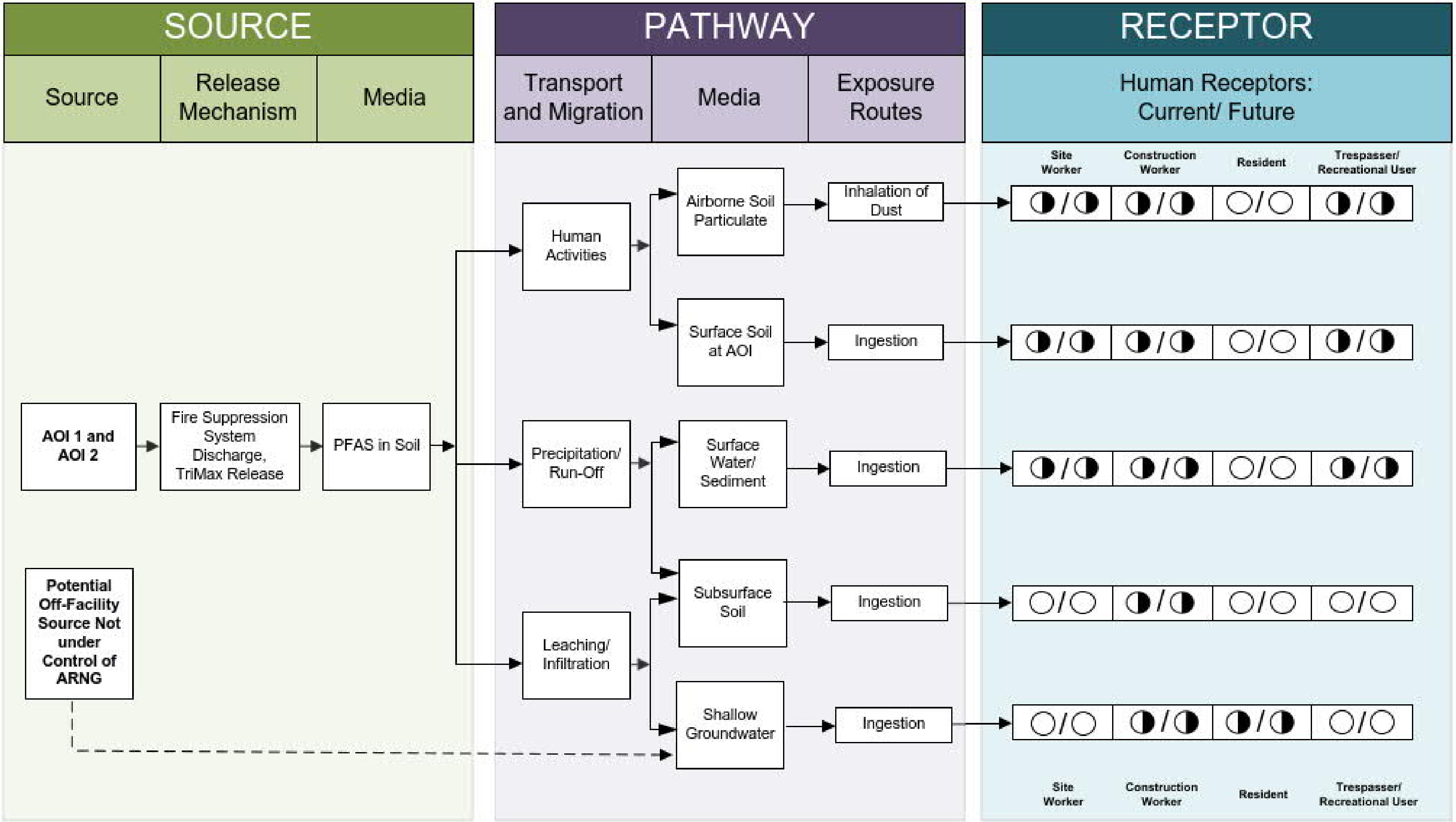


West Bend AASF #1 SI Overview

CSM – Groundwater Features



West Bend AASF #1 SI Overview CSM



	Site Worker	Construction Worker	Resident	Trespasser/ Recreational User
Inhalation of Dust	◐/◐	◐/◐	○/○	◐/◐
Ingestion	◐/◐	◐/◐	○/○	◐/◐
Ingestion	◐/◐	◐/◐	○/○	◐/◐
Ingestion	○/○	◐/◐	○/○	○/○
Ingestion	○/○	◐/◐	◐/◐	○/○

LEGEND

→ Flow-Chart Continues

- - → Partial / Possible Flow

○ Incomplete Pathway

◐ Potentially Complete Pathway

● Complete Pathway

Notes:

1. The resident and recreational user receptors refer to an off-site resident and recreational user.
2. Dermal contact exposure pathway is incomplete for PFAS.

West Bend AASF #1 SI Overview

Planning and Sampling

- Finalize Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP) Addendum
  - Draft Final submitted on 20 May 2020
  - Final to be submitted following the TPP 1&2 meeting
- Continuous soil cores to target depth
  - Soil samples collected at surface, mid point, above water table for new temporary well locations
- Collect a groundwater sample from each temporary well
- Collect surface soil samples

West Bend AASF #1 SI Overview

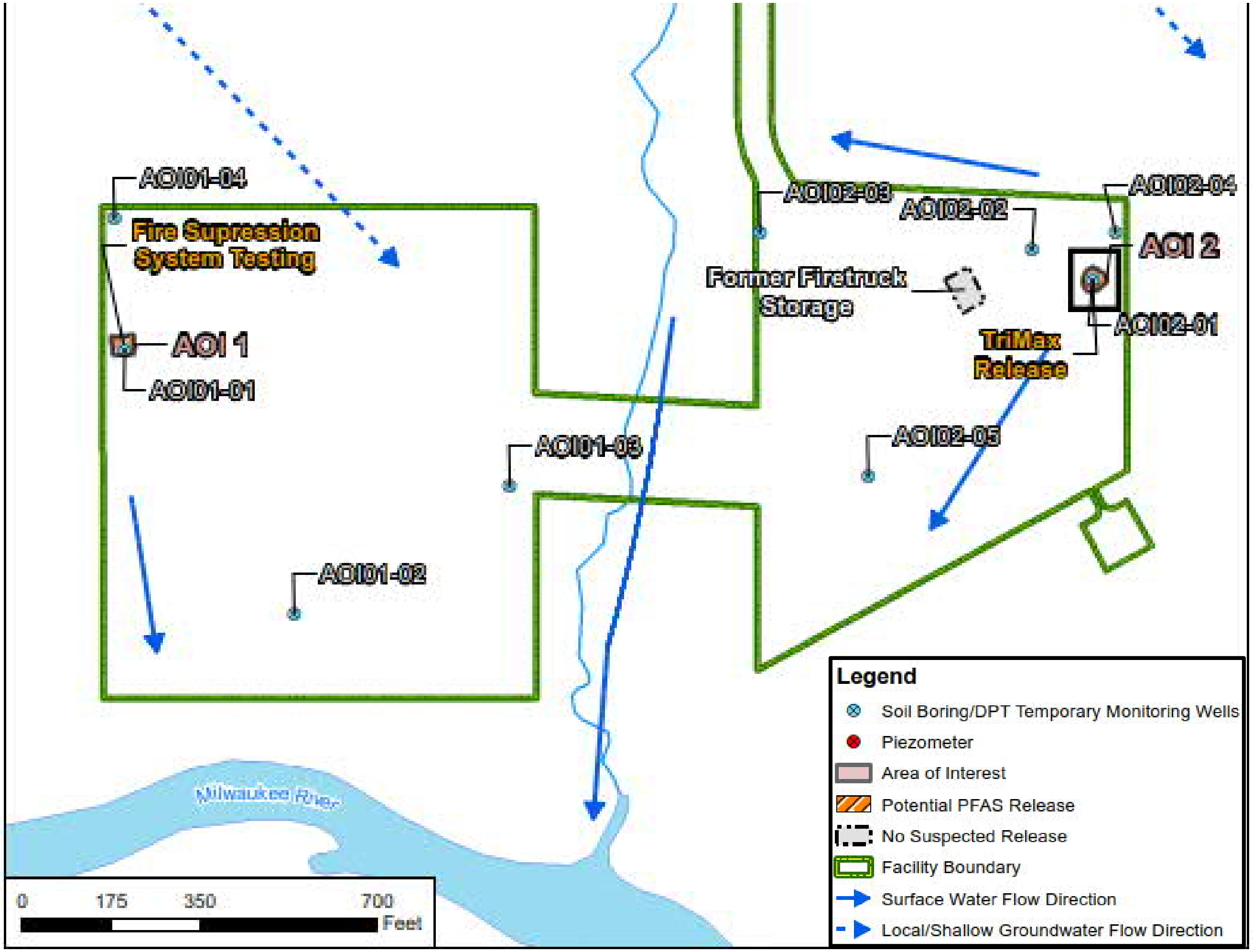
Proposed Sampling Locations

- Groundwater collected from 8 locations

  (8 samples)

- Surface and subsurface soil collected from 8 locations

  (24 samples)



West Bend AASF #1
SI Overview

AOI	Potential Source Area	# of Boring Locations	Target Depth(s) for Borings	Soil Samples	Groundwater Samples
1	Fire Suppression System Testing	4	10 ft	12	4
2	TriMax^{TM} Release	5	10 ft	12	4

- Sample locations will be refined in the field
  - Confirm placement is accessible and will meet DQOs prior to the utility mark-out and locate
- One direct push location in AOI 2 will be converted to a piezometer to establish a gradient for groundwater flow direction

West Bend AASF #1 SI Overview

Analytical Parameters

Perfluorooctanesulfonic acid (PFOS)	Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)	Perfluorononanoic acid (PFNA)
Perfluorooctanoic acid (PFOA)	Perfluorobutanesulfonic acid (PFBS)
Perfluorobutanoic acid (PFBA)	Perfluoropentanoic acid (PFPA)
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)
Perfluorodecanoic acid (PFDA)	Perfluorotetradecanoic acid (PFTA)
Perfluorododecanoic acid (PFDoA)	Perfluorohexanoic acid (PFHxA)
Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnA)
6:2 Fluorotelomer sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonate (8:2 FTS)

- Analysis completed by ELAP/NELAP-certified laboratory (Pace Gulf Coast)
  - Laboratory will be adding Wisconsin PFAS compounds to their ELAP scope next month, and will apply for PFAS certification (September 2020)
- Data will undergo Level III data validation

Stakeholder Involvement

- Use TPPs and open communication to encourage stakeholder involvement
- Key involvement topics
  - Proposed approaches
  - Document review time for WIDNR and other stakeholders
- Schedule:
  - Address remaining comments and issue Final UFP-QAPP Addendum: August 2020
  - Field Investigation: September/October 2020

Questions
and Open Discussion

- Coordination
  - Data transfer
  - Report distribution (paper, electronic, portable document format)
  - Stakeholder relations
- Schedule
- PA findings
- Utility mark-out and clearance procedures
- IDW handling
  - Return IDW to within 10 feet of sample location (downgradient)

Sample Location Refinement

- Confirm placement is accessible and will meet DQOs during utility locate
- Confirm any existing monitoring well locations
- Relocate, if needed, with ARNG, WIDMA, and WIDNR concurrence

Acronyms

- AASF – Army Aviation Support Facility
- AFFF – Aqueous Film Forming Foam
- AOI – Areas of interest
- ARNG – Army National Guard
- CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
- CSM – Conceptual Site Model
- DEQ – Department of Environmental Quality
- DQO – Data Quality Objective
- DSMOA – Defense and State Memorandum of Agreement
- ELAP – Environmental Laboratory Accreditation Program
- EM – Engineering Manual
- WIARNG – Wisconsin Army National Guard
- WIDNR – Wisconsin Department of Natural Resources
- WIDMA – Wisconsin Department of Military Affairs
- NELAP – National Environmental Laboratory Accreditation Program
- PA – Preliminary Assessment
- PFAS – Per- and Polyfluorinated Alkyl Substances
- PFOS – Perfluorooctanesulfonic Acid
- PFOA – Perfluorooctanoic Acid
- SI – Site Inspection
- TPP – Technical Project Planning
- UFP-QAPP – Uniform Federal Policy-Quality Assurance Project Plan
- USACE – United States Army Corps of Engineers

Appendix B – Standard Operating Procedures

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Utility Clearance

Procedure 3-01

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the process for determining the presence of subsurface utilities and other cultural features at locations where planned site activities involve the physical disturbance of subsurface materials.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM under the client contract.

1.3 The procedure applies to the following activities: soil gas surveying, excavating, trenching, drilling of borings and installation of monitoring and extraction wells, use of soil recovery or slide-hammer hand augers, and all other intrusive sampling activities.

1.4 The primary purpose of the procedure is to minimize the potential for damage to underground utilities and other subsurface features, which could result in physical injury, disruption of utility service, or disturbance of other subsurface cultural features.

1.5 If there are procedures, whether it be from AECOM, state, and/or federal, that are not addressed in this SOP and are applicable to utility clearance, those procedures should be added as an appendix to the project specific Quality Assurance Project Plan (QAPP).

1.6 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 Field and subcontractor personnel shall adhere to a site-specific health and safety plan (HASP).

3.0 Terms and Definitions

3.1 Utility

For the proposes of this SOP, a utility is defined as a manmade underground line or conduit, cable, pipe, vault or tank that is, or was, used for the transmission of material or energy (e.g., gas, electrical, telephone, steam, water or sewage, product transfer lines, or underground storage tanks).

3.2 As-Built Plans

As-built plans are plans or blueprints depicting the locations of structures and associated utilities on a property.

3.3 One-Call

The Utility Notification Center is the one-call agency for nationwide call before you dig. The Utility Notification Center is open 24 hours a day and accepts calls from anyone planning to dig. The phone number 811 is the designated call before you dig phone number that directly connects you to your local one-call center. Additional information can be found at www.call811.com.

Calling before you dig ensures that any publicly owned underground lines will be marked so that you can dig around them safely. Having the utility lines marked not only prevents accidental damage to the lines but prevents property damage and personal injuries that could result in breaking a line.

The following information will need to be provided when a call is placed to One-Call:

- Your name, phone number, company name (if applicable), and mailing address.
- What type or work is being done.
- Who the work is being done for.
- The county and city the work is taking place in.
- The address or the street where the work is taking place.
- Marking instructions, (specific instructions as to where the work is taking place).

Under normal circumstances it takes between 2 to 5 days from the time you call (not counting weekends or holidays) to have the underground lines marked. Because these laws vary from state to state, exactly how long it will take depends on where your worksite is located. You will be given an exact start time and date when your locate request is completed, which will comply with the laws in your area.

In the event of an emergency (any situation causing damage to life or property, or a service outage), lines can be marked sooner than the original given time if requested.

3.4 Toning

Toning is the process of surveying an area utilizing one or more surface geophysical methods to determine the presence or absence of underground utilities. Typically, toning is conducted after identifying the general location of utilities and carefully examining all available site utility plans. Each location is marked according to the type of utility being identified. In addition, areas cleared by toning are flagged or staked to indicate that all identified utilities in a given area have been toned.

4.0 Training and Qualifications

4.1 The **Task Order (TO) Manager** is responsible for verifying that these utility locating procedures are performed prior to the initiation of active subsurface exploration.

4.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all utility locating activities are performed in accordance with this procedure.

4.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.0 Equipment and Supplies

5.1 Equipment and supplies necessary for locating subsurface utilities will be provided by the subcontractor; however, the project **Field Manager/Field Personnel** will provide any additional equipment and supplies as needed as well as maintain information regarding the utility clearance activities in the field logbook.

6.0 Procedure

Proceed with the following steps where subsurface exploration will include excavations, drilling, or any other subsurface investigative method that could damage utilities at a site. In addition to the steps outlined below, always exercise caution while conducting subsurface exploratory work.

6.1 Prepare Preliminary Site Plan

- Prepare a preliminary, scaled site plan depicting the proposed exploratory locations as part of the project specific QAPP. Include as many of the cultural and natural features as practical in this plan.

6.2 Review Background Information

- Search existing plan files to review the as-built plans to identify the known location of utilities at the site. Plot the locations of utilities identified onto a preliminary, scaled site plan. Inform the TO Manager if utilities lie within close proximity to a proposed exploration or excavation location. The TO Manager will determine if it is necessary to relocate proposed sampling or excavation locations.
- Include the utility location information gathered during previous investigations (e.g., remedial investigation or remedial site evaluation) in the project design documents for removal or remedial actions. In this manner, information regarding utility locations collected during implementation of a TO can be shared with the subcontractor during implementation of a particular task order. In many instances, this will help to reduce the amount of additional geophysical surveying work the subcontractor may have to perform.
- Conduct interviews with onsite and facility personnel familiar with the site to obtain additional information regarding the known and suspected locations of underground utilities. In addition, if appropriate, contact shall be made with local utility companies to request their help in locating underground lines. Pencil in the dimensions, orientation, and depth of utilities, other than those identified on the as-built plans, at their approximate locations on the preliminary plans. Enter the type of utility, the personnel who provided the information, and the date the information was provided into the field log.
- During the pre-field work interviewing process, the interviewer will determine which site personnel should be notified in the event of an incident involving damage to existing utilities. Record this information in the field logbook with the corresponding telephone numbers and addresses.

6.3 Site Visit/Locate Utilities/Toning

- Prior to the initiation of field activities, the Field Task Manager or similarly qualified field personnel shall visit the site and note existing structures and evidence of associated utilities, such as fire hydrants, irrigation systems, manhole and vault box covers, standpipes, telephone switch boxes, free-standing light poles, gas or electric meters, pavement cuts, and linear depression. Compare notes of the actual site configuration to the preliminary site plan. Note deviations in the field logbook and on the preliminary site plan. Accurately locate or survey and clearly mark with stakes, pins, flags, paint, or other suitable devices all areas where subsurface exploration is proposed. These areas shall correspond with the locations drawn on the preliminary site plan.
- Following the initial site visit by the Field Task Manager, a trained utility locating subcontractor will locate, identify, and tone all utilities depicted on the preliminary site plan. The Field Task Manager or similarly qualified field personnel shall visit the site and identify the areas of subsurface disturbance with white spray paint, chalk, white pin flags or some other easily identifiable marking. The utility locator should utilize appropriate sensing equipment to attempt to locate utilities that might not have appeared on the as-built plans. At a minimum, the utility subcontractor should utilize a metal detector and/or magnetometer; however, it is important to consider the possibility that non-metallic utilities or tanks might be present at the site. Use other appropriate surface geophysical methods such as Ground Penetrating Radar, Radio detection, etc. as appropriate. Clear proposed exploration areas of all utilities in the immediate area where subsurface exploration is proposed. Clearly tone all anomalous areas. Clearly identify all toned areas on the preliminary site plan. All utilities near the area of subsurface disturbance should also be marked out by the utility subcontractor using the universal colors for subsurface utilities (i.e., red – electric; blue – water; green – sewer; yellow – gas; etc.). After toning the site and plotting all known or suspected buried utilities on the preliminary site plan, the utility locator shall provide the Field Task Manager with a copy of the completed preliminary site plan. Alternatively, the Field Task Manager or designee shall document the results of the survey on the preliminary site plan.
- Report to the Field Task Manager anomalous areas detected and toned that are in close proximity to the exploration or excavation areas. The Field Task Manager shall determine the safe distance to maintain from the known or suspected utility. It may be necessary to relocate the proposed

exploration or excavation areas. If this is required, the Field Task Manager or designee shall relocate them and clearly mark them using the methods described above. Completely remove the markings at the prior location. Plot the new locations on the site plan and delete the prior locations from the plan. In some instances, such as in areas extremely congested with subsurface utilities, it may be necessary to dig by hand or use techniques such as air knife to determine the location of the utilities.

6.4 Prepare Site Plan

- Prior to the initiation of field activities, draft a final site plan that indicates the location of subsurface exploration areas and all known or suspected utilities present at the site. Provide copies of this site plan to the client, the TO Manager, and the subcontractor who is to conduct the subsurface exploration/excavation work. Review the site plan with the client to verify its accuracy prior to initiating subsurface sampling activities.

7.0 Quality Control and Assurance

7.1 Utility locating must incorporate quality control measures to ensure conformance to these and the project requirements.

8.0 Records, Data Analysis, Calculations

8.1 A bound field logbook will be kept detailing all activities conducted during the utility locating procedure.

8.2 The logbook will describe any changes and modifications made to the original exploration plan. The trained utility locator shall prepare a report and keep it in the project file. Also, a copy of the final site plan will be kept in the project file.

9.0 Attachments or References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual.* Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Author	Reviewer	Revisions (Technical or Editorial)
Caryn DeJesus Senior Scientist	Bob Shoemaker Senior Scientist	Rev 0 – Initial Issue (June 2012)
Ken O’Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

Logbooks

Procedure 3-02

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the activities and responsibilities pertaining to the identification, use, and control of logbooks and associated field data records.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 In order to keep the logbook clean, store it in a clean location and use it only when outer gloves used for PPE have been removed.

3.0 Terms and Definitions

3.1 Logbook

A logbook is a bound field notebook with consecutively numbered, non-water-repellent binding or pages that is clearly identified with the name of the relevant activity, the person assigned responsibility for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 Data Form

A data form is a predetermined format utilized for recording field data that may become, by reference, a part of the logbook (e.g., soil boring logs, trenching logs, surface soil sampling logs, groundwater sample logs, and well construction logs are data forms).

4.0 Training and Qualifications

4.1 The **Task Order (TO) Manager** or **designee** is responsible for determining which team members shall record information in field logbooks and for obtaining and maintaining control of the required logbooks. The **TO Manager** shall review the field logbook on at least a monthly basis. The **TO Manager** or **designee** is responsible for reviewing logbook entries to determine compliance with this procedure and to ensure that the entries meet the project requirements.

4.2 A knowledgeable individual such as the **Field Manager**, **TO Manager**, or **Program Quality Manager** shall perform a technical review of each logbook at a frequency commensurate with the level of activity (weekly is suggested, or, at a minimum, monthly). Document these reviews by the dated signature of the reviewer on the last page or page immediately following the material reviewed.

4.3 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.4 The **Field Manager** is responsible for ensuring that all **field personnel** follow these procedures and that the logbook is completed properly and daily. The **Field Manager** is also responsible for submitting copies to the **TO Manager**, who is responsible for filing them and submitting a copy (if required by the TO Statement of Work).

4.5 The **logbook user** is responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. The **logbook user** is also responsible for safeguarding the logbook while having custody of it.

4.6 All **field personnel** are responsible for the implementation of this procedure.

5.0 Equipment and Supplies

5.1 Field logbooks shall be bound field notebooks with non-water-repellent binding or pages.

5.2 Ballpoint pens shall have indelible black ink.

6.0 Procedure

6.1 The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct the applicable events. Store the logbook in a clean location and use it only when outer gloves used for personal protective equipment (PPE) have been removed.

6.2 Individual data forms may be generated to provide systematic data collection documentation. Entries on these forms shall meet the same requirements as entries in the logbook and shall be referenced in the applicable logbook entry. Individual data forms shall reference the applicable logbook and page number. At a minimum, include names of all samples collected in the logbook even if they are recorded elsewhere.

6.3 Enter field descriptions and observations into the logbook, as described in Attachment 1, using indelible black ink.

6.4 Typical information to be entered includes the following:

- Dates (month/day/year) and times (military) of all on-site activities and entries made in logbooks/forms;
- Site name and description;
- Site location by longitude and latitude, if known;
- Weather conditions, including temperature and relative humidity;
- Fieldwork documentation, including site entry and exit times;
- Descriptions of, and rationale for, approved deviations from the Quality Assurance Project Plan (QAPP) or field sampling plan;
- Field instrumentation readings;
- Names, job functions, and organizational affiliations of on-site personnel;
- Photograph references;
- Site sketches and diagrams made on site;
- Identification and description of sample morphology, collection locations, and sample numbers;
- Sample collection information, including dates (month/day/year) and times (military) of sample collections, sample collection methods and devices, station location numbers, sample collection depths/heights, sample preservation information, sample pH (if applicable), analysis requested (analytical groups), etc., as well as chain of custody (CoC) information such as sample identification numbers cross-referenced to COC sample numbers;
- Sample naming convention;
- Field quality control (QC) sample information;
- Site observations, field descriptions, equipment used, and field activities accomplished to reconstruct field operations;

- Meeting information;
- Important times and dates of telephone conversations, correspondence, or deliverables;
- Field calculations;
- PPE level;
- Calibration records;
- Contractor and subcontractor information (address, names of personnel, job functions, organizational affiliations, contract number, contract name, and work assignment number);
- Equipment decontamination procedures and effectiveness;
- Laboratories receiving samples and shipping information, such as carrier, shipment time, number of sample containers shipped, and analyses requested; and
- User signatures.

6.5 The logbook shall reference data maintained in other logs, forms, etc. Correct entry errors by drawing a single line through the incorrect entry, then initialing and dating this change. Enter an explanation for the correction if the correction is more than for a mistake.

6.6 At least at the end of each day, the person making the entry shall sign or initial each entry or group of entries.

6.7 Enter logbook page numbers on each page to facilitate identification of photocopies.

6.8 If a person’s initials are used for identification, or if uncommon acronyms are used, identify these on a page at the beginning of the logbook.

6.9 At least weekly and preferably daily, the **preparer** shall photocopy and retain the pages completed during that session for backup. This will prevent loss of a large amount of information if the logbook is lost.

7.0 Quality Control and Assurance

7.1 Review per Section 4.2 shall be recorded.

8.0 Records, Data Analysis, Calculations

8.1 Retain the field logbook as a permanent project record. If a particular TO requires submittal of photocopies of logbooks, perform this as required.

8.2 Deviations from this procedure shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

9.0 Attachments or References

9.1 Attachment 1 – Description of Logbook Entries

9.2 Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue
Ken O'Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

Attachment 1
Description of Logbook Entries

Logbook entries shall be consistent with Section A.1.4 *Field Documentation SOPs* of the UFP-QAPP Manual (DoD 2005) and contain the following information, as applicable, for each activity recorded. Some of these details may be entered on data forms, as described previously.

Name of Activity	**For example, Asbestos Bulk Sampling, Charcoal Canister Sampling, Aquifer Testing.**
Task Team Members and Equipment	Name all members on the field team involved in the specified activity. List equipment used by serial number or other unique identification, including calibration information.
Activity Location	Indicate location of sampling area as indicated in the field sampling plan.
Weather	Indicate general weather and precipitation conditions.
Level of PPE	Record the level of PPE (e.g., Level D).
Methods	Indicate method or procedure number employed for the activity.
Sample Numbers	Indicate the unique numbers associated with the physical samples. Identify QC samples.
Sample Type and Volume	Indicate the medium, container type, preservative, and the volume for each sample.
Time and Date	Record the time and date when the activity was performed (e.g., 0830/08/OCT/89). Use the 24-hour clock for recording the time and two digits for recording the day of the month and the year.
Analyses	Indicate the appropriate code for analyses to be performed on each sample, as specified in the WP.
Field Measurements	Indicate measurements and field instrument readings taken during the activity.
CoC and Distribution	Indicate CoC for each sample collected and indicate to whom the samples are transferred and the destination.
References	If appropriate, indicate references to other logs or forms, drawings, or photographs employed in the activity.
Narrative (including time and location)	Create a factual, chronological record of the team’s activities throughout the day including the time and location of each activity. Include descriptions of general problems encountered and their resolution. Provide the names and affiliations of non-field team personnel who visit the site, request changes in activity, impact the work schedule, request information, or observe team activities. Record any visual or other observations relevant to the activity, the contamination source, or the sample itself. It should be emphasized that logbook entries are for recording data and chronologies of events. The logbook author must include observations and descriptive notations, taking care to be objective and recording no opinions or subjective comments unless appropriate.
Recorded by	Include the signature of the individual responsible for the entries contained in the logbook and referenced forms.
Checked by	Include the signature of the individual who performs the review of the completed entries.

Recordkeeping, Sample Labeling, and Chain of Custody

Procedure 3-03

1.0 Purpose and Scope

1.1 The purpose of this standard operating procedure is to establish standard protocols for all field personnel for use in maintaining field and sampling activity records, writing sample logs, labeling samples, ensuring that proper sample custody procedures are utilized, and completing chain of custody (CoC) /analytical request forms.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

Not applicable.

3.0 Terms and Definitions

3.1 Logbook

A logbook is a bound field notebook with consecutively numbered, non-water-repellent binding or pages that is clearly identified with the name of the relevant activity, the person responsible for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 Chain of Custody

A CoC is documentation of the process of custody control. Custody control includes possession of a sample from the time of its collection in the field to its receipt by the analytical laboratory, and through analysis and storage prior to disposal.

4.0 Training and Qualifications

4.1 The **Task Order (TO) Manager** is responsible for determining which team members shall record information in the field logbook and for checking sample logbooks and CoC forms to ensure compliance with these procedures. The **TO Manager** shall review CoC forms on a monthly basis at a minimum.

4.2 The **TO Manager** and **Program Quality Manager** are responsible for evaluating project compliance with the Project Procedures Manual.

4.3 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.4 The **Laboratory Project Manager** or **Sample Control Department Manager** is responsible for reporting any sample documentation or CoC problems to the **TO Manager** or **TO Laboratory Coordinator** within 24 hours of sample receipt.

4.5 The **Field Manager** is responsible for ensuring that all **field personnel** follow these procedures. The **TO Laboratory Coordinator** is responsible for verifying that the CoC/analytical request forms have been completed properly and match the sampling and analysis plan. The **TO Manager** or **TO Laboratory Coordinator** is responsible for notifying the **laboratory**, **data managers**, and **data validators** in writing if analytical request changes are required as a corrective action. These small changes are different from change orders, which involve changes to the scope of the subcontract with the laboratory and must be made in accordance with a respective contract (e.g., client remedial action contract).

4.6 All **field personnel** are responsible for following these procedures while conducting sampling activities. **Field personnel** are responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature.

5.0 Procedure

This procedure provides standards for documenting field activities, labeling the samples, documenting sample custody, and completing CoC/analytical request forms. The standards presented in this section shall be followed to ensure that samples collected are maintained for their intended purpose and that the conditions encountered during field activities are documented.

5.1 Recordkeeping

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct each day's events. Field logs such as soil boring logs and ground-water sampling logs will also be used. These procedures are described in Procedure 3-02, *Logbooks*.

5.2 Sample Labeling

Affix a sample label with adhesive backing to each individual sample container. Place clear tape over each label (preferably prior to sampling) to prevent the labels from tearing off, falling off, being smeared, and to prevent loss of information on the label. Record the following information with a ballpoint pen or pre-printed text on each label:

- Project name or number (optional);
- CoC sample number;
- Date and time of collection;
- Sampler's initials;
- Matrix (optional);
- Sample preservatives (if applicable); and
- Analysis to be performed on sample (this shall be identified by the method number or name identified in the subcontract with the laboratory).

These labels may be obtained from the analytical laboratory or printed from a computer file onto adhesive labels.

5.3 Custody Procedures

For samples intended for chemical analysis, sample custody procedures shall be followed through collection, transfer, analysis, and disposal to ensure that the integrity of the samples is maintained. Maintain custody of samples in accordance with the U.S. Environmental Protection Agency (EPA) CoC guidelines prescribed in EPA *NEIC Policies and Procedures*, National Enforcement Investigations Center, Denver, Colorado, revised May 1986; EPA *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (TEGD); *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA OSWER Directive 9355 3-01); Appendix 2 of the *Technical Guidance Manual for Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports*; and *Test Methods for Evaluating Solid Waste* (EPA SW-846)

A description of sample custody procedures is provided below.

5.3.1 Sample Collection Custody Procedures

According to the U.S. EPA guidelines, a sample is considered to be in custody if one of the following conditions is met:

- It is in one's actual physical possession or view;
- It is in one's physical possession and has not been tampered with (i.e., it is under lock or official seal);
- It is retained in a secured area with restricted access; and
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal.

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

- Sampler's name or initials; and
- Date and time that the sample/cooler was sealed.

These seals are designed to enable detection of sample tampering. An example of a custody seal is shown in Attachment 1.

Field personnel shall also log individual samples onto CoC forms (carbon copy or computer generated) when a sample is collected. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 5.4, indicating sample identification number, matrix, date and time of collection, number of containers, analytical methods to be performed on the sample, and preservatives added (if any). The **samplers** will also sign the CoC form signifying that they were the personnel who collected the samples. The CoC form shall accompany the samples from the field to the laboratory. When a cooler is ready for shipment to the analytical laboratory, the **person delivering the samples for transport** will sign and indicate the date and time on the accompanying CoC form. One copy of the CoC form will be retained by the **sampler** and the remaining copies of the CoC form shall be placed inside a self-sealing bag and taped to the inside of the cooler. Each cooler must be associated with a unique CoC form. Whenever a transfer of custody takes place, **both parties** shall sign and date the accompanying carbon copy CoC forms, and the **individual relinquishing the samples** shall retain a copy of each form. One exception is when the samples are shipped; the **delivery service personnel** will not sign or receive a copy because they do not open the coolers. The **laboratory** shall attach copies of the completed CoC forms to the reports containing the results of the analytical tests. An example CoC form is provided in Attachment 2.

5.3.2 Laboratory Custody Procedures

The following custody procedures are to be followed by an **independent laboratory** receiving samples for chemical analysis; the procedures in their Naval Facilities Engineering Service Center-evaluated Laboratory Quality Assurance Plan must follow these same procedures. A **designated sample custodian** shall take custody of all samples upon their arrival at the analytical laboratory. The **custodian** shall inspect all sample labels and CoC forms to ensure that the information is consistent, and that each is properly completed. The **custodian** will also measure the temperature of the temperature blank in the coolers upon arrival using either a National Institute for Standards and Technology calibrated thermometer or an infra-red temperature gun. The **custodian** shall note the condition of the samples including:

- If the samples show signs of damage or tampering;
- If the containers are broken or leaking;
- If headspace is present in sample vials;
- If proper preservation of samples has occurred (made by pH measurement, except volatile organic compounds [VOCs] and purgeable total petroleum hydrocarbons [TPH] and temperature). The pH of VOC and purgeable TPH samples will be checked by the **laboratory analyst** after the sample aliquot has been removed from the vial for analysis; and
- If any sample holding times have been exceeded.

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

Discrepancies or improper preservation shall be noted by the **laboratory** as an out-of-control event and shall be documented on an out-of-control form with corrective action taken. The out-of-control form shall be signed and dated by the **sample control custodian** and **any other persons** responsible for corrective action. An example of an out-of-control form is included as Attachment 4.

The **custodian** shall then assign a unique laboratory number to each sample and distribute the samples to secured storage areas maintained at 4 degrees Celsius (soil samples for VOC analysis are to be stored in a frozen state until analysis). The unique laboratory number for each sample, CoC sample number, client name, date and time received, analysis due date, and storage shall also be manually logged onto a sample receipt record and later entered into the laboratory's computerized data management system. The **custodian** shall sign the shipping bill and maintain a copy.

Laboratory personnel shall be responsible for the care and custody of samples from the time of their receipt at the laboratory through their exhaustion or disposal. Samples should be logged in and out on internal laboratory CoC forms each time they are removed from storage for extraction or analysis.

5.4 Completing CoC/Analytical Request Forms

CoC form/analytical request form completion procedures are crucial in properly transferring the custody and responsibility of samples from field personnel to the laboratory. This form is important for accurately and concisely requesting analyses for each sample; it is essentially a release order from the analysis subcontract.

Attachment 2 is an example of a generic CoC/analytical request form that may be used by **field personnel**. Multiple copies may be tailored to each project so that much of the information described below need not be handwritten each time. Attachment 3 is an example of a completed site-specific CoC/analytical request form, with box numbers identified and discussed in text below.

CoC forms tailored to each TO can be drafted and printed onto multi-ply forms. This eliminates the need to rewrite the analytical methods column headers each time. It also eliminates the need to write the project manager, name, and number; QC Level; TAT; and the same general comments each time.

Complete one CoC form per cooler. Whenever possible, place all VOC analyte vials into one cooler in order to reduce the number of trip blanks. Complete all sections and be sure to sign and date the CoC form. One copy of the CoC form must remain with the field personnel.

Box 2 **Bill To:** List the name and address of the person/company to bill only if it is not in the subcontract with the laboratory.

Box 3 **Sample Disposal Instructions:** These instructions will be stated in the Master Service Agreement or each TO statement of work with each laboratory.

Shipment Method: State the method of shipment (e.g., hand carry or air courier via FedEx or DHL).

Comments: This area shall be used by the field team to communicate observations, potential hazards, or limitations that may have occurred in the field or additional information regarding analysis (e.g., a specific metals list, samples expected to contain high analyte concentrations).

Box 4 **Cooler No.:** This will be written on the inside or outside of the cooler and shall be included on the CoC. Some laboratories attach this number to the trip blank identification, which helps track samples for VOC analysis. If a number is not on the cooler, field personnel shall assign a number, write it on the cooler, and write it on the CoC.

QC Level: Enter the reporting quality control (QC) requirements (e.g., Full Data Package, Summary Data Package).

Turnaround time (TAT): TAT will be determined by a sample delivery group (SDG), which may be formed over a 14-day period, not to exceed 20 samples. Once the SDG has been completed, standard TAT is 21 calendar days from receipt of the last sample in the SDG. Entering NORMAL or STANDARD in this field will be acceptable. If quicker TAT is required, it shall be in the subcontract with the laboratory and reiterated on each CoC to remind the laboratory.

Box 5 **Type of Containers:** Write the type of container used (e.g., 1-liter glass amber, for a given parameter in that column).

Preservatives: Field personnel must indicate on the CoC the correct preservative used for the analysis requested. Indicate the pH of the sample (if tested) in case there are buffering conditions found in the sample matrix.

Box 6 **Sample Identification (ID) Number:** This is typically a five-character alphanumeric identifier used by the contractor to identify samples. The use of this identifier is important since the laboratories are restricted to the number of characters they are able to use. Sample numbering shall be in accordance with the project-specific sampling and analysis plan.

Description (Sample ID): This name will be determined by the location and description of the sample, as described in the project-specific sampling and analysis plan. This sample identification should not be submitted to the laboratory, but should be left blank. If a computer CoC version is used, the sample identification can be input, but printed with this block black. A cross-referenced list of the CoC Sample Number and sample identification must be maintained separately.

Date Collected: Record the collection date in order to track the holding time of the sample. Note: For trip blanks, record the date it was placed in company with samples.

Time Collected: When collecting samples, record the time the sample is first collected. Use of the 24-hour military clock will avoid a.m. or p.m. designations (e.g., 1815 instead of 6:15 p.m.). Record local time; the laboratory is responsible for calculating holding times to local time.

Lab ID: This is for laboratory use only.

Box 7 **Matrix/QC:** Identify the matrix (e.g., water, soil, air, tissue, fresh water sediment, marine sediment, or product). If a sample is expected to contain high analyte concentrations (e.g., a tank bottom sludge or distinct product layer), notify the laboratory in the comment section. Mark an “X” for the sample(s) that have extra volume for laboratory QC matrix spike/matrix spike duplicate (MS/MSD) purposes. The sample provided for MS/MSD purposes is usually a field duplicate.

Box 8 **Analytical Parameters:** Enter the parameter by descriptor and the method number desired (e.g., BTEX 8260B, PAHs 8270C, etc.). Whenever practicable, list the parameters as they appear in the laboratory subcontract to maintain consistency and avoid confusion.

If the CoC does not have a specific box for number of sample containers, use the boxes below the analytical parameter, to indicate the number of containers collected for each parameter.

Box 9 **Sampler’s Signature:** The person who collected samples must sign here.

Relinquished By: The person who turned over the custody of the samples to a second party other than an express mail carrier, such as FedEx or DHL, must sign and date here.

Received By: Typically, a representative of the receiving laboratory signs and dates here. Or, a field crew member who delivered the samples in person from the field to the laboratory might sign here. A courier, such as FedEx or DHL, does not sign here because they do not open the coolers. It must also be used by the prime contracting laboratory when samples are to be sent to a subcontractor.

Relinquished By: In the case of subcontracting, the primary laboratory will sign and date the Relinquished By space and fill out an additional CoC to accompany the samples being subcontracted.

Received By (Laboratory): This space is for the final destination (e.g., at a subcontracted laboratory). A representative of the final destination (e.g., subcontracted laboratory) must sign and date here.

Box 10 **Lab No. and Questions:** This box is to be filled in by the laboratory only.

Box 11 **Control Number:** This number is the “CoC” followed by the first contractor identification number in that cooler or contained on that CoC. This control number must be unique (i.e., never used twice). Record the date the CoC is completed. It should be the same date the samples are collected.

Box 12 **Total # of Containers:** Sum the number of containers in that row.

Box 13 **Totals:** Sum the number of containers in each column. Because CoC forms contain different formats depending on who produced the form, not all of the information listed in items 1 to 13 may be recorded; however, as much of this information as possible shall be included.

6.0 Quality Control and Assurance

6.1 Recordkeeping, sample labeling, and CoC activities must incorporate quality control measures to ensure accuracy and completeness.

6.2 Deviations from this procedure or the project-specific TO Quality Assurance Project Plan (QAPP) shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

7.0 Records, Data Analysis, Calculations

7.1 The CoC/analytical request form shall be faxed approximately daily to the **TO Laboratory Coordinator** for verification of accuracy. Following the completion of sampling activities, the sample logbook and CoC forms will be transmitted to the **TO Manager** for storage in project files. The **data validators** shall receive a copy also. The original CoC/analytical request form shall be submitted by the **laboratory** along with the data delivered. Any changes to the analytical requests that are required shall be made in writing to the laboratory. A copy of this written change shall be sent to the data validators and placed in the project files. The reason for the change shall be included in the project files so that recurring problems can be easily identified.

7.2 Deviations from this procedure or the project-specific sampling and analysis plan shall be documented in the records. Significant changes shall be approved by the **Program Quality Manager**.

8.0 Attachments or References

8.1 Attachment 1 – Chain-of-Custody Seal

8.2 Attachment 2 – Generic Chain-of-Custody/Analytical Request Form

8.3 Attachment 3 – Sample Completed Chain-of-Custody

8.4 Attachment 4 – Sample Out-of-Control Form

8.5 Environmental Protection Agency, United States (EPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Interim Final. EPA/540/G-89/004. Office of Emergency and Remedial Response. October.

8.6 EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

8.7 EPA. 1997. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846. 3rd ed., Final Update IIIA. Office of Solid Waste.

8.8 Water Resources Control Board, State of California. 1988. *Technical Guidance Manual for Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports*. August.

8.9 Procedure 3-02, *Logbooks.*

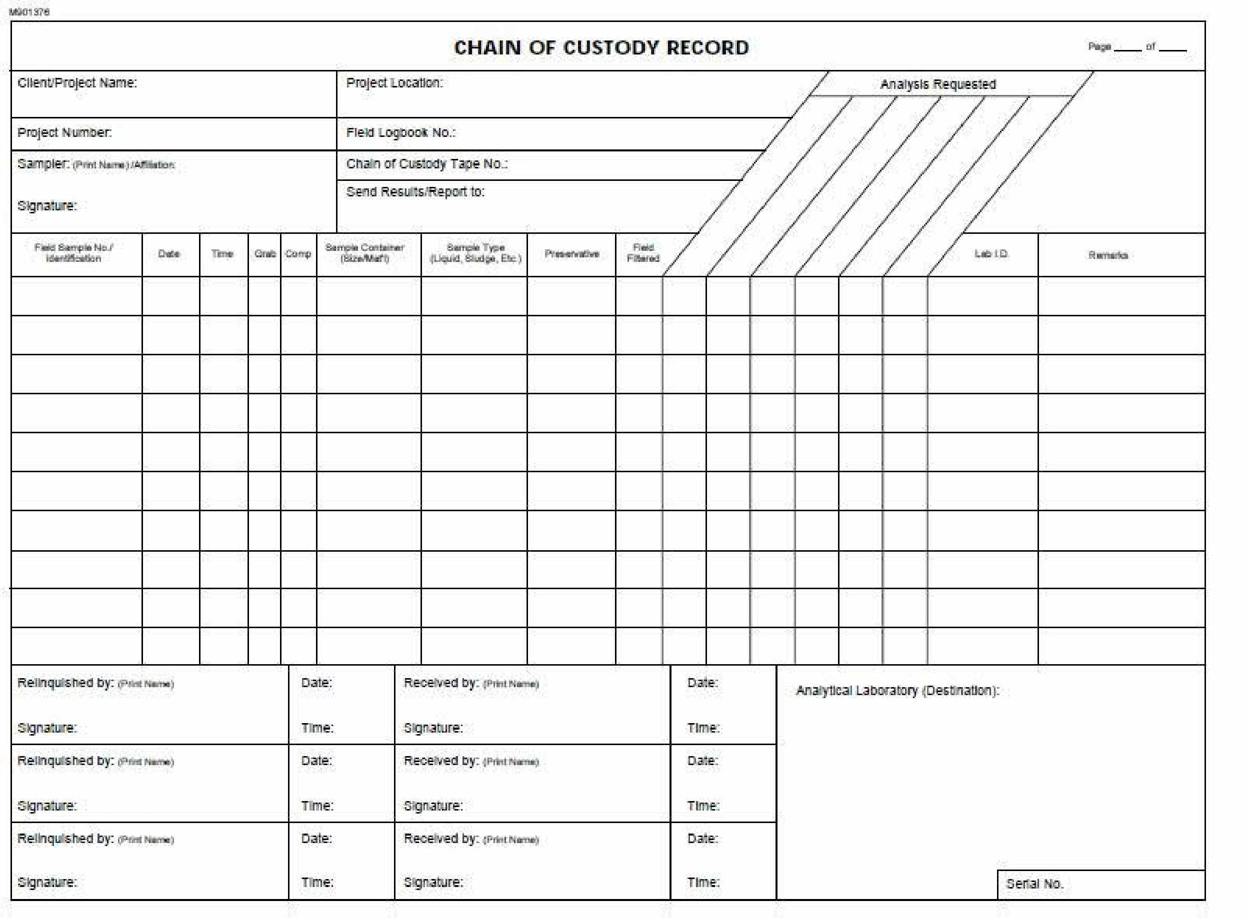
Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue
Ken O’Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

Attachment 1
Chain of Custody Seal

CHAIN-OF-CUSTODY SEAL

[LABORATORY]	SAMPLE NO.	DATE	SEAL BROKEN BY
	SIGNATURE		DATE
	PRINT NAME AND TITLE *(Inspector, Analyst or Technician*		

Attachment 2
Generic Chain of Custody/Analytical Request Form



M901376

CHAIN OF CUSTODY RECORD

Page ____ of ____

Client/Project Name:

Project Location:

Project Number:

Field Logbook No.:

Sampler: (Print Name)/Affiliation:

Signature:

Chain of Custody Tape No.:

Send Results/Report to:

Analysis Requested

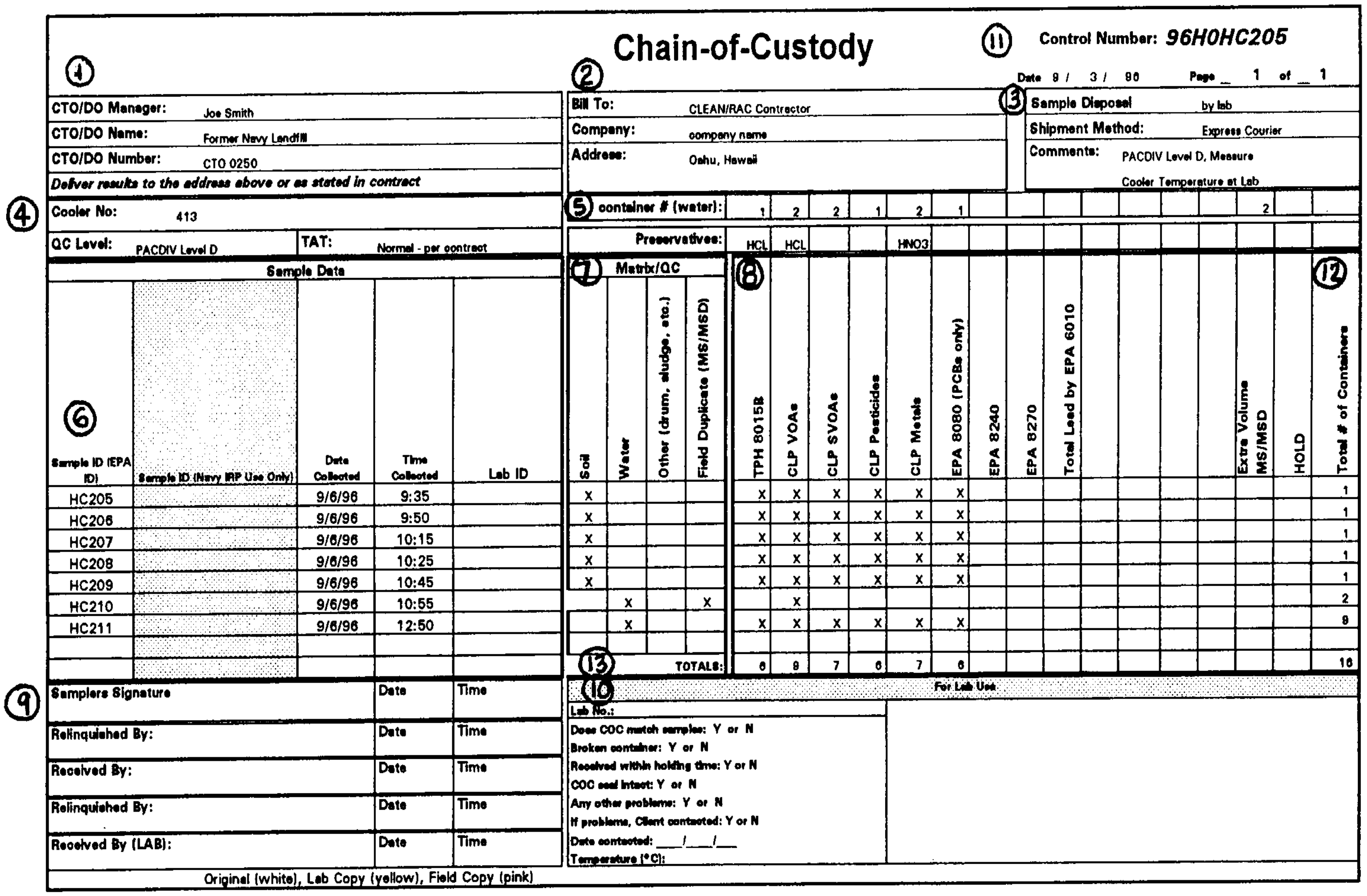
Field Sample No./ Identification	Date	Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Sludge, Etc.)	Preservative	Field Filtered							Lab I.D.	Remarks

Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:
Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:
Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:

Analytical Laboratory (Destination):

Serial No.

Attachment 3
Sample Completed Chain of Custody



Chain-of-Custody

Control Number: 96H0HC205

Date 9 / 3 / 96 Page 1 of 1

CTO/DO Manager:	Joe Smith
CTO/DO Name:	Former Navy Landfill
CTO/DO Number:	CTO 0250

Deliver results to the address above or as stated in contract

Bill To:	CLEAN/RAC Contractor
Company:	company name
Address:	Oahu, Hawaii

Sample Disposal	by lab
Shipment Method:	Express Courier
Comments:	PACDIV Level D, Measure Cooler Temperature at Lab

Cooler No: 413

QC Level: PACDIV Level D TAT: Normal - per contract

Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010				Extra Volume MS/MSD	HOLD	Total # of Containers
								container # (water):	1	2	2	1	2	1							2		
								Preservatives:	HCL	HCL			HNO3										
HC205		9/6/96	9:35		X				X	X	X	X	X	X									1
HC206		9/6/96	9:50		X				X	X	X	X	X	X									1
HC207		9/6/96	10:15		X				X	X	X	X	X	X									1
HC208		9/6/96	10:25		X				X	X	X	X	X	X									1
HC209		9/6/96	10:45		X				X	X	X	X	X	X									1
HC210		9/6/96	10:55			X		X		X													2
HC211		9/6/96	12:50			X			X	X	X	X	X	X									9
								TOTALS:	6	8	7	6	7	6									16

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

For Lab Use

Lab No.:
Does COC match samples: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Original (white), Lab Copy (yellow), Field Copy (pink)

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

PRINTED COPIES ARE UNCONTROLLED. CONTROLLED COPY IS AVAILABLE ON COMPANY INTRANET.

Attachment 4
Sample Out-of-Control Form

OUT OF CONTROL FORM	Status	Date	Initial
	Noted OOC		
	Submit for CA*		
	Resubmit for CA*		
	Completed		

Date Recognized:	By:
Dated Occurred:	Matrix
Parameter (Test Code):	Method:
Analyst:	Supervisor:

Samples Affected (List by Accession AND Sample No.)

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

3. Results of Corrective Action
☐ Return to Control (indicated with)
☐ Corrective Actions Not Successful - DATA IS TO BE FLAGGED with ____________.

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

This page intentionally left blank.

Sample Handling, Storage, and Shipping

Procedure 3-04

1.0 Purpose and Scope

1.1 This standard operating procedure describes the actions to be used by personnel engaged in handling, storing, and transporting samples. The objective is to obtain samples of actual conditions with as little alteration as possible.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 Avoid lifting heavy coolers with back muscles; instead, use leg muscles or dollies.

2.2 Wear powderless nitrile gloves, as defined in the project-specific health and safety plan, when handling sample containers to avoid contacting any materials that may have spilled out of the sample containers.

3.0 Terms and Definitions

None.

4.0 Training and Qualifications

4.1 The **Task Order (TO) Manager** and the **Laboratory Project Manager** are responsible for identifying instances of non-compliance with this procedure and ensuring that future sample transport activities comply with this procedure.

4.2 The **Field Manager** is responsible for ensuring that all samples are shipped according to this procedure.

4.3 **Field personnel** are responsible for the implementation of this procedure.

4.4 The **Program Quality Manager** is responsible for ensuring that sample handling, storage, and transport activities conducted during all TOs comply with this procedure.

4.5 All **field personnel** are responsible for the implementation of this procedure.

5.0 Procedure

5.1 Handling and Storage

Immediately following collection, label all samples according to Procedure 3-03, *Recordkeeping, Sample Labeling, and Chain of Custody*. The lids of the containers shall not be sealed with duct tape but may be covered with custody seals or placed directly into self-sealing polyethylene (e.g., Ziploc brand) bags. Place the sample containers in an insulated cooler with water ice in double, sealed self-sealing Ziploc bags. Samples should occupy the lower portion of the cooler, while the ice should occupy the upper portion. Place an absorbent material (e.g., proper absorbent cloth material) on the bottom of the cooler to contain liquids in case of spillage. Fill all empty space between sample containers with PFAS-free fill material. Prior to shipping, wrap glass sample containers on the sides, tops, and bottoms with polyethylene plastic wrap or other appropriate padding and/or surround them in Styrofoam to prevent breakage during transport. Pack all glass containers for water samples in an upright position, never stacked or on their sides. Prior to shipment, replace the ice in the coolers so that samples will be maintained as close to 4 degrees Celsius (°C) as possible from the time of collection through transport to the analytical laboratory. Ship samples within 24 hours or on a schedule allowing the laboratory to meet holding times for analyses. The procedures for maintaining sample temperatures at 4°C pertain to all field samples.

5.2 Shipping

Follow all appropriate U.S. Department of Transportation regulations (e.g., 49 Code of Federal Regulations [CFR], Parts 171-179) for shipment of air, soil, water, and other samples. Elements of these procedures are summarized below.

5.2.1 Hazardous Materials Shipment

Field personnel must state whether any sample is suspected to be a hazardous material. A sample should be assumed hazardous unless enough evidence exists to indicate it is non-hazardous. If not suspected to be hazardous, shipments may be made as described in the Section 5.2.2 for non-hazardous materials. If hazardous, follow the procedures summarized below.

Any substance or material that is capable of posing an unreasonable risk to life, health, or property when transported is classified as hazardous. Perform hazardous materials identification by checking the list of dangerous goods for that particular mode of transportation. If not on that list, materials can be classified by checking the Hazardous Materials Table (49 CFR 172.102 including Appendix A) or by determining if the material meets the definition of any hazard class or division (49 CFR Part 173), as listed in Attachment 2.

All **persons shipping hazardous materials** must be properly trained in the appropriate regulations, as required by HM-126F, Training for Safe Transportation of Hazardous Materials (49 CFR HM-126F Subpart H). The training covers loading, unloading, handling, storing, and transporting of hazardous materials, as well as emergency preparedness in the case of accidents. **Carriers**, such as commercial couriers, must also be trained. Modes of shipment include air, highway, rail, and water.

When shipping hazardous materials, including bulk chemicals or samples suspected of being hazardous, the proper shipping papers (49 CFR 172 Subpart C), package marking (49 CFR 172 Subpart D), labeling (49 CFR 172 Subpart E), placarding (49 CFR 172 Subpart F, generally for carriers), and packaging must be used. Attachment 1 shows an example of proper package markings. Refer to a copy of 49 CFR each time hazardous materials/potentially hazardous samples are shipped.

According to Section 2.7 of the International Air Transport Association Dangerous Goods Regulations publication, very small quantities of certain dangerous goods may be transported without certain marking and documentation requirements as described in 49 CFR Part 172; however, other labeling and packing requirements must still be followed. Attachment 2 shows the volume or weight for different classes of substances. A “Dangerous Goods in Excepted Quantities” label must be completed and attached to the associated shipping cooler (Attachment 3). Certain dangerous goods are not allowed on certain airlines in any quantity.

As stated in item 4 of Attachment 4, the Hazardous Materials Regulations do not apply to hydrochloric acid (HCl), nitric acid (HNO_3), sulfuric acid (H_2SO_4), and sodium hydroxide (NaOH) added to water samples if their pH or percentage by weight criteria is met. These samples may be shipped as non-hazardous materials as discussed below.

5.2.2 Non-Hazardous Materials Shipment

If the samples are suspected to be non-hazardous based on previous site sample results, field screening results, or visual observations, if applicable, then samples may be shipped as non-hazardous.

When a cooler is ready for shipment to the laboratory, place two copies of the chain of custody (CoC) form inside a self-sealing polyethylene (e.g., Ziploc brand) bag and tape it to the inside of the insulated cooler. Then, seal the cooler with waterproof tape and label it with “Fragile,” “This-End-Up” (or directional arrows pointing up), or other appropriate notices. Place custody seals on the coolers as discussed in Procedure 3-03, *Recordkeeping, Sample Labeling, and Chain of Custody*.

5.2.3 Shipments from Outside the Continental United States

Shipment of sample coolers to the United States from locations outside the continental United States is controlled by the U.S. Department of Agriculture (USDA) and is subject to their inspection and regulation. A “USDA Soil Import Permit” is required to prove that the receiving analytical laboratory is certified by the USDA to receive and properly dispose of soil. In addition, all sample coolers must be inspected by a **USDA representative**, affixed with a label indicating that the coolers contain environmental samples, and accompanied by shipping forms stamped by the **USDA inspector** prior to shipment.

In addition, the U.S. Customs Service must clear samples shipped from U.S. territorial possessions or foreign countries upon entry into the United States. As long as the commercial invoice is properly completed (see below), shipments typically pass through U.S. Customs Service without the need to open coolers for inspection.

Completion and use of proper paperwork will, in most cases, minimize or eliminate the need for the USDA and U.S. Customs Service to inspect the contents. Attachment 5 shows an example of how paperwork may be placed on the outside of coolers for non-hazardous materials. For hazardous materials, refer to Section 5.2.1.

In summary, tape the paperwork listed below to the outside of the coolers to accompany sample shipments. If a shipment is made up of multiple pieces (e.g., more than one cooler), the paperwork need only be attached to one cooler, provided that the **courier** agrees. All other coolers in the shipment need only to be taped and have the address and custody seals affixed.

1. **Courier Shipping Form & Commercial Invoice:** See Attachment 6 and Attachment 7 for examples of the information to be included on the commercial invoices for soil and water, respectively. Place the courier shipping form and commercial invoice inside a clear, plastic, adhesive-backed pouch that adheres to the package (typically supplied by the courier) and place it on the cooler lid as shown in Attachment 5.
2. **Soil Import Permit (soil only):** See Attachment 8 and Attachment 9 for examples of the soil import permit and soil samples restricted entry labels, respectively. The **laboratory** shall supply these documents prior to mobilization. The USDA often stops shipments of soil without these documents. Staple together the 2-inch × 2-inch USDA label (described below) and soil import permit and place them inside a clear plastic pouch. The **courier** typically supplies the clear, plastic, adhesive-backed pouches that adhere to the package.

   Placing one restricted entry label as shown in Attachment 5 (covered with clear packing tape) and one stapled to the actual permit is suggested.

   The USDA does not control water samples, so the requirements for soil listed above do not apply.
3. **Custody Seals:** The **laboratory** should supply the seals. **TO personnel** must sign and date these. At least two seals should be placed in such a manner that they stick to both the cooler lid and body. Placing the seals over the tape (as shown in Attachment 5), then covering it with clear packing tape is suggested. This prevents the seal from coming loose and enables detection of tampering.
4. **Address Label:** Affix a label stating the destination (laboratory address) to each cooler.
5. **Special Requirements for Hazardous Materials:** See Section 5.2.1.

Upon receipt of sample coolers at the laboratory, the **sample custodian** shall inspect the sample containers as discussed in Procedure 3-03, *Recordkeeping, Sample Labeling, and Chain of Custody*. The samples shall then be immediately extracted and/or analyzed, or stored in a refrigerated storage area until they are removed for extraction and/or analysis. Whenever the samples are not being extracted or analyzed, they shall be returned to refrigerated storage.

6.0 Quality Control and Assurance

6.1 Sample handling, storage, and shipping must incorporate quality control measures to ensure conformance to these and the project requirements.

7.0 Records, Data Analysis, Calculations

7.1 Maintain records as required by implementing these procedures.

7.2 Deviations from this procedure or the project-specific sampling and analysis plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

8.0 Attachments or Reference

8.1 Attachment 1 – Example Hazardous Material Package Marking

8.2 Attachment 2 – Packing Groups

8.3 Attachment 3 – Label for Dangerous Goods in Excepted Quantities

8.4 Attachment 4 – SW-846 Preservative Exception

8.5 Attachment 5 – Non-Hazardous Material Cooler Marking Figure for Shipment from Outside the Continental United States

8.6 Attachment 6 – Commercial Invoice – Soil

8.7 Attachment 7 – Commercial Invoice – Water

8.8 Attachment 8 – Soil Import Permit

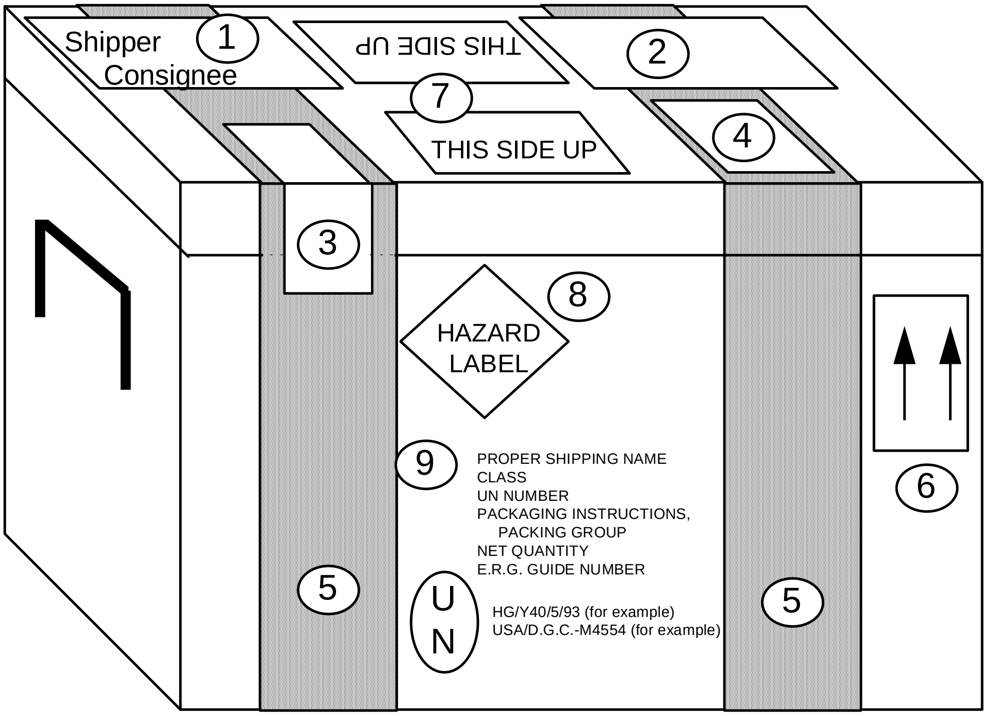
8.9 Attachment 9 – Soil Samples Restricted Entry Labels

8.10 Procedure 3-03, *Recordkeeping, Sample Labeling, and Chain of Custody*.

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue
Ken O'Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Attachment 1
Example Hazardous Material Package Marking



① **AIR BILL/COMMERCIAL INVOICE**

② **USDA PERMIT (Letter to Laboratory from USDA)**

③ **CUSTODY SEAL**

④ **USDA 2" X 2" SOIL IMPORT PERMIT**

⑤ **WATERPROOF STRAPPING TAPE**

⑥ **DIRECTION ARROWS STICKER - TWO REQUIRED**

⑦ **THIS SIDE UP STICKERS**

⑧ **HAZARD LABEL**

⑨ **HAZARDOUS MATERIAL INFORMATION**

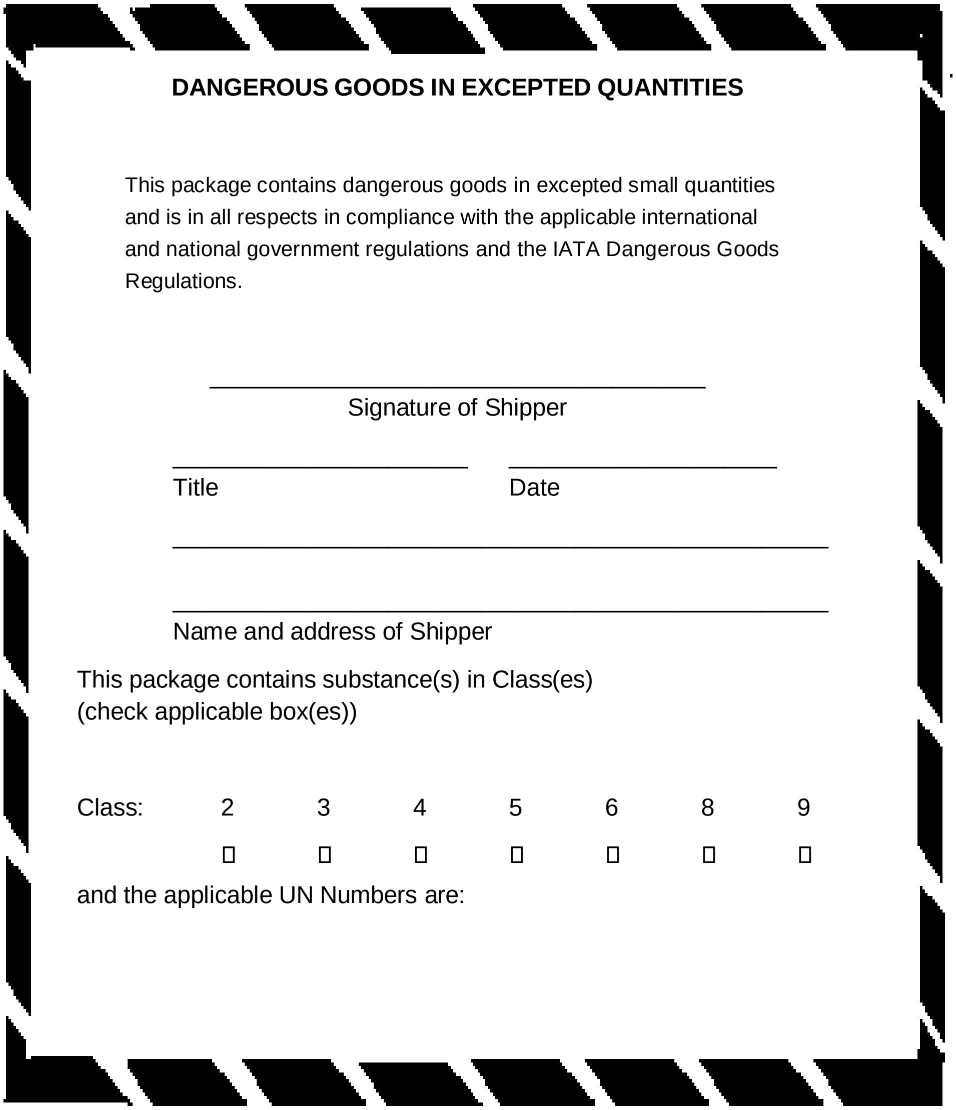
⑩ **PACKAGE SPECIFICATIONS**

Attachment 2
Packing Groups

PACKING GROUP OF THE SUBSTANCE	PACKING GROUP 1		PACKING GROUP II		PACKING GROUP III	
CLASS or DIVISION of PRIMARY or SUBSIDIARY RISK	Packagings		Packagings		Packagings	
	Inner	Outer	Inner	Outer	Inner	Outer
1: Explosives	---------------------------- Forbidden (Note A) ----------------------------------					
2.1: Flammable Gas	---------------------------- Forbidden (Note B) ----------------------------------					
2.2: Non-Flammable, non-toxic gas	---------------------------- See Notes A and B ----------------------------------					
2.3: Toxic gas	---------------------------- Forbidden (Note A) ----------------------------------					
3. Flammable liquid	30 mL	300 mL	30 mL	500 mL	30 mL	1 L
4.1 Self-reactive substances	Forbidden		Forbidden		Forbidden	
4.1: Other flammable solids	Forbidden		30 g	500 g	30 g	1 kg
4.2: Pyrophoric substances	Forbidden		Not Applicable		Not Applicable	
4.2 Spontaneously combustible substances	Not Applicable		30 g	500 g	30 g	1 kg
4.3: Water reactive substances	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.1: Oxidizers	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.2: Organic peroxides (Note C)	See Note A		30 g or 30 mL	500 g or 250 mL	Not Applicable	
6.1: Poisons - Inhalation toxicity	Forbidden		1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - oral toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - dermal toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.2: Infectious substances	---------------------------- Forbidden (Note A) ----------------------------------					
7: Radioactive material (Note D)	---------------------------- Forbidden (Note A) ----------------------------------					
8: Corrosive materials	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
9: Magnetized materials	---------------------------- Forbidden (Note A) ----------------------------------					
9: Other miscellaneous materials (Note E)	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L

Note A: *Packing groups are not used for this class or division.*
Note B: *For inner packagings, the quantity contained in receptacle with a water capacity of 30 mL. For outer packagings, the sum of the water capacities of all the inner packagings contained must not exceed 1 L.*
Note C: *Applies only to Organic Peroxides when contained in a chemical kit, first aid kit or polyester resin kit.*
Note D: *See 6.1.4.1, 6.1.4.2, and 6.2.1.1 through 6.2.1.7, radioactive material in excepted packages.*
Note E: *For substances in Class 9 for which no packing group is indicated in the List of Dangerous Goods, Packing Group II quantities must be used.*

Attachment 3
Dangerous Goods in Excepted Quantities



DANGEROUS GOODS IN EXCEPTED QUANTITIES

This package contains dangerous goods in excepted small quantities and is in all respects in compliance with the applicable international and national government regulations and the IATA Dangerous Goods Regulations.

____
Signature of Shipper

______________________ ______________________
Title Date

____

____
Name and address of Shipper

This package contains substance(s) in Class(es)
(check applicable box(es))

Class:	2	3	4	5	6	8	9
	☐	☐	☐	☐	☐	☐	☐

and the applicable UN Numbers are:

Attachment 4
SW-846 Preservative Exception

Measurement	Vol. Req. (mL)	Container[2]	Preservative[3,4]	Holding Time[5]
MBAS	250	P, G	Cool, 4ºC	48 Hours
NTA	50	P, G	Cool, 4ºC	24 Hours

1. More specific instructions for preservation and sampling are found with each procedure as detailed in this manual. A general discussion on sampling water and industrial wastewater may be found in ASTM, Part 31, p. 72-82 (1976) Method D-3370.

2. Plastic (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

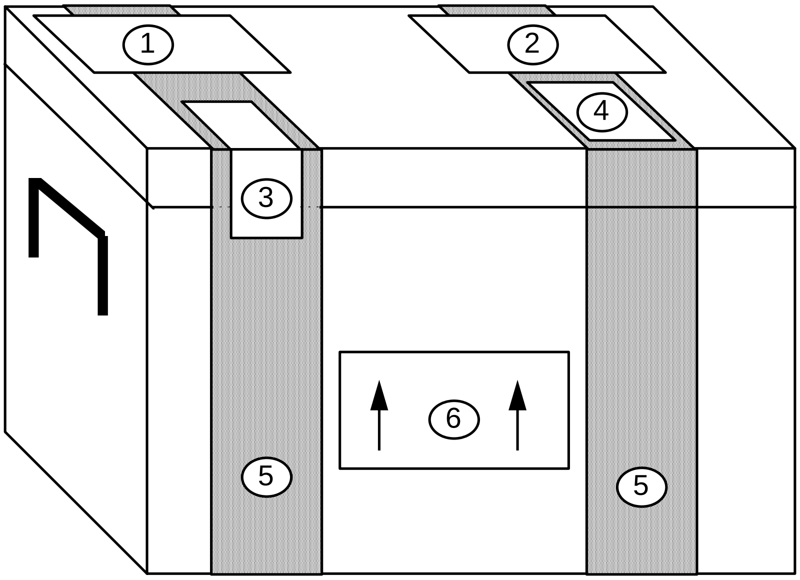
3. Sample preservation should be performed immediately upon sample collection. For composite samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4ºC until compositing and sample splitting is completed.

4. When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. for the preservation requirements of Table 1, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentration of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

5. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of sample under study are stable for the longer time, and has received a variance from the Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show this is necessary to maintain sample stability.

6. Should only be used in the presence of residual chlorine.

Attachment 5
Non-Hazardous Material Cooler Marking Figure for Shipment from Outside the Continental United States



① **AIR BILL/COMMERCIAL INVOICE**

② **USDA PERMIT (Letter to Laboratory from USDA)**

③ **CUSTODY SEAL**

④ **USDA 2" X 2" SOIL IMPORT PERMIT**

⑤ **WATERPROOF STRAPPING TAPE**

⑥ **DIRECTION ARROWS STICKER - TWO REQUIRED**

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Attachment 6
Commercial Invoice – Soil

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <TO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Receipt <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL AIR WAYBILL NO.		(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Soil samples for laboratory analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00
								Check one ☐ F.O.B. ☐ C&F ☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

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

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Attachment 7
Commercial Invoice – Water

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <TO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Receipt <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL AIR WAYBILL NO.		(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Water samples for laboratory analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00
								Check one ☐ F.O.B. ☐ C&F ☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

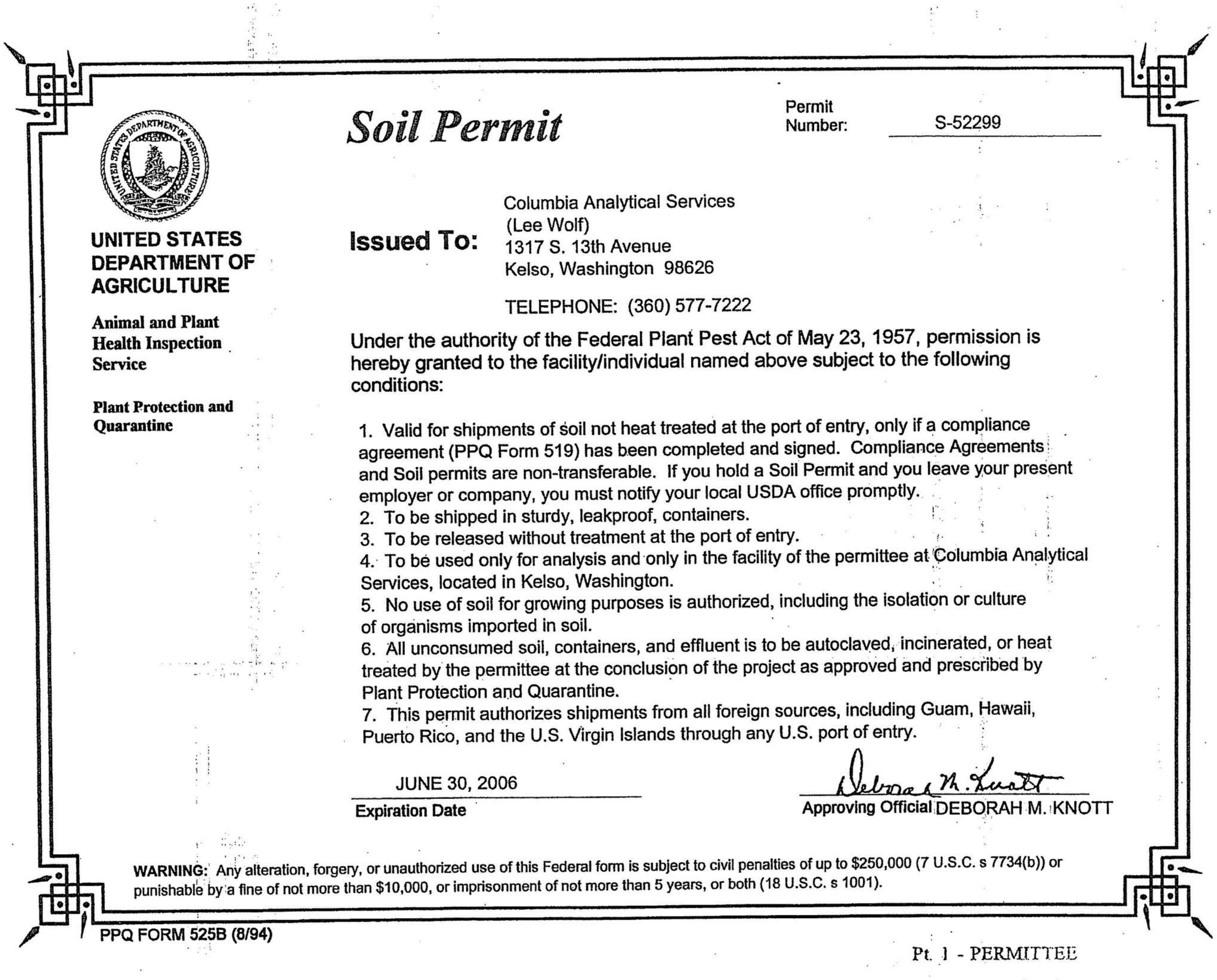
I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Joe Smith, Ogden Joe Smith 1/1/94

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Attachment 8
Soil Import Permit



Soil Permit

Permit Number: S-52299

UNITED STATES DEPARTMENT OF AGRICULTURE

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

Issued To:

Columbia Analytical Services
(Lee Wolf)
1317 S. 13th Avenue
Kelso, Washington 98626

TELEPHONE: (360) 577-7222

Under the authority of the Federal Plant Pest Act of May 23, 1957, permission is hereby granted to the facility/individual named above subject to the following conditions:

1. Valid for shipments of soil not heat treated at the port of entry, only if a compliance agreement (PPQ Form 519) has been completed and signed. Compliance Agreements and Soil permits are non-transferable. If you hold a Soil Permit and you leave your present employer or company, you must notify your local USDA office promptly.
2. To be shipped in sturdy, leakproof, containers.
3. To be released without treatment at the port of entry.
4. To be used only for analysis and only in the facility of the permittee at Columbia Analytical Services, located in Kelso, Washington.
5. No use of soil for growing purposes is authorized, including the isolation or culture of organisms imported in soil.
6. All unconsumed soil, containers, and effluent is to be autoclaved, incinerated, or heat treated by the permittee at the conclusion of the project as approved and prescribed by Plant Protection and Quarantine.
7. This permit authorizes shipments from all foreign sources, including Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands through any U.S. port of entry.

JUNE 30, 2006
Expiration Date

Deborah M. Knott
Approving Official DEBORAH M. KNOTT

WARNING: Any alteration, forgery, or unauthorized use of this Federal form is subject to civil penalties of up to $250,000 (7 U.S.C. s 7734(b)) or punishable by a fine of not more than $10,000, or imprisonment of not more than 5 years, or both (18 U.S.C. s 1001).

PPQ FORM 525B (8/94)

Pt. 1 - PERMITTEE

Attachment 9
Soil Samples Restricted Entry Labels

U.S. DEPARTMENT OF AGRICULTURE

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

PLANT PROTECTION AND QUARANTINE

HYATTSVILLE, MARYLAND 20782

SOIL SAMPLES

RESTRICTED ENTRY

The material contained in this package is imported under authority of the Federal Plant Pest Act of May 23, 1957.

For release without treatment if addressee is currently listed as approved by Plant Protection and Quarantine.

PPQ FORM 550 *Edition of 12/77 may be used*

(JAN 83)

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Investigation Derived Waste Management

Procedure 3-05

1.0 Purpose and Scope

This standard operating procedure (SOP) describes activities and responsibilities of the client with regard to management of investigation-derived waste (IDW). The purpose of this procedure is to provide guidance for the minimization, handling, labelling, temporary storage, inventory, classification, and disposal of IDW generated under the client contract. This procedure will also apply to personal protective equipment (PPE), sampling equipment, decontamination fluids, non-IDW trash, non-indigenous IDW, and hazardous waste generated during implementation of removal or remedial actions. The information presented will be used to prepare and implement work plans (WPs) for IDW-related field activities. The results from implementation of WPs will then be used to develop and implement final IDW disposal plans.

If there are procedures whether it be from AECOM, state and/or federal that are not addressed in this SOP and are applicable to IDW then those procedures may be added as an appendix to the project specific SAP.

This procedure shall serve as management-approved professional guidance for the client and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by both the Task Order (TO) Manager and the Quality Assurance (QA) Manager or Technical Director and documented.

This procedure was developed to serve as management-approved professional guidance for the management of IDW generated under the client contract. It focuses on the requirements for minimizing, segregating, handling, labeling, storing, and inventorying IDW in the field. Certain drum inventory requirements related to the screening, sampling, classification, and disposal of IDW are also noted in this procedure.

2.0 Safety

The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Health and Safety Plan (HASP). In the absence of a HASP, work will be conducted according to the TO WP and/or direction from the **Site Safety Officer (SSO)**.

All **Field Personnel** responsible for IDW management must adhere to the HASP and must wear the PPE specified in the site-specific HASP. Generally, this includes, at a minimum, steel-toed boots or steel-toed rubber boots, safety glasses, American National Standards Institute-standard hard hats, and hearing protection (if heavy equipment is in operation). If safe alternatives are not achievable, discontinue site activities immediately.

3.0 Terms and Definitions

None.

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

4.0 Training and Qualifications

4.1 The **TO Manager** is responsible for ensuring that IDW management activities comply with this procedure. The **TO Manager** is responsible for ensuring that all personnel involved in IDW management shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all IDW is managed according to this procedure.

4.4 All **Field Personnel** are responsible for the implementation of this procedure.

All AECOM personnel who will perform any duties related to management of Resource Conservation and Recovery Act (RCRA) hazardous wastes or shipping of Department of Transportation (DOT) Hazardous Materials will be properly trained in accordance with 40 CFR § 262.34 and §265.16 for RCRA Waste Generators, as well as 49 CFR § 172.704 for DOT Hazardous Materials Shippers. All RCRA Hazardous Wastes are by definition DOT Hazardous Materials. See Section 6.1 for details on determining the IDW waste classification.

5.0 Equipment and Supplies

The equipment and supplies required for implementation of this SOP include the following:

- Containers for waste (e.g., [U.S. Department of Transportation] DOT approved 55-gallon open and closed top drums) and material to cover waste to protect from weather (e.g., plastic covering);
- Hazardous /non-hazardous waste drum labels (weatherproof);
- Permanent marking pens;
- Inventory forms for project file;
- Plastic garbage bags, zip lock storage bags, roll of plastic sheeting; and
- Steel-toed boots, chemical resistant gloves, coveralls, safety glasses, and any other PPE required in the HASP.

6.0 Procedure

The following procedures are used to handle the IDW.

6.1 Drum Handling

6.1.1 IDW shall be containerized using DOT approved drums. The drums shall be made of steel or polyethylene, be completely painted or opaque, and have removable lids (i.e., United Nations Code 1A2 or 1H2). Always consider IDW physical and chemical characterises to make sure the drum material is compatible. Typically, 55-gallon drums are used, however small drums may be used depending on the amount of waste generated. Large overpack drums may be used if smaller drums become damaged. New drums are preferred. The use of recycled drums should be avoided.

6.1.2 Recycled drums should not be used for hazardous waste, PCBs or other regulated shipments. For short-term storage of liquid IDW prior to discharge, double-walled bulk steel or plastic storage tanks may be used. For this scenario, consider the scheduling and cost-effectiveness of this type of bulk storage, treatment, and discharge system versus longer-term drum storage.

6.1.3 For long-term IDW storage at other project locations, the DOT approved drums with removable lids are recommended. Verify the integrity of the foam or rubber sealing ring located on the underside of some drum lids prior to sealing drums containing IDW liquids.

6.1.4 If the sealing ring is only partially attached to the drum lid, or if a portion of the sealing ring is missing, select another drum lid with a sealing ring that is in sound condition.

6.1.5 To prevent damage to drums, loss of drum integrity/containment, and/or presenting hazards to drum handlers, the following “Rules-of-Thumb” should be applied when filling drums.

- Liquid, soil, PPE/plastics, and construction debris must be segregated by media into individual drums.
- A **void space of 4 to 6 inches** from the top of the drum (the upper drum ring on most drums) will be left in the drum to allow room for ice expansion when filling drums with water or oil/water emulsions. Under freezing temperatures, expanding ice in a full drum can deform the bottom of a drum such that it is no longer DOT compliant, cause ruptures and/or dislodge the drum lid and present a containment breach. The consequences of this damage can be both economic and environmental.
- Compatibility between the chemical component(s) of the IDW and the drum material must be considered before choosing the type of drum/container to use. Steel drums are susceptible to corrosion and loss of integrity when in contact with high pH water. Lime-based products (cement, concrete, grout, etc.) should not be disposed in steel drums containing water or soil water mixtures, and liquid IDW should not be disposed in steel drums used to mix lime-based products (separate reusable containers for mixing should be used when possible). If high (>12) or low (<2) pH conditions are possible, IDW liquids should be monitored for pH using a calibrated pH meter or pH test strips. The use of plastic drum liners or polyethylene drums is also recommended for high or low pH liquid IDW.
- Soil drums will be filled to no more than two thirds of the drum capacity. Drums completely full of soil can weigh over 600 pounds. Although drum handling tools and carts provide some assistance, moving such excessive weights present significant hazards, including; muscle strain, crushing (foot and fingers), and loss of drum control, such as sliding off of lift gates.
- Drums should not be overfilled filled with PPE and plastic (tubing, old macrocores) such that the material is excessively compacted. Pinch points are presented as the drum is closed under force, and the compressed material can spring up when the drums are opened.

6.1.6 Stacking full or partially full drums is prohibited.

6.1.7 To prepare IDW drums for labelling, wipe clean the outer wall surfaces and drum lids of all material that might prevent legible and permanent labelling. If potentially contaminated material adheres to the outer surface of a drum, wipe that material from the drum, and segregate the paper towel or rag used to remove the material with visibly soiled PPE and disposable sampling equipment. Label all IDW drums and place them on pallets prior to storage.

6.2 Labelling

6.2.1 Containers used to store IDW must be properly labelled. Two general conditions exist: 1) from previous studies or on-site data, waste characteristics are known to be either hazardous or nonhazardous; or 2) waste characteristics are unknown until additional data are obtained.

6.2.2 For situations where the waste characteristics are known, the waste containers should be packaged and labelled in accordance with state regulations and any federal regulations that may govern the labelling of waste.

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

6.2.3 The following information shall be placed on all non-hazardous waste labels:

- Description of waste (i.e., purge water, soil cuttings);
- Contact information (i.e., contact name and telephone number);
- Date when the waste was first accumulated.

6.2.4 The following information shall be placed on all hazardous waste labels:

- Description of waste (i.e., purge water, soil cuttings);
- Generator information (i.e., name, address, contact telephone number);
- EPA identification number (supplied by on-site client representative);
- Date when the waste was first accumulated.

6.2.5 When the final characterization of a waste is unknown, a notification label should be placed on the drum with the words “waste characterization pending analysis” and the following information included on the label:

- Description of waste (i.e., purge water, soil cuttings);
- Contact information (i.e., contact name and telephone number);
- Date when the waste was first accumulated.

6.2.6 Once the waste has been characterized, the label should be changed as appropriate for a nonhazardous or hazardous waste.

6.2.7 Waste labels should be constructed of a weatherproof material and filled out with a permanent marker to prevent being washed off or becoming faded by sunlight (faded entries should be remarked during inspections performed as specified in Section 6.2.4). It is recommended that waste labels be placed on the side of the container, since the top is more subject to weathering. However, when multiple containers are accumulated together, it may also be helpful to include labels on the top of the containers to facilitate organization and disposal. In addition to a label, each drum should be numbered on the side and top with a paint pen or wax pencil for easy identification.

6.2.8 Each container of waste generated shall be recorded in the field notebook used by the person responsible for labelling the waste. After the waste is disposed of, either by transportation off-site or disposal on-site in an approved disposal area, an appropriate record shall be made in the same field notebook to document proper disposition of IDW.

6.3 Types of Site Investigation Waste

Several types of waste are generated during site investigations that may require special handling. These include solid, liquid, and used PPE, as discussed further below.

Solid Waste

Soil cuttings from boreholes will typically be placed in containers unless site specific requirements allow for soil cuttings to be placed back into the borehole after drilling is complete. Drilling mud generated during investigation activities shall be collected in containers. Covers should be included on the containers and must be secured at all times and only open during filling activities. The containers shall be labelled in accordance with this SOP. An inventory containing the source, volume, and description of material put in the containers shall be logged on prescribed forms and kept in the project file.

Non-hazardous solid waste can be disposed on-site in the designated site landfill or in a designated evaporation pond if it is liquefied. Hazardous wastes must be disposed off-site at an approved hazardous waste landfill.

Liquid Waste

Groundwater generated during monitoring well development, purging, and sampling can be collected in truck-mounted containers and/or other transportable containers (i.e., 55-gallon drums). Lids or bungs on drums must be secured at all times and only open during filling or pumping activities. The containers shall be labelled in accordance with this SOP. Non-hazardous liquid waste can be disposed of in one of the designated lined evaporation ponds on-site. Hazardous wastes must be handled separately and disposed off-site at an approved hazardous waste facility.

Personal Protective Equipment

PPE that is generated throughout investigation activities shall be placed in plastic garbage bags. If the solid or liquid waste that was being handled is characterized as hazardous waste, then the corresponding PPE should also be disposed as hazardous waste. If not, all PPE should be disposed as non-hazardous waste in the designated on-site landfill. Trash that is generated as part of field activities may be disposed of in the landfill as long as the trash was not exposed to hazardous media.

6.1 IDW Waste Classification

State and federal regulations require specific handling and storage requirements for wastes classified as hazardous, such as secondary containment and waste removal deadlines (see Section 6.2.2). The Site owner/operator must determine whether the IDW may contain a listed hazardous waste based on the source of contamination, contaminants, and waste manifests or any other documentation of wastes generated at the Site. It is presumed that the IDW will be considered a solid waste (40 CFR 261.2) but this should be verified during the work plan development. If the available documentation indicates that a listed hazardous waste was generated at the Site, then the IDW will be considered a hazardous waste regulated under RCRA.

If there is inconclusive documentation concerning the IDW generated at the Site, then the U.S. EPA has stated the IDW is not a listed hazardous waste. However, in this case, further evaluation is necessary to evaluate whether the IDW in question exhibits a characteristic of hazardous waste. This is determined by analytical testing or knowledge. An IDW that may be characteristically hazardous should be evaluated for the following hazardous characteristics:

- Characteristic of ignitability (40 CFR §261.21)
- Characteristic of corrosivity (40 CFR §261.22)
- Characteristic of reactivity (40 CFR §261.23)
- Characteristic of toxicity (40 CFR §261.24)

If the RDW contains a listed hazardous waste, then U.S. EPA's contained-in policy (53 FR 31138, 31142, 31148, 57 FR 21453, 61 FR 18795) for contaminated environmental media should be evaluated. U.S. EPA considers IDW to contain hazardous waste:

- when it exhibits a characteristic of hazardous waste; or
- when it is impacted with concentrations of hazardous constituents from listed hazardous wastes that are above health-based levels.

Generally, IDW that does not (or no longer) contain hazardous waste are not subject to RCRA, but in some circumstances, the IDW that contained hazardous waste when first generated remain subject to land disposal restrictions (LDR) (40 CFR §268.45). There are also special LDR standards specific to contaminated debris (40 CFR §268.45).

6.2 Waste Accumulation On-Site

6.2.1 Solid, liquid, or PPE waste generated during investigation activities that are classified as nonhazardous or “characterization pending analysis” should be disposed of as soon as possible. Until off-site transport and disposal is arranged, drums should be moved to a staging location accessible by pickup by truck. This location should be relatively flat, have a hard surface (densely compact dirt, concrete, or asphalt), and be secure (by a fence or building).

6.2.2 Solid, liquid, or PPE waste generated during investigation activities that are classified as hazardous **shall not** be accumulated on-site longer than **90 days**. All hazardous waste containers shall be stored in a secured storage area. The following requirements for the hazardous waste storage area must be implemented:

- Proper hazardous waste signs shall be posted as required by any state or federal statutes that may govern the labelling of waste;
- Secondary containment to contain spills;
- Spill containment equipment must be available;
- Fire extinguisher;
- Adequate aisle space for unobstructed movement of personnel.

6.2.3 When possible, drums should be segregated in the storage area by media and or classification (liquid, solid, non-hazardous, hazardous, etc.) to facilitate type identification during characterization sampling and pickup and reduce the need to rearrange drums if multiple pickups by type are required.

6.2.4 Throughout the project, an inventory shall be maintained to itemize the type and quantity of the waste generated. During active site work, weekly storage area inspections should be performed and documented to ensure compliance with the requirements specified above. Monthly storage area inspections should be performed following the completion of active site work and the date the IDW is removed from the storage area by the waste hauler. Containers should be inventoried and inspected regularly. Labels should be checked to make sure they remain legible. Inspection notes should include the condition of the staging area as this will be important when coordinating the labour and equipment the waste hauler will require. Anomalies should be documented and photographed.

6.3 Waste Disposal

6.3.1 Solid, liquid, and PPE waste will be characterized for disposal through the use of client knowledge, laboratory analytical data created from soil or groundwater samples gathered during the field activities, and/or composite samples from individual containers. The selected disposal facility will prepare a waste profile based on the characterization results. The waste generator (Navy representative or authorized agent) will review and sign the profile.

6.3.2 All waste generated during field activities will be stored, transported, and disposed of according to applicable state, federal, and local regulations. All wastes classified as hazardous will be disposed of at a licensed treatment storage and disposal facility or managed in other approved manners.

6.3.3 Disposal facilities for waste generated during activities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) will require EPA approval under the Off-Site Rule (OSR) procedures (40 CFR 300.440) to ensure the facility is operating in compliance with RCRA or other Federal and State requirements. After the waste profile is finalized, the generator will submit it with an OSR request form to the EPA project manager for approval. An example OSR request form is provided in Attachment A. IDW may not be shipped to the facility until approval is granted by the EPA. OSR approvals per waste profile are valid for 90 days.

6.3.4 In general, waste disposal should be carefully coordinated with the facility receiving the waste. Facilities receiving waste have specific requirements that vary even for non-hazardous waste, so characterization should be conducted to support both applicable regulations and facility requirements.

6.4 Regulatory Requirements

The following federal and state regulations shall be used as resources for determining waste characteristics and requirements for waste storage, transportation, and disposal:

- Code of Federal Regulations (CFR), Title 40, Part 261;
- CFR, Title 49, Parts 172, 173, 178, and 179.

6.5 Waste Transport

A state-certified hazardous waste hauler shall transport all wastes classified as hazardous. Typically, the facility receiving any waste can coordinate a hauler to transport the waste. Shipped hazardous waste shall be disposed of in accordance with all RCRA/USEPA requirements. All waste manifests or bills of lading will be signed either by the client or the client’s designee.

7.0 Quality Control and Assurance

7.1 Management of IDW must incorporate quality control measures to ensure conformance to these and the project requirements.

8.0 Records, Data Analysis, Calculations

8.1 Maintain records as required by implanting the procedures in this SOP.

8.2 Deviations from this procedure or the sampling and analysis plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

9.0 Attachments or References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual.* Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of Energy, United States (DOE). 1994. *The Off-Site Rule*. EH-231-020/0194. Office of Environmental Guidance. March.

1999. *Management of Remediation Waste under the Resource Conservation and Recovery Act (RCRA)*. Office of Environmental Policy and Assistance. 20 December.

Environmental Protection Agency, United States (EPA). 1991. *Management of Investigative-Derived Wastes During Site Inspections*. Office of Emergency and Remedial Response. EPA/540/G-91/009. May.

1992a. *Guidance for Performing Site Inspections under CERCLA*. EPA/540/R-92/021. Office of Emergency and Remedial Response. September.

1992b. *Guide to Management of Investigative-Derived Wastes*. Quick reference fact sheet. OSWER Dir. 9345.3-03FS. Office of Solid Waste and Emergency Response. January.

1997a. *Sending Wastes Off Site? OSC and RPM Responsibilities under the Off-Site Rule*. EPA/540-F-97-006, Office of Solid Waste and Emergency Response. September.

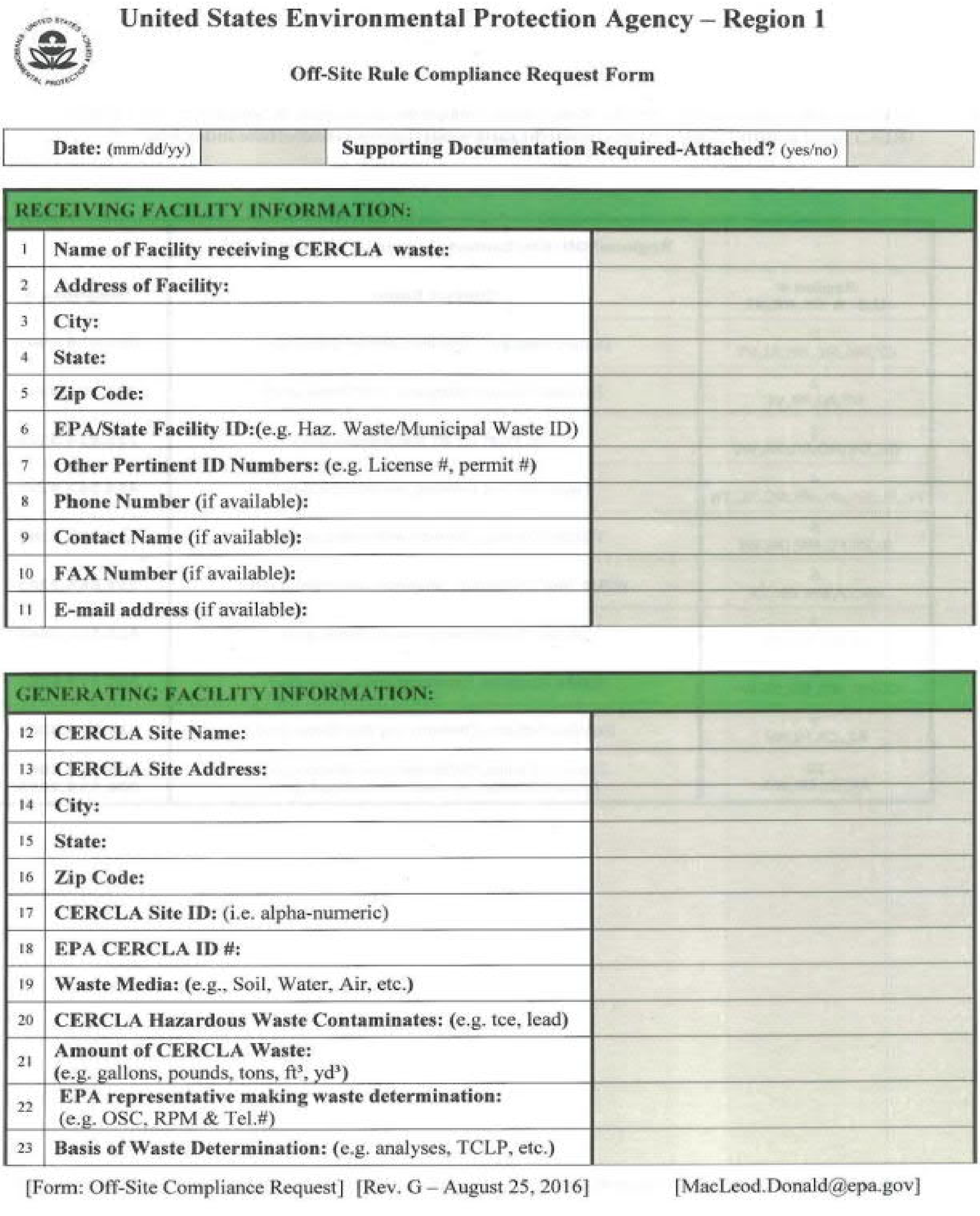
1997b. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IIIA. Office of Solid Waste. Updates available: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

1998. *Management of Remediation Waste under RCRA*. EPA/530-F-98-026. Office of Solid Waste and Emergency Response. October.

(No Date). *Compliance with the Off-Site Rule During Removal Actions.* Office of Regional Counsel (Region 3). Hendershot, Michael.

Author	**Reviewer**	**Revisions (Technical or Editorial)**
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)
Joshua Millard Senior Geologist	Andrew Borden Geologist	Rev 1 – Technical (Jan 2017)
Ken O’Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 2 – PFAS sampling update (July 2019)

ATTACHMENT A – OFF SITE RULE REQUEST FORM



United States Environmental Protection Agency – Region 1

Off-Site Rule Compliance Request Form

Date: (mm/dd/yy)		**Supporting Documentation Required-Attached?** (yes/no)	

RECEIVING FACILITY INFORMATION:

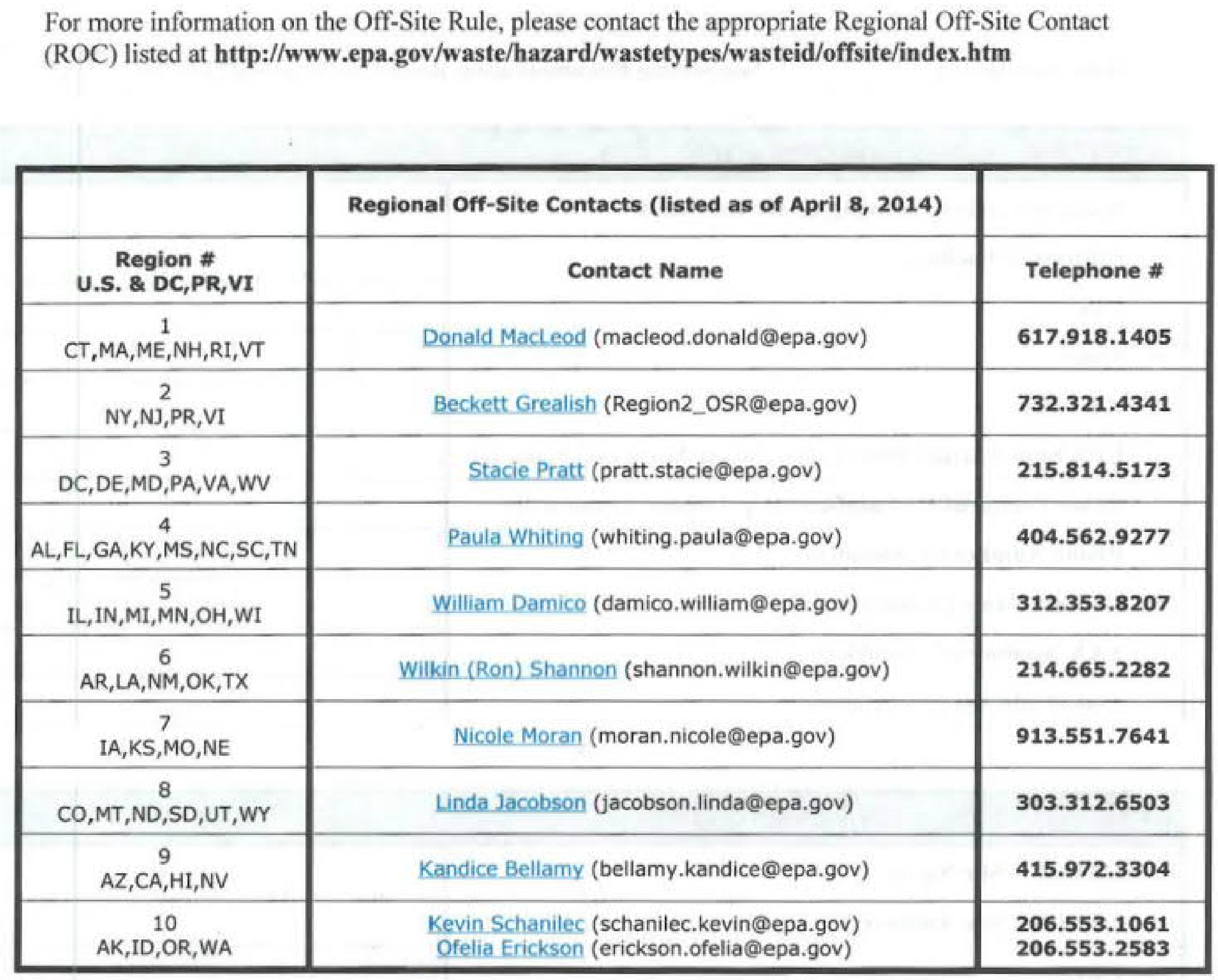
1	**Name of Facility receiving CERCLA waste:**	
2	**Address of Facility:**	
3	**City:**	
4	**State:**	
5	**Zip Code:**	
6	**EPA/State Facility ID:**(e.g. Haz. Waste/Municipal Waste ID)	
7	**Other Pertinent ID Numbers:** (e.g. License #, permit #)	
8	**Phone Number** (if available):	
9	**Contact Name** (if available):	
10	**FAX Number** (if available):	
11	**E-mail address** (if available):	

GENERATING FACILITY INFORMATION:

12	**CERCLA Site Name:**	
13	**CERCLA Site Address:**	
14	**City:**	
15	**State:**	
16	**Zip Code:**	
17	**CERCLA Site ID:** (i.e. alpha-numeric)	
18	**EPA CERCLA ID #:**	
19	**Waste Media:** (e.g., Soil, Water, Air, etc.)	
20	**CERCLA Hazardous Waste Contaminates:** (e.g. tce, lead)	
21	**Amount of CERCLA Waste:** (e.g. gallons, pounds, tons, ft³, yd³)	
22	**EPA representative making waste determination:** (e.g. OSC, RPM & Tel.#)	
23	**Basis of Waste Determination:** (e.g. analyses, TCLP, etc.)	

[Form: Off-Site Compliance Request] [Rev. G – August 25, 2016] [MacLeod.Donald@epa.gov]

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.



For more information on the Off-Site Rule, please contact the appropriate Regional Off-Site Contact (ROC) listed at **http://www.epa.gov/waste/hazard/wastetypes/wasteid/offsite/index.htm**

	Regional Off-Site Contacts (listed as of April 8, 2014)	
Region # U.S. & DC,PR,VI	**Contact Name**	**Telephone #**
1 CT,MA,ME,NH,RI,VT	Donald MacLeod (macleod.donald@epa.gov)	**617.918.1405**
2 NY,NJ,PR,VI	Beckett Grealish (Region2_OSR@epa.gov)	**732.321.4341**
3 DC,DE,MD,PA,VA,WV	Stacie Pratt (pratt.stacie@epa.gov)	**215.814.5173**
4 AL,FL,GA,KY,MS,NC,SC,TN	Paula Whiting (whiting.paula@epa.gov)	**404.562.9277**
5 IL,IN,MI,MN,OH,WI	William Damico (damico.william@epa.gov)	**312.353.8207**
6 AR,LA,NM,OK,TX	Wilkin (Ron) Shannon (shannon.wilkin@epa.gov)	**214.665.2282**
7 IA,KS,MO,NE	Nicole Moran (moran.nicole@epa.gov)	**913.551.7641**
8 CO,MT,ND,SD,UT,WY	Linda Jacobson (jacobson.linda@epa.gov)	**303.312.6503**
9 AZ,CA,HI,NV	Kandice Bellamy (bellamy.kandice@epa.gov)	**415.972.3304**
10 AK,ID,OR,WA	Kevin Schanilec (schanilec.kevin@epa.gov) Ofelia Erickson (erickson.ofelia@epa.gov)	**206.553.1061** **206.553.2583**

Equipment Decontamination

Procedure 3-06

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes methods of equipment decontamination, to be used for activities where samples for chemical analysis are collected or where equipment will need to be cleaned before leaving the site or before use in subsequent activities.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

It is the responsibility of the **Site Safety and Health Officer (SSHO)** to set up the site zones (i.e., exclusion, transition, and clean) and decontamination areas. Generally, the decontamination area is located within the transition zone, upwind of intrusive activities, and serves as the washing area for both personnel and equipment to minimize the spread of contamination into the clean zone. Typically, for equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing cleaning solvents as described in this procedure or the Task Order (TO) Quality Assurance Project Plan (QAPP) and deionized water are used for final rinsing of equipment. Depending on the nature of the hazards and the site location, decontamination of heavy equipment, such as augers, pump drop pipe, and vehicles, may be accomplished using a variety of techniques.

All **Field Personnel** responsible for equipment decontamination must adhere to the site-specific Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) and must wear the personal protective equipment (PPE) specified in the site-specific APP/SSHP. Generally, this includes, at a minimum, Tyvek® coveralls, steel-toed boots with boot covers or steel-toed rubber boots, safety glasses, American National Standards Institute-standard hard hats, and hearing protection (if heavy equipment is in operation). Air monitoring by the **SSHO** may result in an upgrade to the use of respirators and cartridges in the decontamination area; therefore, this equipment must be available on site. If safe alternatives are not achievable, discontinue site activities immediately.

In addition to the aforementioned precautions, the following sections describe safe work practices that will be employed.

2.1 Chemical Hazards associated with Equipment Decontamination

- Avoid skin contact with and/or incidental ingestion of decontamination solutions and water.
- Utilize PPE as specified in the site-specific APP/SSHP to maximize splash protection.
- Refer to material safety data sheets, safety personnel, and/or consult sampling personnel regarding appropriate safety measures (i.e., handling, PPE including skin and respiratory).
- Take the necessary precautions when handling detergents and reagents.

2.2 Physical Hazards associated with Equipment Decontamination

- To avoid possible back strain, it is recommended to raise the decontamination area 1 to 2 feet above ground level.

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

- To avoid heat stress, over exertion, and exhaustion, it is recommended to rotate equipment decontamination among all site personnel.
- Take necessary precautions when handling field sampling equipment.

3.0 Terms and Definitions

None.

4.0 Training and Qualifications

4.1 The **TO Manager** is responsible for ensuring that decontamination activities comply with this procedure. The **TO Manager** is responsible for ensuring that all personnel involved in equipment decontamination shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all field equipment is decontaminated according to this procedure.

4.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.0 Procedure

Decontamination of equipment used in soil/sediment sampling, groundwater monitoring, well drilling and well development, as well as equipment used to sample groundwater, surface water, sediment, waste, wipe, asbestos, and unsaturated zone, is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program requires consideration of the following factors:

- Location where the decontamination procedures will be conducted
- Types of equipment requiring decontamination
- Frequency of equipment decontamination
- Cleaning technique and types of cleaning solutions appropriate to the contaminants of concern
- Method for containing the residual contaminants and wash water from the decontamination process
- Use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsections describe standards for decontamination, including the frequency of decontamination, cleaning solutions and techniques, containment of residual contaminants and cleaning solutions, and effectiveness.

5.1 Decontamination Area

Select an appropriate location for the decontamination area at a site based on the ability to control access to the area, the ability to control residual material removed from equipment, the need to store clean equipment, and the ability to restrict access to the area being investigated. Locate the decontamination area an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

5.2 Types of Equipment

Drilling equipment that must be decontaminated includes drill bits, auger sections, drill-string tools, drill rods, split barrel samplers, tremie pipes, clamps, hand tools, and steel cable. Decontamination of monitoring well development and groundwater sampling equipment includes submersible pumps, bailers, interface probes, water level meters, bladder pumps, airlift pumps, peristaltic pumps, and lysimeters. Other sampling equipment that requires decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless-steel spoons and bowls, soil sample liners and caps, wipe sampling templates, composite liquid waste samplers, and dippers. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and shall be properly disposed of after one use.

5.3 Frequency of Equipment Decontamination

Decontaminate down-hole drilling equipment and equipment used in monitoring well development and purging prior to initial use and between each borehole or well. Down-hole drilling equipment, however, may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, decontaminate the drilling tools prior to drilling deeper. Initiate groundwater sampling by sampling groundwater from the monitoring well where the least contamination is suspected. Decontaminate groundwater, surface water, and soil sampling devices prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

5.4 Cleaning Solutions and Techniques

Decontamination can be accomplished using a variety of techniques and fluids. The preferred method of decontaminating major equipment, such as drill bits, augers, drill string, and pump drop-pipe, is steam cleaning. To steam clean, use a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, thoroughly steam wash equipment and rinse it with potable tap water to remove particulates and contaminants.

A rinse decontamination procedure is acceptable for equipment such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following: (1) wash with a PFAS-free detergent (Alconox®, Liquinox®, or other suitable detergent) and deionized water solution, and (2) rinse in triplicate with deionized water. If possible, disassemble equipment prior to cleaning. Add an additional wash as needed at the beginning of the process if equipment is very soiled.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. Decontaminate these pumps by washing and rinsing the outside surfaces using the procedure described for small equipment or by steam cleaning. Decontaminate the internal surfaces by recirculating fluids through the pump while it is operating. This recirculation may be done using a relatively long (typically 4 feet) large-diameter pipe (4-inch or greater) equipped with a bottom cap. Fill the pipe with the decontamination fluids, place the pump within the capped pipe, and operate the pump while recirculating the fluids back into the pipe. The decontamination sequence shall include: (1) detergent and deionized water solution, and (2) rinse in triplicate with deionized water rinse. Change the decontamination fluids after each decontamination cycle.

Solvents other than isopropyl alcohol may be used, depending upon the contaminants involved. For example, if polychlorinated biphenyls or chlorinated pesticides are contaminants of concern, hexane may be used as the decontamination solvent; however, if samples are also to be analyzed for volatile organics, hexane shall not be used. In addition, some decontamination solvents have health effects that must be considered. Decontamination water shall consist of deionized water. Decontamination solvents to be used during field activities will be specified in the TO QAPP.

Rinse equipment used for measuring field parameters, such as pH (indicates the hydrogen ion concentration – acidity or basicity), temperature, specific conductivity, and turbidity with deionized water after each measurement. Also wash new, unused soil sample liners and caps with a fresh detergent solution and rinse them with deionized water to remove any dirt or cutting oils that might be on them prior to use.

5.5 Containment of Residual Contaminants and Cleaning Solutions

A decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water.

When contaminated material and cleaning fluids must be contained from heavy equipment, such as drill rigs and support vehicles, the area must be properly floored, preferably with a concrete pad that slopes toward a sump pit. If a concrete pad is impractical, planking can be used to construct solid flooring that is then covered by a nonporous surface and sloped toward a collection sump. If the decontamination area lacks a collection sump, use plastic sheeting and blocks or other objects to create a bermed area for collection of equipment decontamination water. Situate items, such as auger flights, which can be placed on metal stands or other similar equipment, on this equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Store clean equipment in a separate location to prevent recontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers as described below.

Use wash buckets or tubs to catch fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices. Collect the decontamination fluids and store them on site in secured containers, such as U.S. Department of Transportation-approved drums, until their disposition is determined by laboratory analytical results. Label containers in accordance with Procedure 3-05, *IDW Management*.

6.0 Quality Control and Assurance

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment blank samples or wipe testing. Equipment blanks consist of analyte-free deionized water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a PFAS-free cotton cloth over the surface of the equipment after cleaning. These quality control measures provide "after-the fact" information that may be useful in determining whether or not cleaning methods were effective in removing the contaminants of concern.

7.0 Records, Data Analysis, Calculations

Any project where sampling and analysis is performed shall be executed in accordance with an approved sampling and analysis plan. This procedure may be incorporated by reference or may be incorporated with modifications described in the plan.

Deviations from this procedure or the sampling and analysis plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

8.0 Attachments or References

8.1 ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites.* ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.

8.2 Procedure 3-05, *IDW Management*.

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue
Ken O’Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Land Surveying

Procedure 3-07

1.0 Purpose and Scope

1.1 The purpose of this document is to define the standard operating procedure (SOP) for acquiring land surveying data to facilitate the location and mapping of geologic, hydrologic, geotechnical data, and analytical sampling points and to establish topographic control over project sites.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM under the client contract.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review. If there are procedures whether it be from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to surface water sampling then those procedures may be added as an appendix to the project-specific Quality Assurance Project Plan (QAPP).

1.4 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Program Quality Manager. Deviations to this SOP will be documented in the field records.

1.5 If there are procedures, whether it be from Resolution Consultants, state and/or federal, that are not addressed in this SOP and are applicable to land surveying then those procedures may be added as an appendix to the project-specific QAPP.

2.0 Safety

2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to conducting fieldwork. All **field sampling personnel** must review the project-specific Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) paying particular attention to the control measures planned for the specific field tasks. Conduct preliminary area monitoring to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vaper and liquid phase through the use of respirators and disposable clothing.

2.2 In addition, observe standard health and safety practices according to the project-specific APP/SSHP. Suggested minimum protection includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves, rubberized steel-toed boots, and an American National Standards Institute-standard hard hat. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations, and shall always be available on site.

2.3 Daily safety briefs will be conducted at the start of each working day before any work commences. These daily briefs will be facilitated by the **Site Safety and Health Officer (SSHO)** or designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the APP/SSHP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSHO.

2.4 The health and safety considerations for the work associated with land surveying include:

- Slip, trips and falls associated with work in the field;

- Biological hazards associated with work in the field; and,
- Potential hazards associated with chemicals of concern (COCs) that may be located in the survey area,

3.0 Terms and Definitions

3.1 Boundary Survey

Boundary surveys are conducted by Certified Land Surveyors in order to delineate a legal property line for a site or section of a site.

3.2 Global Positioning System

A global positioning system (GPS) is a system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

4.0 Interferences

4.1 Commercially available GPS units typically have real-time sub-meter accuracy. Field corrections can be made as described in Section 8.3 below.

5.0 Training and Qualifications

5.1 Qualifications and Training

5.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **Task Order (TO) Manager** is responsible for ensuring that land surveying activities comply with this procedure. The TO Manager is responsible for ensuring that all field sampling personnel involved in land surveying shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Site Supervisor (SS)** is responsible for ensuring that all field personnel follow these procedures. In virtually all cases, subcontractors will conduct these procedures. The SS or designee is responsible for overseeing the activities of the subcontractor and ensuring that sampling points and topographic features are properly surveyed.

6.0 Equipment and Supplies

6.1 The following equipment list contains materials that may be needed in carrying out the procedures outlined in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- Personal protective equipment (PPE) and other safety equipment, as required by the APP/SSHP;
- Commercially available GPS unit; and,
- Field Logbook.

7.0 Calibration or Standardization

7.1 An authorized manufacturer's representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than six months prior to the start of the survey work.

7.2 Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet.

8.0 Procedure

8.1 Theodolite/Electronic Distance Measurement (EDM)

Follow the procedures listed below during theodolite/EDM land surveying:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- Reference surveys to the local established coordinate systems.
- Reference surveyed points to site designated vertical datum, such as Mean Sea Level (Lower Low Water Level) and North American Vertical Datum of 1988 (NAVD 88).
- Jointly determine appropriate horizontal and vertical control points prior to the start of survey activities. If discrepancies in the survey (e.g., anomalous water level elevations) are observed, the surveyor may be required to verify the survey by comparison to a known survey mark. If necessary, a verification survey may be conducted by a qualified third party.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified by the project Quality Assurance Project Plan (QAPP).
- Begin and end all surveys at the designated horizontal and vertical control points to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly coloured weatherproof flagging and paint.
- Clearly mark the point on a monitoring well casing or well riser that is surveyed by filing grooves into the casing/riser on either side of the surveyed point, or by marking the riser with a permanent ink marker.

8.2 Global Positioning System to Conduct Land Survey

Follow the procedures listed below during land surveying using GPS:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- Reference surveys to the local established coordinate systems.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified in the project QAPP.
- Begin and end all surveys at the designated horizontal and vertical control points (as applicable) to determine the degree of accuracy of the surveys.

- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly coloured weatherproof flagging and paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

8.3 Global Positioning System to Position Sample Locations or Locate Site Features

Experienced field personnel may use a GPS system unit to position sample locations (e.g. grid positioned samples, soil boring locations) at a site. The decision to use field personnel or a licensed land surveyor will depend on the objectives of the survey (e.g. vertical elevation is not required) and the levels of precision required. Typically, when a level of accuracy greater than 0.03 meter is required, a licensed surveyor will be required. When a level of accuracy of (±) 1 meter is sufficient to meet project requirements (i.e. when laying sampling grids, identifying significant site features, or locating features identified in geographic information system [GIS] figures) experienced field personnel may use commercially available, consumer-grade GPS units. Follow the procedures listed below to locate samples or site features using GPS:

- A commercially available Trimble Geo 7X high-accuracy Global Navigation Satellite System.
- If waypoints are to be imported into a GIS database, the same grid projection system should be used.
- If a permanent reference point near the site is available, it is recommended that a waypoint at this location be taken every day waypoints are stored.
- When laying out a sampling grid from a GIS map, upload the coordinates from GIS to the GPS unit, including coordinates for an easily identified, permanent, nearby feature (i.e. building corner, roadway intersection, or United States Geological Survey benchmark).
- If during the initial site walk, the permanent feature identified does not overlay within (±) 1 meter as identified in the GPS unit, field corrections of the waypoints should be made.
- Field corrections can be made by adding/subtracting the difference in x,y coordinates between the field measurement of the permanent site feature and the anticipated x,y coordinates. This correction should then be applied to the x,y coordinates for each sampling location to be marked. Corrected x,y coordinates can then be uploaded into the GPS unit.
- Sampling points and site features can then be located in the field using the GPS units “Go To” function. When the distance to the sampling point or feature remains close to zero, the location can be marked.
- If no field corrections to the sampling location need to be made, or if sampling locations are to be surveyed by a licensed surveyor at a later date, no additional waypoints need to be taken. If significant changes to the sampling location are made, GPS coordinates at the corrected location shall be stored and labelled.
- GPS files containing field coordinates must be uploaded to a storage device such as PC at the end of each day. A new GPS file must be created for each day in the field.
- Field logs shall indicate manufacturer and model number for GPS unit used, map datum and projection used, and any field corrections made. If the GPS unit cannot lock onto a Wide Area Augmentation System (WAAS) system at the site, this should also be noted.

9.0 Quality Control and Assurance

GPS field data to be differentially corrected and imported into GIS and checked for accuracy on a daily basis.

10.0 Data and Records Management

The surveyor shall record field notes daily using generally accepted practices. The data shall be neat, legible, in indelible ink, and easily reproducible. Copies of the surveyor's field notes and calculation forms generated during the work shall be obtained and placed in the project files.

Surveyor's field notes shall, at a minimum, clearly indicate:

- The date of the survey;
- General weather conditions;
- The name of the surveying firm;
- The names and job titles of personnel performing the survey work;
- Equipment used, including serial numbers; and,
- Field book designations, including page numbers.

A land surveyor registered in the state or territory in which the work was done shall sign, seal, and certify the drawings and calculations submitted by the surveyor.

Dated records of land surveying equipment calibration shall be provided by the surveyor and placed in the project files. Equipment serial numbers shall be provided in the calibration records.

11.0 Attachments or References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Author	Reviewer	Revisions (Technical or Editorial)
Robert Shoemaker Senior Scientist	Naomi Ouellette, Project Manager	Rev 0 – Initial Issue
Joshua Millard Geologist	James Bourdeau GIS Specialist	Rev 1 – Technical
Ken O'Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 2 – PFAS sampling update (July 2019)

Monitoring Well Installation

Procedure 3-12

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the methods to be used during the installation of groundwater monitoring wells. It describes the components of monitoring well design and installation and sets forth the rationale for use of various well installation techniques in specific situations.

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP). Additionally, work will be conducted according to the Task Order (TO) Quality Assurance Project Plan (QAPP) and/or direction from the **Site Safety and Health Officer (SSHO)**.

2.2 Before well installation commences, appropriate entities (e.g., DigSafe, local public works departments, company facilities) must be contacted to assure the anticipated well locations are marked for utilities, including electrical, telecommunications, water, sewer, and gas.

2.3 Physical Hazards Associated with Well Installation

- Stay clear of all moving equipment and avoid wearing loose fitting clothing.
- When using an approved retractable-blade knife, always cut away from oneself and make sure there are no other people in the cutting path or the retractable-blade knife.
- To avoid slip/trip/fall conditions during drilling activities, keep the area clear of excess soil cuttings and groundwater. Use textured boots/boot cover bottoms in muddy areas.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and personal protective equipment (PPE), drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- To avoid hazards associated with subsurface utilities, ensure all sampling locations have been properly surveyed as described in SOP 3-01, Utility Clearance.
- Be aware of restricted mobility caused by PPE.

3.0 Terms and Definitions

3.1 **Annulus:** The annulus is the down-hole space between the borehole wall and the well casing and screen.

3.2 **Bridge:** A bridge is an obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by the placement of filter pack materials during well completion. Bridging can also occur in the formation during well development.

3.3 **Filter Pack:** Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

3.4 **Grout:** Grout is a fluid mixture of cement and water that can be forced through a tremie pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

3.5 **Heaving (Running) Sands:** Loose sands in a confined water-bearing zone or aquifer which tend to rise up into the drill stem when the confining unit is breached by the drill bit. Heaving sands occur when the water in the aquifer has a pressure head great enough to cause upward flow into the drill stem with enough velocity to overcome the weight of the sand.

3.6 **Sieve Analysis:** Sieve analysis is the evaluation of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

4.0 Interferences

4.1 Heaving sands may be problematic in unconsolidated sands encountered below the water table.

4.2 Rotary drilling methods requiring bentonite-based drilling fluids should be used with caution to drill boreholes that will be used for monitoring well installation. The bentonite mud builds up on the borehole walls as a filter cake and permeates the adjacent formation, potentially reducing the permeability of the material adjacent to the well screen.

4.3 Drill rigs and accessory equipment (e.g., compressors, decontamination units, drill rods, plastic sleeving, etc.) should be evaluated and all PFAS-bearing parts or materials (e.g., O-rings, Teflon tape, etc.) replaced with confirmed PFAS-free parts. Special attention should be placed on evaluation of lubricants or greases used for the equipment.

4.4 If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids should be obtained and analyzed for chemical constituents that may be of interest at the site. In addition, an attempt should be made to recover the quantity of fluid or water that was introduced, either by flushing the borehole prior to well installation and/or by overpumping the well during development.

4.5 Track-mounted drill rigs are suitable for travelling on many types of landscapes that truck-mounted units cannot access, but may have limitations on extremely uneven or soft terrain.

4.6 Care should be taken to prevent cross-contamination between well locations. All drilling equipment coming in contact with potentially contaminated soil and/or groundwater will be decontaminated by the drilling subcontractor prior to initial drilling activities and between drilling locations in accordance with SOP 3-06, Equipment Decontamination.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 **TO Managers** are responsible for issuing a Quality Assurance Project Plan (QAPP) that reflects the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and possibly state regulatory agencies enforce regulations that may include well construction and installation requirements. The **TO Manager** shall be familiar with current local and state regulations, and ensure that these regulations are followed. The **TO Manager** is responsible for ensuring that all personnel involved in monitoring well installation shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Site Supervisor (SS)** is responsible for direct supervision of the installation of monitoring wells and ensuring that procedures and specifications are implemented in the field in accordance with the approved QAPP and well installation permits. The qualifications for the **SS** must be in accordance with local jurisdictions with authority over the operations conducted.

5.2.4 All field personnel are responsible for the implementation of this procedure.

5.2.5 The on-site hydrogeologist/engineer is expected to obtain a description of the lithologic samples obtained during the excavation and construction of a monitoring well. These data are often required to provide guidance regarding the installation of specific components of the monitoring well. Guidance for lithologic sample collection and sample description is contained within SOP 3-16, Soil and Rock Classification.

6.0 Equipment and Supplies

6.1 Materials provided by the drilling contractor may include:

- Confirmed PFAS-free Drill rig, drill rods, hollow stem augers, etc.
- PFAS-free lubricants and greases
- Decontamination equipment (e.g., steam cleaner, high-pressure washer, brushes, etc.)
- Decontamination pad materials
- Well screen/riser pipe with flush-threaded couplings including riser and bottom caps
- Clean, filter sand
- Bentonite chips or pellets
- Cement grout and tremie pipe
- Portland cement for well pad completion
- Stainless steel protective riser covers and locking caps
- Weighted calibrated tape
- Split-spoon samplers
- 55-gallon drums or containers for drill cuttings, decontamination fluids, etc.

6.2 In addition to those materials provided by the drilling contractor, equipment and materials required by the project geologist/engineer may include, but is not limited to, the following:

- Photoionization Detector (PID)
- Spill kit, including at a minimum sorbent pads and shovel (if not provided by subcontractor)
- Polyethylene plastic sheeting
- Teaspoon or spatula
- Resealable polyethylene (e.g., Ziploc brand) plastic bags
- Boring Log Records
- Decontamination materials (per SOP No. 3-06 - Equipment Decontamination)
- Weighted Teflon-free measuring tape for depth measurement

- Soil logging materials (e.g. United Soil Classification System classification field card, millimeter rule, hand lens, etc.)
- Survey lathes or pin flags
- Digital camera
- PPE as required by the APP/SSHP and QAPP
- Planning documents including the site-specific APP/SSHP and QAPP
- Large indelible ink or paint pen
- Field logbook/field forms/site maps (non-water-repellent)

7.0 Procedure

7.1 General Procedures

- Specific drilling, sampling, and installation equipment and methodology will be dictated by the type of well to be installed (e.g., single case [Type II], double case [Type III], bedrock, etc.), geologic characteristics of the site, the type of contaminants being monitored, and local and state regulations.
- For access to locations when travelling over difficult terrain, an appropriate line should be chosen before mobilizing the drill rig or other support vehicles. If clearing of trees or ground cover is required, perform these activities in advance to avoid down time. Avoid wet or soft areas where possible or use ground mats and/or timbers to aid in supporting the rig as it travels. If drilling on soft material, place geomatting and ground mats under the rig tracks or stabilizers prior to drilling.
- A utility locate must be conducted to identify all underground utilities at the site prior to drilling (refer to SOP 3-01, Utility Clearance*)*. Proper clearance procedures for aboveground/overhead utilities must also be followed as specified in the APP/SSHP.
- Although new well materials (well screen and riser pipe) generally arrive at the site boxed and sealed within plastic bags, it is sometimes necessary to decontaminate the materials prior to their use. Well materials should be inspected by the project geologist/engineer upon delivery to check for cleanliness. If the well materials appear dirty, or if local or regional regulatory guidance requires decontamination, then well material decontamination should be performed by the drilling subcontractor in accordance with SOP 3-06, Equipment Decontamination.
- The diameter of the borehole must be a minimum of 2 inches greater than the outside diameter of the well screen or riser pipe used to construct the well. This is necessary so that sufficient annular space is available to install filter packs, bentonite seals, and grout seals, and allow the passage of tremie pipe where grouting at depth is required. Bedrock wells may require reaming after coring in order to provide a large enough borehole diameter for well installation.
- When soil sampling is required (refer to the QAPP), soil samples will be collected for visual logging by advancing split-spoon samplers through the augers. The soil will be visually logged by a field geologist and include lithologic characteristics (i.e., soil type, color, density, moisture content, etc.) using the methods described in SOP 3-16, Soil and Rock Classification. This information will be recorded on a boring/well log form, along with well construction details.

7.2 Drilling Techniques

Drilling of monitoring well boreholes may be accomplished by a variety of methods as described below. Preferred methods include those that temporarily case the borehole during drilling (i.e., hollow stem auger and sonic methods) using an override system. Drill rig components, drilling fluids, and consumable equipment will be evaluated for PFAS prior to the start of drilling activities, with special attention placed on evaluating any lubricants and greases used during drilling. Other methods can be used where specific subsurface conditions or well design criteria dictate.

- Hollow stem auger (HSA) – Borings are advanced by rotating steel hollow stem augers with an attached cutting head. Soil cuttings are displaced by the cutting head and transported to the surface via continuous spiral flights attached to each auger stem. This method is widely used for unconsolidated soils that have a tendency to collapse within the boring. A bottom plug can be placed in the bottom auger to prevent soils from entering and clogging the auger, especially in the case of heaving sands. However, a bottom plug cannot be used when soil samples are to be collected through the augers. Soil plugs that accumulate in the bottom of the auger must be removed or knocked out prior to sampling or well installation.
- Solid stem auger – This type of drilling method is similar to HSA drilling using a solid stem or sealed hollow stem auger flights to advance the boring. Solid stem, continuous flight auger use is limited to semi-consolidated sediments or to cohesive or semi-cohesive unconsolidated sediments that don't have a tendency to collapse when disturbed.
- Sonic methods – Sonic drilling consists of advancing concentric hollow drill casings (inner and outer) using rotation in conjunction with axial vibration of the drill casing. Once the casings are advanced to the appropriate depth, the inner string is removed with a core of drill cuttings while the outer casing remains in place to keep the borehole open. Cuttings are removed from the inner casing relatively intact for logging or sampling purposes. This drilling method is used for a variety of soil types, from heaving sands to consolidated or indurated formations. Smearing of the formation along the borehole walls is minimal since moderate vibration and rotation techniques are used to advance the casings. Since the total borehole diameter in sonic drilling is only incrementally larger than the inner casing diameter, care should be taken during installation of the monitoring well to ensure the well is centered and adequate space is available for annular materials.
- Rotary methods (water or mud) – Rotary drilling methods consist of drill rods coupled to a drill bit that rotates and cuts through the soils to advance the borehole. Water or drilling fluid ("mud") is forced through the hollow drill rods and drill bit as the rods are rotated. The soil cuttings are forced up the borehole with the drilling fluids to the surface and the fluids recirculated. The drilling fluid provides a hydrostatic pressure that reduces or prevents the borehole from collapsing. Clean, potable, PFAS-free water must be used for water-rotary drilling to prevent introducing trace contaminants. A sample of the potable water should be collected during the course of well installation for analysis of the same parameters defined for the groundwater samples. If mud-rotary is used to advance boreholes, only potable, PFAS-free water and bentonite drilling mud should be used. No chemical additives shall be mixed in the drilling fluid to alter viscosity or lubricating properties. Adequate well development is essential for removal of drilling mud and fluids from the formation materials and ensure collection of representative groundwater samples.
- Rotary methods (Air) – Air rotary methods are similar to water rotary but use high air velocities in place of drilling fluids to rotate the drill bit and carry the soil cuttings up the borehole to the surface. Care must be taken to ensure that contaminants are not introduced into the air stream from compressor oils, etc. Most compressor systems are compatible with a coalescing filter system. Cuttings exiting the borehole under pressure must be controlled, especially when drilling in a zone of potential contamination. This can be accomplished by using an air diverter with hose or pipe to carry the cuttings to a waste container. Letting the cuttings blow uncontrolled from the borehole is not acceptable.

7.3 Well Construction and Installation

- If rotary drilling techniques are used, the borehole should be flushed or blown free of material prior to well installation. If hollow stem augers are used, the soil or bottom plug should be removed and the augers raised approximately six inches above the bottom of the borehole, while slowly rotating the augers to remove cuttings from the bottom of the boring. The depth of the borehole should be confirmed with a weighted, calibrated tape.

- The riser pipe and screen should be connected with flush-threaded joints and assembled wearing clean, disposable gloves. No solvent or anti-seize compound should be used on the connections. The full length of the slotted portion of the well screen and unslotted riser pipe should be measured and these measurements recorded on a well construction form (Attachment 1).
- If placed in an open borehole, the assembled well should be carefully lowered and centered in the borehole so that the well is true, straight, and vertical throughout. Centering can also be accomplished with the use of centralizers, if necessary. However, centralizers should be placed so that they do not inhibit the installation of filter sand, bentonite seal, and annular grout. Wells less than 50 deep generally do not require centralizers.
- If hollow stem augers are used, the well should be lowered through the augers and each auger flight removed incrementally as the filter sand, bentonite seal, and grout are tremied or poured into the annular space of the well. The well should be temporarily capped before filter sand and other annular materials are installed.
- Clean, silica sand should be placed around the well screen to at least 1 foot above the top of the screen. The filter sand should be appropriately graded and compatible with the selected screen size and surrounding formation materials. In general, the filter pack should not extend more than 3 feet above the top of the screen to limit the thickness of the monitoring zone. As the filter pack is placed, a weighted tape should be lowered in the annular space to verify the depth to the top of the layer. This measurement will be recorded on the well construction form (Attachment 1). If necessary, to eliminate possible bridging or creation of voids, placement of the sand pack may require the use of a tremie pipe. Tremie pipe sandpack installations are generally suggested for deeper wells and for wells which are screened some distance beneath the water table.
- A minimum 2-foot thick layer of bentonite pellets or slurry seal will be installed immediately above the filter sand to prevent vertical flow within the boring from affecting the screened interval. Bentonite chips/pellets must be hydrated if place above the water table prior to grouting. If bridging is of concern as in the case of deep wells, powdered bentonite may be mixed with water into a very thick slurry and a tremie pipe used to place the seal to the desired depth. Placement of the bentonite seal in the borehole will be recorded on the well construction form (Attachment 1).
- The remaining annular space around the well will be grouted from the top of the bentonite seal to the surface with a grout composed of neat cement, a bentonite cement mixture, or high solids sodium bentonite grout.
- Each well riser will be secured with an expandable, locking cap (vented if possible). Optionally, a hole can be drilled in the upper portion of the riser to allow venting of the well.
- The well will be completed within a concrete well pad consisting of a Portland cement/sand mixture. Well pads are generally 3 feet by 3 feet square but may be larger or smaller depending on site conditions and state-specific well construction standards. Round concrete well pads are also acceptable. A minimum of 1 inch of the finished pad should be below grade to prevent washing and undermining by soil erosion.
- If completed as a flush-mount well, the well riser will be cut off approximately 4 to 6 inches below ground surface and an expandable, locking cap placed on the well riser. The area around the riser is dug out and a steel well vault or manhole cover placed over the riser and set almost flush to the ground to protect the well. The manhole cover should be water-tight and secured with bolts to prevent casual access. The well pad will then be constructed around the well vault and slightly mounded at the center and sloping away to prevent surface water from accumulating in the well vault.
- If completed as a stick-up well, the well riser is cut approximately 2.5 to 3 feet above the ground surface and an expandable, locking cap placed on the well riser. A steel guard pipe with hinged, locking cap is placed over the well riser as a protective casing. The bottom of the guard pipe will be set approximately 2 feet below ground surface and sealed by pouring concrete from the top of the annular grout around

the pipe to grade. The concrete well pad should be completed at the same time. Weep holes will be drilled in the base of the guard pipe to facilitate draining of rainwater or purge water from inside the guard pipe.

- Bumper posts or bollards may be necessary for additional well protection, especially in high traffic areas. The bumper posts should be placed around the well pad in a configuration that provides maximum protection to the well and extend a minimum of 3 feet above the ground.

7.4 Double Cased Wells

Under certain site conditions, the use of a double-cased or telescoping (Type III) well may be necessary. Installation of double-cased wells may be required to prevent the interconnection of two separate aquifers, seal off a perched aquifer without creating a vertical hydraulic conduit, prevent cross-contamination during construction of wells in deeper aquifers hydro-stratigraphically below impacted aquifers, or case off highly impacted soils present above the aquifer to prevent potential “dragging down” of contaminants.

Similar to conventional wells, construction of double-cased wells can be accomplished using a variety of drilling methods. Well construction is initiated by “keying” a large diameter, outer casing into a stratigraphic zone of low permeability (clay layer or bedrock). The size of the outer casing should be a minimum of 2 inches greater than the outside diameter of the inner casing to allow installation of annular seal materials during well completion. A pilot borehole should be drilled through the overburden soil and/or contaminated zone into a clay confining layer or bedrock. The borehole for the outer casing should be of sufficient size to contain the outer casing with a minimum of 2 inches around the outside diameter to allow sufficient annular space for tremie or pressure grouting. The boring should extend a minimum of 2 feet into a clay layer and a minimum of 1 foot into bedrock, if possible, to ensure an adequate seal. The boring should never breach a confining layer or keyed zone under any circumstances.

Once the boring is completed, the outer casing can be set in the borehole and sealed with grout. The outer casing can be set two ways, with or without a bottom cap. If no bottom cap is applied, the casing is usually driven approximately 6 inches into the clay confining unit. A grout plug is generally placed in the bottom of the casing and once set, standing water in the casing is evacuated prior to drilling below the casing. As an alternative, a cap can be placed on the bottom of the casing and if set below the water table, the casing can be filled with clean, potable water to hold down the casing in the boring. Grouting should be conducted using tremie-grouting or pressure-grouting methods by pumping grout into the annular space between the outer casing and the borehole wall from the bottom of the casing to the ground surface. Grout around the casing should be allowed to cure at least 24 hours before attempting to drill through the bottom.

Once the grout is cured, a smaller diameter drill pipe/bit is used to bore through the grout plug or bottom cap to the desired well depth. The well is then constructed as described in Section 7.3 above.

7.5 Post Installation Procedures

- Wells should be permanently labelled or marked for identification. Well tags can be used to record the site name, well number, total depth, installation date, etc. At a minimum, the well number will be written in paint on both the outside of the protective casing and inside beneath the casing lid, as well as on the riser pipe.
- A measuring point will be marked on the top of the riser pipe for taking water level measurements. The measuring point can be notched using a knife or saw. The measuring point will also be the point which will be surveyed for vertical elevation data.
- Upon completion, the following measurements will be taken by the field geologist/engineer and recorded on the well construction diagram.
  - Depth to static water level
  - Depth of non-aqueous phase liquid (NAPL), if present
  - Total depth of well measured from top of casing (TOC)

- Height of well casing above ground surface
  - Height of protective casing above ground surface
- All monitoring wells will be surveyed for horizontal and vertical control by a licensed surveyor.
- Investigation-derived waste (IDW) including drill cuttings, spent materials (e.g., PPE), and decontamination water should be properly managed in accordance with SOP 3-05, IDW Management.

8.0 Quality Control and Assurance

8.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the QAPP. Certain quality control (QC) measures should be taken to ensure proper well installation and construction in accordance with this SOP, project specific QAPP, and applicable well standards.

8.2 The borehole will be checked for total open depth, and extended by further drilling or shortened by backfilling, as required before installation of the well materials.

8.3 Water level and NAPL presence will be checked during well installation to ensure that the positions of well screen, filter sand, and seals relative to water level conform to project requirements

8.4 The depth to top of each layer of annular materials (i.e., filter sand, bentonite, grout) will be verified and adjusted as necessary for proper placement.

9.0 Records, Data Analysis, Calculations

All field information will be recorded in the field logbook and/or standardized field forms by field personnel. Field data recorded will include drilling contractor information, drilling methods, well material and construction information provided on the boring logs and well construction forms, observations or problems encountered during drilling, fluid level data, and any deviations from the procedures in this SOP and other project plans. Well Construction Forms (Attachment 1) will provide visual and descriptive information the monitoring well and are often the most critical form of documentation generated during the installation of a monitoring well. The field logbook is kept as a general log of activities and should not be used in place of the boring log.

10.0 Attachments or References

10.1 Attachment 1 – Monitoring Well Construction Form

10.2 Environmental Protection Agency, United States (EPA). 1987*. A Compendium of Superfund Field Operations Methods*. Office of Solid Waste and Emergency Response. EPA/540/P-87/001.

10.3 EPA. 1990. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*. EPA/600/4-89/034. Office of Research and Development, Washington. March.

10.4 EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

10.5 EPA, 2008. SESD Operating Procedure SESDGUID-101-R0: *Design and Installation of Monitoring Wells*. USEPA, Science and Ecosystem Support Division (SESD), Athens, Georgia. Effective Date February 18, 2008.

10.6 U.S. Army Corps of Engineers. 2008. Manual No. EM 385-1-1. *Safety and Health Requirements*. 15 November 2008. http://140.194.76.129/publications/eng-manuals/em385-1-1/2008_English/toc.html.

10.7 SOP 3-01, *Utility Clearance*.

10.8 SOP 3-05, *IDW Management*

10.9 SOP 3-06, *Equipment Decontamination*.

10.10 SOP 3-16, *Soil and Rock Classification.*

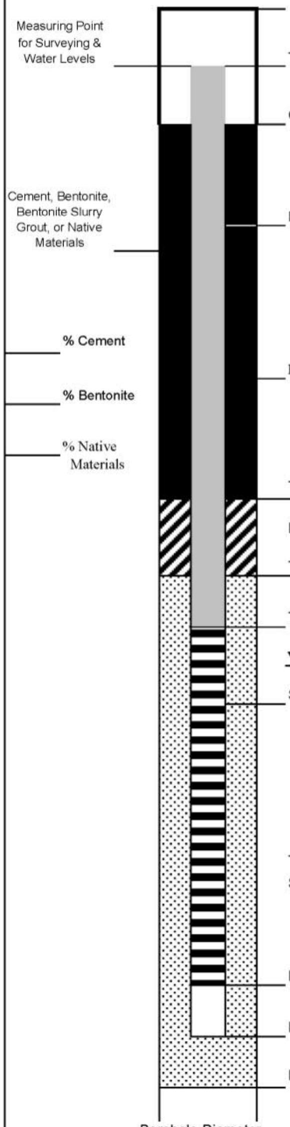
Author	***Reviewer***	***Revisions (Technical or Editorial)***
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)
Ken O'Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

AECOM

Attachment 1
Monitoring Well Construction Form

	Client:	***WELL ID:***
	Project Number:	
	Site Location:	*Date installed:*
	Well Location: *Coords:*	*Inspector:*
	Method:	*Contractor:*

MONITORING WELL CONSTRUCTION DETAIL



	Depth from G.S. (feet)	Elevation(feet) Datum ________
Top of Steel Guard Pipe	________	________
Top of Riser Pipe	________	________
Ground Surface (G.S.)	0.0	________
Top of Bentonite	________	________
Top of Sand	________	________
Top of Screen	________	________
▼ Stabilized Water Level	________	________
Bottom of Screen	________	________
Bottom of Tail Pipe:	________	________
Bottom of Borehole	________	________

Riser Pipe:
Length ________
Inside Diameter (ID) ________
Type of Material ________

________ % Cement
________ % Bentonite
________ % Native Materials

Bottom of Steel Guard Pipe

Bentonite Seal Thickness ________

Screen:
Length ________
Inside Diameter (ID) ________
Slot Size ________
Type of Material ________

Type/Size of sand ________
Sand Pack Thickness ________

Bottom of Tail Pipe:
Length ________

Borehole Diameter ________

Approved:

________ Signature ________ Date

Describe Measuring Point:
____

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

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Monitoring Well Development

Procedure 3-13

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the procedures used for developing newly installed monitoring wells and/or redeveloping existing wells.

1.2 The purpose of well development is to remove interferences from a well to provide better connection between the well and the formation, to improve pumping performance of the well, and to be able to collect more representative information from the well (e.g., samples, test results, etc.). Proper well development will:

- Remove drilling residuals (e.g., water, mud) from the borehole and surrounding formations;
- Improve or restore hydraulic conductivity of the surrounding formations which may have been disturbed during the drilling process;
- Remove residual fines from the well screen and sand pack (filter pack) materials, thus reducing turbidity of groundwater and permitting the collection of more representative groundwater samples.

1.3 There may be circumstances where well development is not desirable, for example, in the presence of non-aqueous phase liquids (NAPL) or other significant contamination if development could worsen the contaminant impact. If NAPL begins to intrude during development, the development process will be halted. This situation will be considered a cause for sample modification requiring approval by the Task Order (TO) Manager and other stakeholders, as applicable.

1.4 The applicable well development procedures for a particular site may be subject to State or local regulatory requirements. In all cases, the project team should consult their local regulatory requirements and document the selected well development procedure in the project-specific Quality Assurance Project Plan (QAPP). For project-specific information refer to the QAPP, which takes precedence over these procedures.

1.5 This procedure is the Program-approved professional guidance for work performed by AECOM under the client contract.

1.6 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP). Work will be conducted according to the TO QAPP and/or direction from the Site Safety and Health Officer (SSHO).

2.2 Monitoring well development may involve chemical hazards associated with potential contaminants in the soil or aquifer being characterized and may involve physical hazards associated with use of well development equipment.

3.0 Terms and Definitions

None.

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

4.0 Interferences

4.1 Equipment/materials used for development may react with the groundwater during development. Appropriate development equipment has been selected for the anticipated condition of the groundwater.

4.2 Appropriate development methods such as using a surge-block to flush suspended fines in the groundwater in and out of the well screen can improve the yield of wells and improve their potential to be developed successfully. However, the effectiveness of development can be significantly reduced in wells that do not yield sufficient water to allow this flushing to take place.

4.3 For formations with a significant content of fine-grained materials (silts and clays), or wells with improperly sized screens, it may not be possible to reduce turbidity to commonly acceptable levels. Possible solutions may include collecting a sample even if excessively turbid, or installing a replacement well.

4.4 Development itself disturbs the surrounding formation and disrupts equilibrium conditions within the well. Groundwater samples will not be collected until a minimum of 24 hours after a well is developed to allow conditions to stabilize. For sites with fine-grained formations (silts and clays) and highly sorptive contamination, a longer time period between development and sampling should be considered.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **TO Manager** is responsible for ensuring that well development activities comply with this procedure. The **TO Manager** is responsible for ensuring that all personnel involved in well development shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Site Supervisor (SS)** is responsible for ensuring that all well development activities are conducted according to the either this procedure or the applicable procedure presented in the project-specific QAPP.

5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure.

5.2.5 The field sampler and/or task manager is responsible for directly supervising the well development procedures to ensure that they are conducted according to this procedure and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

6.1 This equipment list was developed to aid in field organization and should be used in planning and preparation. Depending on the site-specific requirements and the development method selected, additional or alternative material and equipment may be necessary. In addition, for sites where groundwater is expected to be contaminated, the materials to be placed down the well and in contact with groundwater should be evaluated so that they are compatible with the chemical conditions expected in the well.

6.2 Equipment and materials used for well development may include, but is not limited to:

Well development equipment

- Surge block
- Disposable HDPE bailers, appropriate to the diameter of the well(s): 1-inch to 1.5-inch for 2-inch inside diameter (ID) monitoring wells.
- Watterra® footvalve
- PFAS-free (e.g., Teflon-free) electric submersible pump
- 12-volt power source for electric pump
- High density polyethylene (HDPE) tubing appropriately sized for Watterra® footvalve and/or electric submersible pump
- Drums or containers for storage of purge water
- Nephelometer to measure turbidity
- Multi-parameter water quality meter(s) to measure temperature, potential of hydrogen (pH), conductivity, dissolved oxygen (DO), and oxidation reduction potential (ORP)
- Instrument calibration solutions
- Teflon-free water level meter
- Oil/water interface probe

General equipment

- Project-specific plans including the site-specific APP/SSHP and QAPP
- Non-water-repellent field notebook/field forms/site maps
- Ball point pens or fine-point indelible marker
- 5-gallon HDPE or polypropylene buckets

Equipment decontamination supplies (refer to SOP 3-06, Equipment Decontamination)

- Health and safety supplies, including personal protective equipment (PPE) as specified by the APP/SSHP
- Appropriate hand tools
- Keys or combinations to access monitoring wells
- PFAS-free deionized water supply
- Disposable bailer string (polypropylene)
- Plastic trash bags

7.0 Procedure

Development generally consists of removing water and entrained sediment from the well until the water is clear (to the extent feasible) and the turbidity is reduced, which indicates the well is in good hydraulic connection with the surrounding formation. In addition to simply removing water, development can be improved when flushing through the well screen and gravel pack takes place in both directions, that is, both into the well and into the formation. This action breaks down sediment bridges that can occur in the formation or sand pack, which reduce the connection between the well and the formation

7.1 General Preparation

- All down-well equipment should be decontaminated prior to use and between well locations in accordance with SOP 3-06, Equipment Decontamination
- Although equipment is decontaminated between well locations, if wells are known or suspected to be contaminated based on observations during well installation, it is recommended that well

development be conducted in order from the least contaminated to the most contaminated well to minimize the chances of cross-contamination.

- Management of investigation-derived waste (IDW), including development purge water and miscellaneous expendable materials generated during the development process, will be conducted in accordance with SOP 3-05, IDW Management.
- Prior to accessing the well, the wellhead should be cleared of debris and/or standing water. Nothing from the ground surface should be allowed to enter the well.
- The depth to water and total well depth should be measured with a Teflon-free water level meter and recorded in the field logbook or on a Well Development Record (Attachment 1). This information will be used to calculate the volume of standing water (i.e., the well volume) within the well, and plan the specific details of the well development. If wells are suspected to contain NAPL, an oil/water interface probe should be used to measure liquid levels and depth to bottom of the well.
- Permanent monitoring wells will be developed no sooner than 24 hours after well installation is completed in order to allow well completion materials to set properly.

7.2 Monitoring Well Development Procedures

Generally, development will begin by gently surging the well with a surge block or bailer as described in Sections 7.2.1 and 7.2.2, respectively. Surging can become more vigorous as development progresses but initially the well must be gently surged to allow material blocking the screen to become suspended without damaging the well. Next, a bailer can be used to remove the sediment settled at the base of the well. A bailer, Watterra® pump, or electric submersible pump will then be used to purge the well, per Sections 7.2.2, 7.2.3, or 7.2.4, respectively. The well will be purged until the removed water becomes less turbid or per the requirements of the project-specific QAPP, or State or local requirements. At this point the well will be surged again with a surge block or bailer. The well can be surged more vigorously at this point. After surging, the well will be purged again until the turbidity once again decreases. The surge/purge cycle should be completed at least three times during the development process. After the last surge, the well will be purged until the development completion criteria outlined in 7.3.2 or per the project-specific QAPP are met.

7.2.1 Surge Block

The default method of well development is the use of a surge block in conjunction with pumping or bailing to remove sediment-laden water.

- The construction of the surge block must be appropriate for the diameter of the well. The surge block must be mounted on rods or other stiff materials to extend it to the appropriate depths and to allow for the surge block to be moved up and down in the well.
- Insert the surge block into the well and lower it slowly to the screened or open interval below the static water level. Start the surge action by slowly and gently moving the surge block up and down in the well. A slow initial surging, using plunger strokes of approximately 1 meter or 3 feet, will allow material which is blocking the screen to separate and become suspended.
- After 5 to 10 plunger strokes, remove water from the well using a separate bailer (Section 7.2.2) or pumping techniques (Sections 7.2.3 or 7.2.4). The returned water should be heavily laden with suspended fines. The water will be discharged to 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific QAPP.
- In some cases, the bailer or Watterra® foot valve can act as a surge block, flushing water in and out of the well screen as groundwater is removed.
- Repeat the process of surging and pumping/bailing. As development continues, slowly increase the depth of surging to the bottom of the well screen. Surging within the riser portion of the well is neither necessary nor effective.

7.2.2 Bailer

- Tie a string or other cable securely to the bailer. Lower it to the screened or open interval of the monitoring well below the static water level.
- The bailer may be raised and lowered repeatedly within the screened interval to attempt to simulate the action of a surge block by pulling fines through the well screen and pushing water out into the formation to break down bridging.
- With the bailer full of water, remove it from the well and discharge the water into 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific QAPP.
- The Watterra® system (Section 7.2.3) or electric submersible pump (Section 7.2.4) may be used as a complementary development method to the bailer, especially when removal of additional water at a faster rate is beneficial.
- Continue alternately surging and bailing, monitoring the purge water periodically (Section 7.3.1) until development completion criteria are met (Section 7.3.2).

7.2.3 Watterra® system

- Attach high-density polyethylene (HDPE) tubing to the decontaminated Watterra® pump foot valve
- Lower the foot valve and tubing assembly near the bottom of the well.
- Lift and lower the tubing to allow water to enter the Watterra® foot valve and travel up the tubing and discharge the water into 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific QAPP.
- The lifting and lowering action of the Watterra® system will cause some surging action to aid in breaking up fine material in the surrounding formation.
- A bailer (Section 7.2.2) may be used as a complementary development method to the Watterra® system, especially during the initial stages of development when a high volume of sediment may be required to be removed.
- An electric submersible pump (Section 7.2.4) may also be used as a complementary development method to the Watterra® system, especially when more volume of water is desired to be pumped or the turbidity criteria cannot be met due to the surging action of the Watterra® system.
- Continue alternately surging and pumping, monitoring the purge water periodically (Section 7.3.1) until well development completion criteria are met (Section 7.3.2).

7.2.4 Electric Submersible Pump

- Attach HDPE tubing to the decontaminated electric submersible pump.
- Lower the pump and tubing assembly near the bottom of the well, at least a few inches above the well total depth.
- Begin pumping, discharging the water into 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific QAPP.
- Continue alternately surging and pumping, monitoring the purge water discharge periodically (Section 7.3.1) until well development completion criteria are met (Section 7.3.2).

7.3 Discharge Monitoring

7.3.1 Monitoring the Progress of Development

The progress of the development is evaluated through visual observation of the suspended sediment load and measurement of the turbidity and other parameters in the purged discharge water. As development progresses, the water should become clearer, measured turbidity should decrease, and specific capacity (pumping rate divided by drawdown) should stabilize. Water quality parameters, including DO, conductivity, ORP, pH, temperature, and turbidity may be measured and recorded periodically to determine the progress of development using the criteria outlined in Section 7.3.2 or per the project-specific QAPP. Water quality parameters should be measured on each well volume removed.

7.3.2 Completion of Development

The well will be considered developed when the following criteria are met or per the criteria set forth in the project-specific QAPP:

- A minimum of three times the standing water volume in a well (to include the well screen and casing plus saturated annulus, assuming 30 percent porosity) is removed.
- Groundwater parameters for three consecutive standing water volumes are within the following:
  - pH – within ± 0.2 units
  - Specific conductivity – within ± 3%
  - ORP – within ± 10 mV
  - Temperature – within ±1 degree Celsius
  - Turbidity – at or below 10 nephelometric turbidity units (NTU) or within ± 10% if above 10 NTU.
- The sediment thickness remaining within the well is less than 1 percent of the screen length or less than 30 millimeters (0.1 ft) for screens equal to or less than 10 feet long.

Dissolved oxygen (DO) readings may be recorded but DO readings will not be used as development completion criteria because DO may not stabilize.

If the well has slow groundwater recharge and is purged dry, the well will be considered developed when bailed or pumped dry three times in succession and the turbidity has decreased, or per the requirements set forth in the project-specific QAPP. Water quality parameters may be recorded if feasible using the flow-through cell.

If any water is added to the well’s borehole during development or drilling, three times the volume of water added will also be removed during well development, or per the requirements set forth in the project-specific QAPP.

7.4 Development of Wells with Low Yield

Water is the primary mechanism to remove fines and flush water through the gravel pack for effective development. Therefore, development can be a challenge in wells that do not yield sufficient water to recharge when water is removed. However, often these wells are the most in need of development to improve their performance as they are typically installed in low permeability formations with a high content of fines. Development of these wells can improve their yield.

The surging portion of the development can be successfully performed in a well with standing water regardless of its yield. It is the subsequent removal of fine materials that is hindered when insufficient water is recharged to the well. When wells go dry or drawdown significantly during development, development can be performed intermittently, allowing sufficient water to recharge prior conducting the next stage of surging. These intermittent procedures can take place hours or even days apart, depending on project-specific time constraints.

7.5 Wells containing NAPL

Additional care should be taken when planning development of wells that contain NAPL. If the NAPL is flammable, there are health and safety as well as handling issues to consider. If NAPL in excess of a persistent sheen is noted, the recharge rate will be evaluated through hand bailing. In most cases, it is generally preferable to remove NAPL by bailing to the extent practical prior to performing development. Groundwater parameters, excluding turbidity, will not be collected during well development if NAPL or excessive sheen is noticed in the purged water during development to ensure the meter probes are not fouled or destroyed. Well development will be halted.

Development by surging or pumping the well dry can result in the spreading of NAPL vertically in the soil column around the well. These methods can be used, if information exists describing the vertical thickness of the NAPL smear zone around the well, and if the methods do not result in mounding or drawdown that exceeds this thickness. Alternate methods such as bailing may also be used, but any method should not allow the well to be pumped dry or result in significant drawdown that would spread the NAPL vertically.

7.6 Temporary Well Points

For certain projects, temporary well points (TWPs) may be installed to collect groundwater samples at a site. Since no sand pack, bentonite chips, or bentonite grout are generally used in the construction of the TWPs, development can proceed as soon as sufficient water has entered the well to static conditions. Due to the small diameter of these wells, generally ¾-inch to 1-inch ID, development will be performed using either a small diameter (0.5-inch) bailer and/or a peristaltic pump with HDPE tubing. The TWPs will have minimal water column and may purge dry during development. However, attempts will be made to remove fines from the well prior to sampling. Purging and sampling may occur as soon as approximately 80% of the static water has re-entered the TWP, or per the requirements set forth in the project-specific QAPP.

8.0 Quality Control and Assurance

8.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific QAPP.

8.2 Quality control (QC) requirements are dependent on project-specific sampling objectives. The project-specific QAPP will provide requirements for equipment decontamination (frequency and materials) and IDW handling.

9.0 Records, Data Analysis, Calculations

9.1 All data and information (e.g., development method used) must be documented on field data sheets (Attachment 1) or within site logbooks with permanent ink. Data recorded may include the following:

- Well Location
- Weather conditions
- Date and Time
- Purge Method
- Reading/measurements obtained

10.0 Attachments or References

Attachment 1 – Well Development Record

SOP 3-05, *IDW Management*.

SOP 3-06, *Equipment Decontamination*.

Author	Reviewer	Revisions (Technical or Editorial)
Shawn Dolan Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (June 2012)
Ken O'Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Attachment 1
Well Development Record

Well/Piezometer Development Record

Well ID:

Client: ____________

Project No: ____________ Date: ________ Developer: ____________________

Site Location: ____

Well/Piezometer Data

Well ☐ Piezometer ☐ Diameter __________ Material ____________

Measuring Point Description ____________

Geology at Screen Interval (if known) ____________

Depth to Top of Screen (ft.) ____________

Depth to Bottom of Screen (ft.) ____________

Time of Water Level Measurement ________

Total Well Depth (ft.) ____________

Calculate Purge Volume (gal.) ________

Depth to Static Water Level (ft.) ____________

Disposal Method ____________

Headspace ____________

Original Well Development ☐ Redevelopment ☐ Date of Original Development ________

DEVELOPMENT METHOD ______________________________

PURGE METHOD ______________________________

Time	Total Volume Purged (gal.)	Flow Rate (gpm)	Turbidity (NTU)	Color	pH	Temp	Other

ACCEPTANCE CRITERIA (from workplan)

Minimum Purge Volume Required _____ gallons

Maximum Turbidity Allowed _____ NTUs

Stabilization of parameters _____%

	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Has parameters stabilized	☐	☐	☐

If no or N/A explain below:

____

____

____

Signature ______________________________ Date: ____________

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Monitoring Well Sampling

Procedure 3-14

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the actions to be used during monitoring well sampling activities and establishes the method for sampling groundwater monitoring wells for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples that are representative of aquifer conditions with as little alteration to water chemistry as possible.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM under the client contract.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. All field sampling personnel responsible for sampling activities must review the project-specific Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) paying particular attention to the control measures planned for the well sampling tasks. Conduct preliminary area monitoring of sampling wells to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor phase and liquid matrix through the use of appropriate personal protective equipment (PPE).

2.2 Observe standard health and safety practices according to the project-specific APP/SSHP. Suggested minimum protection during well sampling activities includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves and rubberized steel-toed boots. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on evaluation for PFAS and on the contaminant concentrations. Refer to the project-specific APP/SSHP for the required PPE.

2.3 Physical Hazards associated with Well Sampling

- To avoid lifting injuries associated with pump and bailers retrieval, use the large muscles of the legs, not the back.
- Stay clear of all moving equipment, and avoid wearing loose fitting clothing.
- When using tools for cutting purposes, cut away from yourself. The use of appropriate, task specific cutting tools is recommended.
- To avoid slip/trip/fall conditions as a result of pump discharge, use textured boots/boot cover bottoms.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- Be aware of restricted mobility due to PPE.

3.0 Terms and Definitions

None.

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

4.0 Interferences

4.1 Potential interferences could result from cross-contamination between samples or sample locations. Minimization of the cross-contamination will occur through the following:

- The use of clean sampling tools at each location as necessary.
- Avoidance of material that is not representative of the media to be sampled.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **Task Order (TO) Manager** is responsible for ensuring that monitoring well sampling activities comply with this procedure. The **TO Manager** is responsible for ensuring that all field sampling personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Field Manager** is responsible for ensuring that all field sampling personnel follow these procedures.

5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure.

5.2.5 The field sampler and/or task manager is responsible for directly supervising the groundwater sampling procedures to ensure that they are conducted according to this procedure and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

6.1 Purging and Sampling Equipment

- Pump (Peristaltic, Portable Bladder, Submersible)
- Polyethylene bladders (for portable bladder pumps)
- Bladder pump controller (for portable bladder pumps)
- Air compressor (for portable bladder pumps)
- Nitrogen cylinders (for portable bladder pumps)
- 12-volt power source
- Polyethylene inlet and discharge tubing
- Silicone tubing appropriate for peristaltic pump head
- HDPE bailer appropriately sized for well
- Disposable bailer string (polypropylene)
- Individual or multi-parameter water quality meter(s) with flow-through cell to measure temperature, pH, specific conductance, dissolved oxygen (DO), oxidation reduction potential (ORP), and/or turbidity
- Turbidity meter
- Teflon-free water level meter
- Oil/water interface probe

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

6.2 General Equipment

- Sample kit (i.e., bottles, labels, preservatives, custody records and tape, cooler, wet ice)
- Sample Chain-of-Custody (COC) forms
- Sample Collection Records
- Sample packaging and shipping supplies
- Fine-tipped Sharpie® marker
- Deionized water supply
- Polyethylene water dispenser bottles
- HDPE flow measurement cup or bucket
- 5-gallon buckets
- Instrument calibration solutions
- Stopwatch or watch
- Disposable, powderless Nitrile gloves
- Cotton towels
- Trash bags
- Zipper-lock (e.g., Ziploc brand) bags
- Equipment decontamination supplies (e.g., Alconox®, Liquinox®, NOT Decon 90™)
- Health and safety supplies (as required by the APP/SSHP)
- Approved plans such as: project-specific APP/SSHP and Quality Assurance Project Plan (QAPP)
- Well keys or combinations
- Monitoring well location map(s)
- Field project logbook/ballpoint pen

7.0 Calibration or Standardization

7.1 Field instruments will be calibrated daily according to the requirements of the QAPP and manufacturer's specifications for each piece of equipment. Equipment will be checked daily with the calibration solutions at the end of use of the equipment. Calibration records shall be recorded in the field logbook or appropriate field form.

7.2 If readings are suspected to be inaccurate, the equipment shall be checked with the calibration solutions and/or re-calibrated.

8.0 Procedure

8.1 Preparation

8.1.1 Site Background Information

Establish a thorough understanding of the purposes of the sampling event prior to field activities. Conduct a review of all available data obtained from the site and pertinent to the water sampling. Review well history data including, but not limited to, well locations, sampling history, purging rates, turbidity problems, previously used purging methods, well installation methods, well completion records, well development methods, previous analytical results, presence of an immiscible phase, historical water levels, and general hydrogeologic conditions.

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that might be encountered during sampling, such as excessive turbidity and low well yield. They may also indicate where dedicated pumps are placed in the water column. To help minimize the potential for cross-contamination, well purging and sampling and water level measurement collection shall proceed from the least contaminated to the most contaminated well as indicated by previous analytical results. This order may be changed in the field if conditions warrant it, particularly if dedicated sampling equipment is used. A review of prior sampling procedures and results may also identify which purging and sampling techniques are appropriate for the parameters to be tested under a given set of field conditions.

8.1.2 Groundwater Analysis Selection

Establish the requisite field and laboratory analyses prior to water sampling. Decide on the types and numbers of quality assurance/quality control (QA/QC) samples to be collected (refer to the project-specific QAPP), as well as the type and volume of sample preservatives, the type and number of sample containers, the number of coolers required, and the quantity of ice or other chilling materials. The field sampling personnel shall ensure that the appropriate number and size sample containers are brought to the site, including extras in case of breakage or unexpected field conditions. Refer to the project-specific QAPP for the project analytical requirements.

8.2 Groundwater Sampling Procedures

Groundwater sampling procedures at a site shall include:

1) An evaluation of the well security and condition prior to sampling;
2) Decontamination of equipment;
3) Measurement of well depth to groundwater;
4) Assessment of the presence or absence of an immiscible phase;
5) Assessment of purge parameter stabilization;
6) Purging of static water within the well and well bore; and
7) Obtaining a groundwater sample.

Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events. In all cases, consult the State and local regulations for the site, which may require more stringent time separation between well development and sampling.

8.2.1 Well Security and Condition

At each monitoring well location, observe the conditions of the well and surrounding area. The following information may be noted on a Groundwater Sample Collection Record (Attachment 1) or in the field logbook:

- Condition of the well's identification marker.
- Condition of the well lock and associated locking cap.
- Integrity of the well – well pad condition, protective outer casing, obstructions or kinks in the well casing, presence of water in the annular space, and the top of the interior casing.
- Condition of the general area surrounding the well.

8.2.2 Decontamination of Equipment

Where possible, dedicated supplies should be used at each well location to minimize the potential for cross-contamination and minimize the amount of investigation derived waste (IDW) fluids resulting from the decontamination process. If decontamination is necessary, establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with PE plastic sheeting and be located upwind of the well being sampled. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in SOP 3-06, Equipment Decontamination.

Decontaminate each piece of equipment prior to entering the well. Also, conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without on-site decontamination.

8.2.3 Measurement of Static Water Level Elevation

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. The best practice, if possible, is to measure all site wells (or wells within the monitoring well network) prior to sampling. If the well cap is not vented, remove the cap several minutes before measurement to allow water levels to equilibrate to atmospheric pressure.

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). If not already present, mark an easily identified reference point for water level measurements which will become the measuring point for all water level measurements. This location and elevation must be surveyed.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. A Teflon-free electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

At each location, measure water levels several times in quick succession to ensure that the well has equilibrated to atmospheric conditions prior to recording the measurement. As stated above, measure all site wells (or wells within the monitoring well network) prior to sampling whenever possible. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Prior to sampling, measure the water level in each well immediately prior to purging the well to ascertain that static conditions have been achieved prior to sampling.

8.2.4 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL before the well is purged for conventional sampling. These procedures may not be required for all wells. Consult the project-specific QAPP to determine if assessing the presence of LNAPL and/or DNAPL is necessary.

1) Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a PID or an organic vapor analyzer, and record the measurements.
2) Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements.
3) Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.
4) In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water table contour maps until they are corrected for depression by the product.
5) If the well contains an immiscible phase, it may be desirable to sample this phase separately. Section 8.2.6 presents immiscible phase sampling procedures. It may not be meaningful to conduct water sample analysis of water obtained from a well containing LNAPLs or DNAPLs. Consult the **TO Manager** and **Program Quality Manager** if this situation is encountered.

8.2.5 Purging Equipment and Use

General Requirements

The water present in a well prior to sampling may not be representative of in situ groundwater quality and shall be removed prior to sampling. Handle all groundwater removed from potentially contaminated wells in accordance with the IDW handling procedures in SOP 3-05, IDW Management. Purging shall be accomplished by methods as indicated in the project-specific QAPP or by those required by State requirements. For the purposes of this SOP, purging methods will be described by removing groundwater from the well using low-flow techniques.

According to the U.S. Environmental Protection Agency (EPA) (EPA, 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/minute. EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated corrosion or reaction products in the well. EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. In addition, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of increasing the turbidity of the sample due to mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The field sampler shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells should not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated based on the results of either the well development task or historical sampling events. In general, place the intake of the purge pump in the middle of the saturated screened interval within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified. If the well is purged dry, allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis during well purging and analyze them in the field preferably using in-line devices (i.e., flow through cell) for temperature, pH, specific conductivity, dissolved oxygen (DO), and oxidation-reduction (redox) potential. Turbidity should be measured separately (outside of the flow-through cell) with a nephelometer or similar device.

Readings should be taken every 2 to 5 minutes during the purging process. These parameters are measured to demonstrate that the natural character of the formation waters has been restored.

Purging shall be considered complete per the requirements set forth in the project-specific QAPP, State requirements, or when three consecutive field parameter measurements of temperature, pH, specific conductivity, DO and ORP stabilize within approximately 10 percent and the turbidity is at or below 10 nephelometric turbidity units (NTU) or within ± 10% if above 10 NTU. This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process into a groundwater sampling log. Attachment 1 shows an example of a groundwater sampling log and the information typically included in the form. Whatever form is used, all blanks need to be completed on the field log during field sampling.

Groundwater removed during purging shall be stored according to the project-specific QAPP or per SOP 3-05, IDW Management.

Purging Equipment and Methods

Submersible Pump

A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling the groundwater for semivolatile and non-volatile constituents, but are generally not preferred for VOCs unless there are no other options (e.g., well over 200 feet deep). For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to overpumpage of the wells (<1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to limit the amount of water that will flow back down the drop pipe into the well. Place the pump in the middle of the saturated screened interval within the well and maintain it in that position during purging.

Bladder Pump

A stainless-steel bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Use of the bladder pump is most effective in low to moderate yield wells and are often the preferred method for low-flow sampling. When sampling for VOCs and/or SVOCs and PFAS, polyethylene bladders and PFAS-free O-rings and pump accessories should be used.

Either compressed dry nitrogen or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use.

Centrifugal, Peristaltic, or Diaphragm Pump

A centrifugal, peristaltic, or diaphragm pump may be utilized to purge a well if the water level is within 20 feet of ground surface. New or dedicated HDPE tubing is inserted into the midpoint of the saturated screened interval of the well. Water should be purged at a rate that satisfies low-flow requirements (i.e., does not cause drawdown). Centrifugal, peristaltic, or diaphragm pump are generally discouraged for VOCs sampling; however, follow methods allowed per the project-specific QAPP or State requirements.

Air Lift Pump

Airlift pumps are not appropriate for purging or sampling.

Bailer

Avoid using a bailer to purge a well because it can result in overdevelopment of the well and create excessive purge rates. If a bailer must be used, the bailer should either be dedicated or disposable. An HDPE balier with polypropylene string mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well.

8.2.6 Monitoring Well Sampling Methodologies

Sampling Light, Non-Aqueous Phase Liquids (LNAPL)

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water interface depth as determined by measurement with the interface probe. Allow the bailer to fill with LNAPL and retrieve it.

When sampling LNAPLs, never drop bailers into a well and always remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. Teflon bailers should always be used when sampling LNAPL. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

Sampling Dense, Non-Aqueous Phase Liquids (DNAPL)

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

Groundwater Sampling Methodology

The well shall be sampled when groundwater within it is representative of aquifer conditions per the methods described in Section 8.2.5. Prior to sampling the flow-through cell shall be removed and the samples collected directly from the purge tubing. Flow rates shall not be adjusted once aquifer conditions are met. Additionally, a period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling in order to monitor drawdown when using low-flow techniques and gauge well volumes removed and recharged when using non-low-flow techniques.

Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers, minimizing exposure to sunlight, and immediately placing the sample on ice once collected.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride (PVC) bailers, Tygon® tubing, silicon rubber bladders, neoprene impellers, polyethylene, and Viton® are not acceptable when sampling for organics and PFAS. If bailers are used, an inert cable/chain (e.g., polypropylene string or stainless steel wire or cable) shall be used to raise and lower the bailer. Dedicated equipment is highly recommended for all sampling programs.

Submersible Pumps

The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and HDPE, sample discharge lines composed of HDPE) and must have a controller mechanism allowing the required low-flow rate. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low-flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low-flow rate.

Bladder Pumps

A gas-operated stainless steel bladder pump with adjustable flow control and equipped with a polyethylene bladder and HDPE tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. If only inorganics are being sampled, polyvinyl bladders and tubing may be used. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge.

When using a compressor, take several precautions. If the compressor is being powered by a gasoline generator, position the generator downwind of the well. Ground fault circuit interrupters (GFCIs) should always be used when using electric powered equipment. Do not connect the compression hose from the compressor to the pump controller until after the engine has been started.

When all precautions are completed and the compressor has been started, connect the compression hose to the pump controller. Slowly adjust the control knobs to discharge water in the shortest amount of time while maintaining a near constant flow. This does not mean that the compressor must be set to discharge the water as hard as possible. The optimal setting is one that produces the largest volume of purge water per minute (not per purge cycle) while maintaining a near constant flow rate.

Prior to sampling, adjust the flow rate (purge rate) to yield 100 to 300 mL/minute. Avoid settings that produce pulsating streams of water instead of a steady stream if possible. Operate the pump at this low flow rate for several minutes to ensure that drawdown is not occurring. At no time shall the sample flow rate exceed the flow rate used while purging.

For those samples requiring filtration, it is recommended to use an in-line high capacity filter after all non-filtered samples have been collected.

***Peristaltic Pumps*:**

A peristaltic pump is a type of positive displacement pump that moves water via the process of peristalsis. The pump uses a flexible hose fitted inside a circular pump casing. A rotor with cams compresses the flexible tube as the rotor turns, which forces the water to be pumped to move through the tube. In peristaltic pumps, no moving parts of the pump are in contact with the water being pumped. Displacement is determined by tube size, so delivery rate can only be changed during operation by varying pump speed. Peristaltic pumps are simple and quite inexpensive for the flow rates they provide.

There are several methods available for transferring the sample into the laboratory containers. The selected method may vary based on State requirements and should be documented in the project-specific QAPP. Samples typically can be collected directly from the discharge end of the HDPE tubing, after it has been disconnected from the flow through cell. For volatile analyses, the sampler should make sure that the pump is set such that a smooth laminar flow is achieved. In all cases, the project team should consult their local regulatory requirements and document the selected sample collection procedure in the project-specific QAPP.

Bailers

A single- or double-check valve HDPE or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical, regulatory, or logistical reasons.

Dedicated or disposable bailers should always be used in order to eliminate the need for decontamination and to limit the potential of cross-contamination. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

8.2.7 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable and require preservation. The U.S. EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods (SW-846)* (EPA 1997), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 provides guidance on the types of sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory or State requirements prior to obtaining field samples. In many cases, the laboratory will supply the necessary sample bottles and required preservatives. In some cases, the field sampling personnel may add preservatives in the field.

Improper sample handling may alter the analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the project-specific QAPP. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens (TOX)
2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Nitrate and ammonia
10. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. The analytical laboratory performing the analysis shall provide these vials. Collect groundwater from the sampling device in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that has high concentrations of dissolved gasses. In these cases, the field sampling personnel shall document the occurrence in the field logbook and/or sampling worksheet at the time the sample was collected. Likewise, the analytical laboratory shall note in the laboratory analysis reports any headspace in the sample container(s) at the time of receipt by the laboratory.

Special Handling Considerations

In general, samples for organic analyses should not be filtered. However, high turbidity samples for PCB analysis may require filtering. Consult the project-specific QAPP for details on filtering requirements. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples should be handled in the same manner as VOC samples.

When collecting total and dissolved metals samples, the samples should be collected sequentially. The total metals sample is collected from the pump unfiltered. The dissolved metals sample is collected after filtering with a 0.45-micron membrane in-line filter. Allow at least 500 mL of effluent to flow through the filter prior to sampling to ensure that the filter is thoroughly wetted and seated in the filter capsule. If required by the project-specific QAPP, include a filter blank for each lot of filters used and always record the lot number of the filters.

Because there is some evidence that PFOS may sorb onto glass fiber filters, it is preferred not to filter samples for PFAS analysis in the field or laboratory. Field filtration is generally prohibited unless specifically requested by a client. If filtering is required by client's and regulatory agency's request, it is recommended that the following be considered and discussed with the client and regulatory agency:

- Evaluate if filtered results are meaningful, and, therefore, if filtering in the field or laboratory is required.
- Consider use of low flow sampling in the field to reduce the need for sample filtering.
- Consider use of a centrifuge in the laboratory to reduce the need for sample filtering.
- If filtering is required, determine the nature of the filters used and do not use glass fiber filters.

Field Sampling Preservation

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. Guidance for the preservation of environmental samples can be found in the U.S. EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other U.S. EPA documents (EPA 1992, 1996).

Field Sampling Log

A groundwater sampling log provided as Attachment 1 shall document the following:

- Identification of well
- Well depth

- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Types of sample containers used
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data
- Field observations on sampling event
- Name of sampler
- Weather conditions

9.0 Quality Control and Assurance

9.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific QAPP. The goal of the QA program should be to ensure precision, accuracy, representativeness, completeness, and comparability in the project sampling program.

9.2 Quality control (QC) requirements for sample collection are dependent on project-specific sampling objectives. The project-specific QAPP will provide requirements for sample preservation and holding times, container types, sample packaging and shipment, as well as requirements for the collection of various QC samples such as trip blanks, field blanks, equipment rinse blanks, and field duplicate samples.

10.0 Data and records management

10.1 Records will be maintained in accordance with SOP 3-03, Recordkeeping, Sample Labelling, and Chain-of-Custody. Various forms are required to ensure that adequate documentation is made of the sample collection activities. These forms may include:

- Sample Collection Records;
- Non-water repellent field logbook;
- Chain-of-custody forms; and
- Shipping labels.

10.2 Sample collection records (Attachment 1) will provide descriptive information for the purging process and the samples collected at each monitoring well.

10.3 The field logbook is kept as a general log of activities and should not be used in place of the sample collection record.

10.4 Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes.

10.5 Shipping labels are required is sample coolers are to be transported to a laboratory by a third party (courier service).

11.0 Attachments or References

Attachment 1 – Groundwater Sampling Collection Record

ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites.* ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.

Environmental Protection Agency, United States (EPA). 1982. *Handbook for Sampling and Sample Preservation of Water and Wastewater.* EPA-600/4-82-029. Cincinnati: EPA Office of Research and Development, Environmental Monitoring and Support Laboratory.

EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

EPA. 1996. *Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA/540/S-95/504. Office of Solid Waste and Emergency Response. April.

EPA. 1997. *Test Methods for Evaluating Solid Waste, Physical/Chemical Method (SW-846)*. 3rd ed., Final Update IIIA. Office of Solid Waste. Online updates at: http://www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

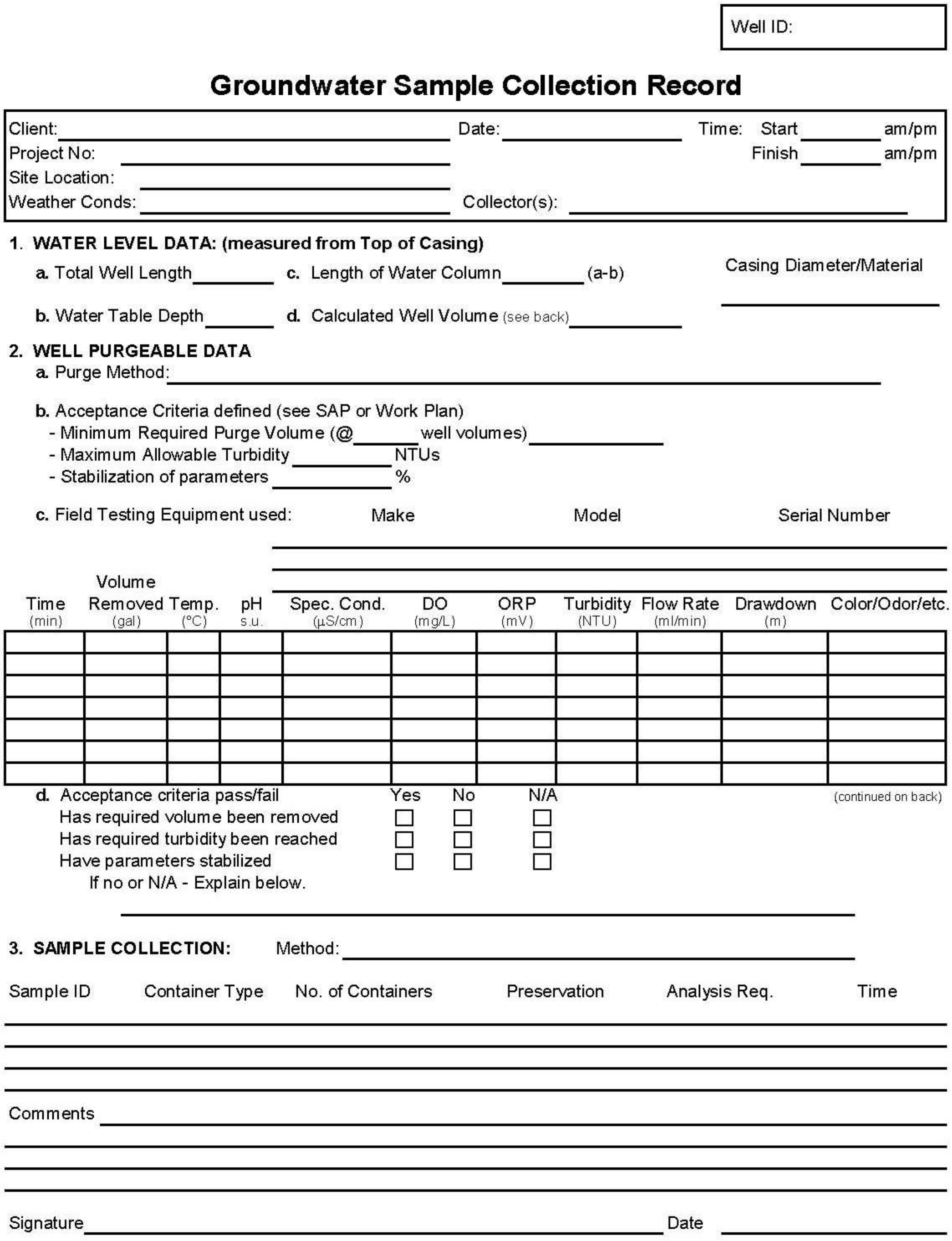
SOP 3-03, *Recordkeeping, Sample Labelling, and Chain-of-Custody*.

SOP 3-05, *IDW Management.*

SOP 3-06, *Equipment Decontamination*.

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)
Ken O'Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

Attachment 1
Groundwater Sample Collection Record



Well ID:

Groundwater Sample Collection Record

Client:________________ Date:____________ Time: Start ________ am/pm
Project No: ________________ Finish ________ am/pm
Site Location: ________________
Weather Conds: ________________ Collector(s): ________________

1. WATER LEVEL DATA: (measured from Top of Casing)

a. Total Well Length________ **c.** Length of Water Column________ (a-b)
b. Water Table Depth________ **d.** Calculated Well Volume (see back)__________

Casing Diameter/Material
____

2. WELL PURGEABLE DATA

a. Purge Method:________________________________

b. Acceptance Criteria defined (see SAP or Work Plan)
- Minimum Required Purge Volume (@______well volumes)____________
- Maximum Allowable Turbidity __________ NTUs
- Stabilization of parameters __________ %

c. Field Testing Equipment used:

Make	Model	Serial Number

Time (min)	Volume Removed (gal)	Temp. (°C)	pH s.u.	Spec. Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (m)	Color/Odor/etc.

(continued on back)

d. Acceptance criteria pass/fail

	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Have parameters stabilized	☐	☐	☐

If no or N/A - Explain below.

____

3. SAMPLE COLLECTION: Method:________________________________

Sample ID	Container Type	No. of Containers	Preservation	Analysis Req.	Time

Comments ____
____
____
____

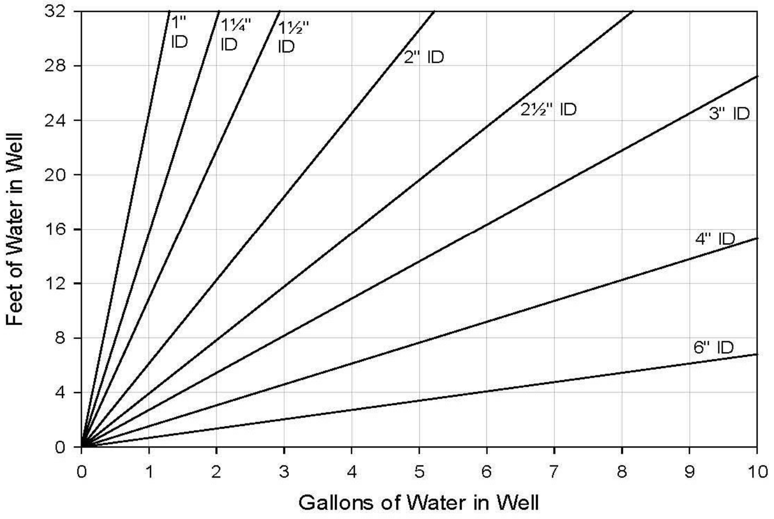
Signature________________________________ Date ________________

Page 1 of 2

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Purge Volume Computation

Well ID:



Volume / Linear Ft. of Pipe		
ID (in)	**Gallon**	**Liter**
¼	0.0025	0.0097
³/₈	0.0057	0.0217
½	0.0102	0.0386
¾	0.0229	0.0869
1	0.0408	0.1544
1¼	0.0637	0.2413
1½	0.0918	0.3475
2	0.1632	0.6178
2½	0.2550	0.9653
3	0.3672	1.3900
4	0.6528	2.4711
6	1.4688	5.5600

(continued from front)

Time (min)	Volume Removed (gal)	Temp. (°C)	pH s.u.	Spec. Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (m)	Color/Odor/etc.

Signature______________________________ Date ____________

Monitoring Well Abandonment

Procedure 3-15

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the methods used for the abandonment of groundwater monitoring wells and peizometers.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM under the client contract.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP). Work will be conducted according to the Task Order (TO) Quality Assurance Project Plan (QAPP) and/or direction from the Site Safety and Health Officer (SSHO).

2.2 Physical hazards associated with well installation include:

- To avoid lifting injuries associated with well abandonment practices, use the large muscles of the legs, not the back. The drilling contractor should use the drill rig wenching cables and appropriate heavy equipment to minimize manual lifting.
- Stay clear of all moving equipment and avoid wearing loose fitting clothing.
- When using an approved retractable-blade knife, cut away from one self.
- To avoid slip/trip/fall conditions during site activities, keep the area clear of excess soil cuttings and formation groundwater and use textured boots/boot cover bottoms in muddy areas.
- To avoid heat/cold stress because of exposure to extreme temperatures and personal protective equipment (PPE), drink electrolyte replacement fluids (1 - 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- Be aware of restricted mobility caused by PPE.

3.0 Terms and Definitions

3.1 **Annulus:** The annulus is the down-hole space between the borehole wall and the well casing and screen.

3.2 **Bridge:** A bridge is an obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by the placement of filter pack materials during well completion. Bridging can also occur in the formation during well development.

3.3 **Filter Pack:** Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

3.4 **Grout:** Grout is a fluid mixture of cement and water that can be forced through a tremie pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

4.0 Interferences

4.1 The total depth of the monitoring well will be measured and the measurement will be compared to the original well completion log prior to abandonment.

4.2 A map with the location of the well to be abandoned and the surrounding wells, if any, will be utilized in the field to confirm the location of the well to be abandoned.

4.3 Information from the well identification tags/markings will be noted and the information compared to both the well completion log and the total depth measurement obtained in the field to confirm the identity of the well being abandoned.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **TO Manager** is responsible for ensuring that well abandonment activities comply with this procedure. The **TO Manager** is responsible for ensuring that all personnel involved in well abandonment shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Site Supervisor (SS)** is responsible for ensuring that all well abandonment activities are conducted according to the either this procedure or the applicable procedure presented in the project-specific QAPP.

5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure.

5.2.5 The **field sampler and/or task manager** is responsible for directly supervising the well abandonment procedures to ensure that they are conducted according to this procedure and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

6.1 Equipment and materials used during monitoring well and piezometer abandonment include the following:

- Drill rig or trailer-mounted mixer and grout pump
- Filter pack material
- Pure sodium bentonite with no additives
- Bentonite pellets/chips
- Bentonite grout
- Portland Type II cement
- Water from an approved source
- Weighted tape measure
- Flexible hose

- Tremie pipe (small-diameter, rigid polyvinyl chloride [PVC] pipe)
- Weatherproof bound field logbook with numbered pages
- Appropriate health and safety equipment

7.0 Procedure

7.1 General Procedures

The following procedure applies to the abandonment of wells aborted prior to completion and existing wells determined to be ineffective or otherwise in need of closure. Prior to abandoning any developed well, you may need to acquire a permit from the State or local governing body in which you are working. The permit application may require a detailed design of the well abandonment. In addition, prior to abandonment, all obstructions (e.g., pumps, lost equipment) must be removed from the well. Some States are strict in requiring the removal of all lost equipment prior to abandonment and will not allow the closure of a well with lost equipment in it. The State may require the removal of all objects to allow a proper seal during abandonment. Great lengths must be taken to reclaim lost items, such as the use of downhole video cameras to inspect and aid in the recovery of items. Prior to abandonment, confirm that the well selected for abandonment is properly located and identified to avoid abandoning the wrong well.

At locations where a well log is not available, the following procedure shall be implemented:

- The casing should be pulled, drilled out, or thoroughly pierced.
- With the use of a tremie pipe, grout should be placed from the bottom of the hole to within 3 feet of the ground surface.
- The material should be allowed to settle for 24 hours.
- The remainder of the hole should be filled with concrete.
- All historical sample data and abandonment procedures should be included in the records of work.

At locations where a well completion log is available, the following procedure shall be implemented:

- With the use of a tremie pipe, grout should be placed from the bottom of the hole to within 3 feet of the ground surface.
- The material should be allowed to settle for 24 hours.
- The remainder of the hole should be filled with concrete.
- All boring logs, historical sample data, completion records, and abandonment procedures should be included in the records of work.

Depending on the regulatory body under which you are working, the procedures listed above may differ. All work shall be performed by a licensed well driller in the State work is being performed. The licensed well driller is responsible for documenting the abandonment of the monitoring well with the appropriate State agency.

7.2 Replacement Wells

Replacement wells (if any) should normally be offset at least 15 feet from any abandoned well in an upgradient or crossgradient groundwater flow direction. Site-specific conditions may necessitate variation of this placement requiring the replacement well to be located either closer or further in proximity to the original well. To avoid potential issues related to grout migration into a well filter pack and/or screen section, replacement wells should be installed after the original/adjacent well is properly abandoned.

7.3 Grout

Bentonite grout is preferred for the abandonment of monitoring wells. Cement grout, if used for abandonment, should be composed of the following by weight:

- 20 parts cement (Portland cement, Type II or V)
- 0.4 to 1-part (maximum) (2 to 5 percent) bentonite
- 8 gallons (maximum) approved water per 94-pound bag of cement

Neither additives nor borehole cuttings should be mixed with the grout. Bentonite should be added after the required amount of cement has been mixed with the water. All grout material should be combined in an aboveground container and mechanically blended to produce a thick, lump-free mixture. The mixed grout should be recirculated through the grout pump prior to placement. The mixture can be combined and recirculated through a drill rig equipped for mud rotary drilling or through a mixer and grout pump mounted on a trailer.

Grout should be placed with the use of a commercially available grout pump and a rigid tremie pipe. Casing and grouting should be removed in stages, aquifer by aquifer, sealing the boring from the bottom to ground surface. This should be accomplished by placing a tremie pipe to the bottom and pumping grout through the pipe until undiluted grout reaches the bottom of the next higher section of casing or, for the topmost section, until grout flows from the boring at the ground surface.

After 24 hours, the abandoned drilling site should be checked for grout settlement. Any settlement depression should be filled with grout and rechecked 24 hours later. This process should be repeated until firm grout remains at the ground surface.

Be aware that when the drillers are finished, they will need a large supply of water to rinse out their equipment. This wash water must be containerized as IDW in accordance with SOP 3-05, *IDW Management*. Also, any materials (such as the removed protective casing, manhole covers, and concrete collars) shall be disposed of properly, or per the requirements of the project-specific QAPP.

8.0 Quality Control and Assurance

8.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific QAPP.

8.2 Quality Control (QC) measures should be taken to ensure proper well abandonment in accordance with this SOP, project-specific QAPP, and applicable well standards.

9.0 Records, Data Analysis, Calculations

9.1 All field information must be documented in the field logbook and/or on field data sheets with permanent ink. Data recorded may include the following:

- Date/time
- Well/piezometer location
- Personnel/subcontractor on site
- Abandonment method
- Depth of well/piezometer
- Materials used to seal each stratum
- Detailed description of procedure
- Date/time of return visit(s)
- Activities performed on return visit(s)
- Observations or problems encountered during abandonment

10.0 Attachments or References

Environmental Protection Agency, United States (EPA). 1987*. A Compendium of Superfund Field Operations Methods*. Office of Solid Waste and Emergency Response. EPA/540/P-87/001.

SOP 3-05, *IDW Management*.

Author	Reviewer	Revisions (Technical or Editorial)
Shawn Dolan Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (June 2012)
Ken O’Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

Soil and Rock Classification

Procedure 3-16

1.0 Purpose and Scope

1.1 The purpose of this document is to define the standard operating procedure (SOP) to thoroughly describe the physical characteristics of the sample and classify it according to the Unified Soil Classification System (USCS).

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM under the client contract.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review. If there are procedures whether it be from AECOM, state and/or federal that are not addressed in this SOP and are applicable to surface water sampling then those procedures may be added as an appendix to the project-specific Quality Assurance Project Plan (QAPP).

1.4 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Program Quality Manager. Deviations to this SOP will be documented in the field records.

2.0 Safety

2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling. All **field sampling personnel** responsible for sampling activities must review the project-specific Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP), paying particular attention to the control measures planned for the sampling tasks. Conduct preliminary area monitoring to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor and liquid phase through the use of respirators and disposable clothing.

2.2 In addition, observe standard health and safety practices according to the project-specific APP/SSHP. Suggested minimum protection during well sampling activities includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves, rubberized steel-toed boots, and an American National Standards Institute-standard hard hat. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations, and shall always be available on site.

2.3 Daily safety briefs will be conducted at the start of each working day before any work commences. These daily briefs will be facilitated by the **Site Safety and Health Officer (SSHO)** or designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the APP/SSHP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSHO.

2.4 The health and safety considerations for the work associated with soil classification include:

- At no time during classification activities are personnel to reach for debris near machinery that is in operation, place any samples in their mouth, or come in contact with the soils/rocks without the use of gloves.

- Stay clear of all moving equipment and be aware of pinch points on machinery. Avoid wearing loose fitting clothing.
- When using cutting tools, cut away from yourself. The use of appropriate, task specific cutting tools is recommended.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and in case of extreme cold, wear insulating clothing.

3.0 Terms and Definitions

None.

4.0 Interference

None.

5.0 Training and Qualifications

5.1 The **Task Order (TO) Manager** is responsible for ensuring that the soil and rock classification procedures comply with this procedure. The **TO Manager** is responsible for ensuring that all personnel involved in soil and rock classification shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.3 The **Site Supervisor (SS)** is responsible for ensuring that all project **field personnel** follow these procedures.

5.4 Field personnel are responsible for the implementation of this procedure. Minimum qualifications for **field sampling personnel** require that one individual on the field team shall have a minimum of 6 months of experience with soil and rock classification.

5.5 The **project geologist** and/or **task manager** is responsible for directly supervising the soil and rock classification procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the **Program Quality Manager** and then documented in the field logbook and associated report or equivalent document.

6.0 Equipment and Supplies

6.1 The following equipment list contains materials which may be needed in carrying out the procedures outlined in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- Personal protective equipment (PPE) and other safety equipment, as required by the APP/SSHP
- Field log book and pen with indelible ink
- Boring log
- Munsell Soil Color Chart
- Scoopula, spatula, and/or other small hand tools
- California Sampler
- Hand-held penetrometer

7.0 Calibration or Standardization

None.

8.0 Procedure

8.1 Soil Classification

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

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

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

- Classification group name (e.g., silty sand)
- Color, moisture, and odor
- Range of particle sizes and maximum particle size
- Approximate percentage of boulders, cobbles, gravel, sand, and fines
- Plasticity characteristics of the fines
- In-place conditions, such as consistency, density, and structure
- USCS classification symbol

The USCS serves as ”shorthand“ for classifying soil into 15 basic groups:

GW[1]	Well graded (poorly sorted) gravel (>50 percent gravel, <5percent fines)
GP[1]	Poorly graded (well sorted) gravel (>50percent gravel, <5percent fines)
GM[1]	Silty gravel (>50 percent gravel, >15 percent silt)
GC[1]	Clayey gravel (>50 percent gravel, >15 percent clay)
SW[1]	Well graded (poorly sorted) sand (>50 percent sand, <5 percent fines)
SP[1]	Poorly graded (well sorted) sand (>50 percent sand, <5 percent fines)
SM[1]	Silty sand (>50 percent sand, >15 percent silt)
SC[1]	Clayey sand (>50 percent sand, >15 percent clay)
ML[2]	Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness, and plasticity)

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

CL[2]	Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)
MH[2]	Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)
CH[2]	Inorganic, high plasticity (fat) clay (no dilatancy, high toughness, and plasticity)
OL	Organic low plasticity silt or organic silty clay
OH	Organic high plasticity clay or silt
PT	Peat and other highly organic soil

Figure8-1 defines the terminology of the USCS. Flow charts presented in Figure 8-2 and indicate the process for describing soil. The particle size distribution and the plasticity of the fines are the two properties of soil used for classification. In some cases, it may be appropriate to use a borderline classification (e.g., SC/CL) if the soil has been identified as having properties that do not distinctly place the soil into one group.

8.1.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. Being proficient in estimating this factor requires extensive practice and frequent checking. The steps involved in determining particle size distribution are listed below:

1. Select a representative sample (approximately 1/2 of a 6-inch long by 2.5-inch diameter sample liner).
2. Remove all particles larger than 3 inches from the sample. Estimate and record the percent by volume of these particles. Only the fraction of the sample smaller than 3 inches is classified.
3. Estimate and record the percentage of dry mass of gravel (less than 3 inches and greater than 1/4 inch).
4. Considering the rest of the sample, estimate, and record the percentage of dry mass of sand particles (about the smallest particle visible to the unaided eye).
5. Estimate and record the percentage of dry mass of fines in the sample (do not attempt to separate silts from clays).
6. Estimate percentages to the nearest 5 percent. If one of the components is present in a quantity considered less than 5 percent, indicate its presence by the term “trace”.
7. The percentages of gravel, sand, and fines must add up to 100 percent. “Trace” is not included in the 100 percent total.

8.1.2 Soil Dilatancy, Toughness, and Plasticity

8.1.2.1 Dilatancy

To evaluate dilatancy, follow these procedures:

1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 millimeters [mm]) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
2. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or

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[2] If the soil is estimated to have 15 percent to 25 percent sand or gravel, or both, the words “with sand” or “with gravel” (whichever predominates) shall be added to the group name (e.g., clay with sand, CL; or silt with gravel, ML). If the soil is estimated to have 30 percent or more sand or gravel, or both, the words “sandy” or “gravely” (whichever predominates) shall be added to the group name (e.g., sandy clay, CL). If the percentage of sand is equal to the percent gravel, use “sandy.”

pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 8-1. The reaction is the speed with which water appears while shaking and disappears while squeezing.

Table 8-1: Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

8.1.2.2 Toughness

Following the completion of the dilatancy test, shape the test specimen into an elongated pat and roll it by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, spread it into a thin layer and allow it to lose some water by evaporation.) Fold the sample threads and re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble at a diameter of 1/8 inch when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, lump the pieces together and knead it until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 8-2.

Table 8-2: Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread near the plastic limit. The thread and the lump have very high stiffness.

Figure8-1: Unclassified Soil Classification System (USCS)

DEFINITION OF TERMS

MAJOR DIVISIONS			SYMBOLS	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More Than Half of Material is Larger Than No. 200 Sieve Size	**GRAVELS** More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN GRAVELS** (Less than 6% Fines)	**GW**	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS With Fines	**GM**	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN SANDS** (Less than 6% Fines)	**SW**	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SANDS With Fines	**SM**	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More Than Half of Material is Smaller Than No. 200 Sieve Size	**SILTS AND CLAYS** Liquid Limit is Less Than 50%		**ML**	Inorganic silts, rock flour, fine sandy silts or clays, and clayey silts with non- or slightly-plastic fines
			CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limit is Greater Than 50%		**MH**	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, clayey silt
			CH	inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			**PT**	Peat and other highly organic soils

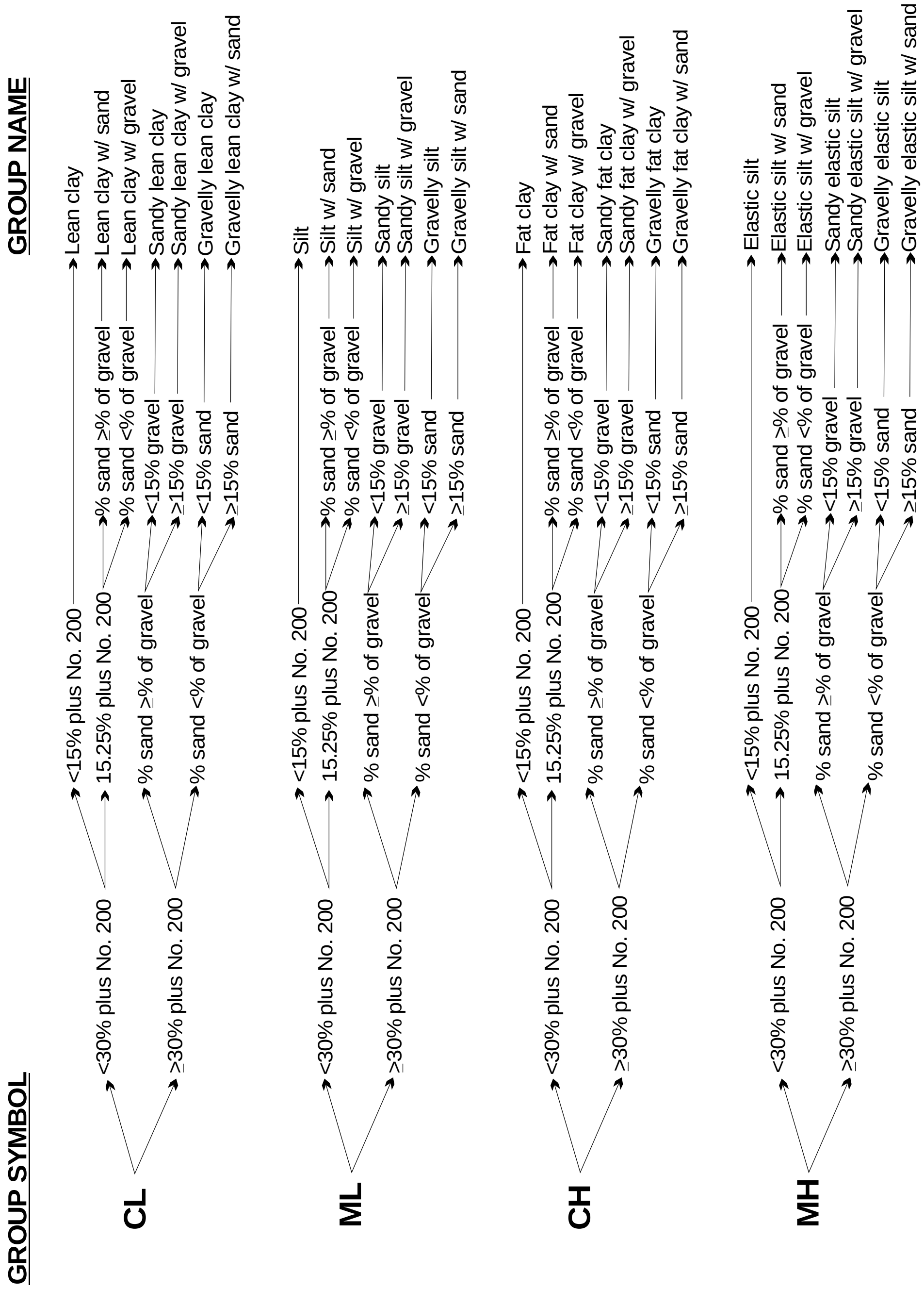
GRAIN SIZES

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

200 40 10 4 3/4“ 3“ 12“

U.S. STANDARD SERIES SIEVE CLEAR SQUARE SIEVE OPENINGS

Figure 8-2: Flow Chart for Fine Grain Soil Classification



NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

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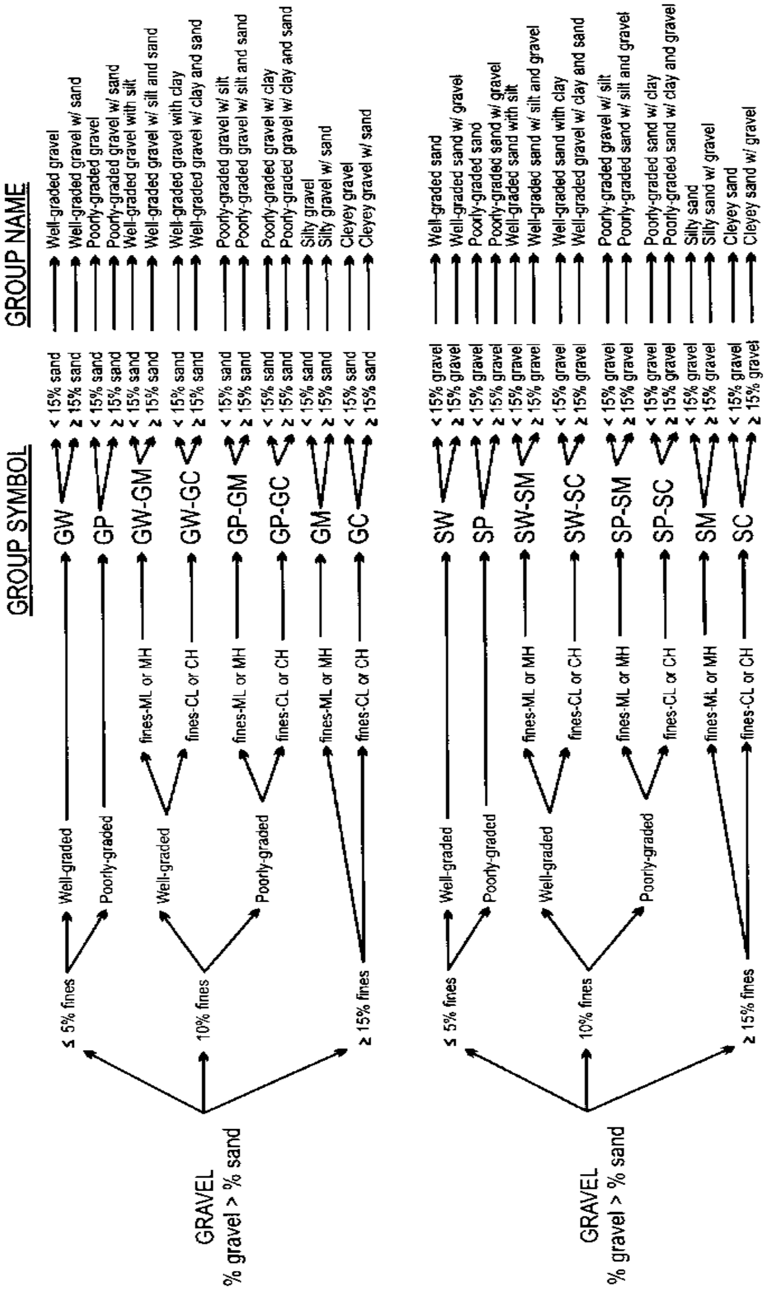
Figure 8-3: Flow Chart for Soil with Gravel



NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

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8.1.2.3 Plasticity

The plasticity of a soil is defined by the ability of the soil to deform without cracking, the range of moisture content over which the soil remains in a plastic state, and the degree of cohesiveness at the plastic limit. The plasticity characteristic of clays and other cohesive materials is defined by the liquid limit and plastic limit. The liquid limit is defined as the soil moisture content at which soil passes from the liquid to the plastic state as moisture is removed. The test for the liquid limit is a laboratory, not a field, analysis.

The plastic limit is the soil moisture content at which a soil passes from the plastic to the semi-solid state as moisture is removed. The plastic limit test can be performed in the field and is indicated by the ability to roll a 1/8-inch (0.125-inch) diameter thread of fines, the time required to roll the thread, and the number of times the thread can be re-rolled when approaching the plastic limit.

The plasticity tests are not based on natural soil moisture content, but on soil that has been thoroughly mixed with water. If a soil sample is too dry in the field, add water prior to performing classification. If a soil sample is too sticky, spread the sample thin and allow it to lose some soil moisture.

Table 8-3 presents the criteria for describing plasticity in the field using the rolled thread method.

Table 8-3: Criteria for Describing Plasticity

Description	Criteria
Non-Plastic	A 1/8-inch thread cannot be rolled.
Low Plasticity	The thread can barely be rolled.
Medium Plasticity	The thread is easy to roll and not much time is required to reach the plastic limit.
High Plasticity	It takes considerable time rolling the thread to reach the plastic limit.

8.1.3 Angularity

The following criteria describe the angularity of the coarse sand and gravel particles:

- **Rounded** particles have smoothly-curved sides and no edges.
- **Subrounded** particles have nearly plane sides but have well-rounded corners and edges.
- **Subangular** particles are similar to angular but have somewhat rounded or smooth edges.
- **Angular** particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

8.1.4 Color, Moisture, and Odor

The natural moisture content of soil is very important. Table **8-4** shows the terms for describing the moisture condition and the criteria for each.

Table 8-4: Soil Moisture Content Qualifiers

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

Color is described by hue and chroma using the Munsell Soil Color Chart (Munsell 2000). For uniformity, all site geologists shall utilize this chart for soil classification. Doing so will facilitate correlation of geologic units between boreholes logged by different geologists. The Munsell Color Chart is a small booklet of numbered color chips with names like “5YR 5/6, yellowish-red.” Note mottling or banding of colors. It is particularly important to note and describe staining because it may indicate contamination.

In general, wear a respirator if strong organic odors are present. If odors are noted, describe them if they are unusual or suspected to result from contamination. An organic odor may have the distinctive smell of decaying vegetation. Unusual odors may be related to hydrocarbons, solvents, or other chemicals in the subsurface. An organic vapor analyzer may be used to detect the presence of volatile organic contaminants.

8.1.5 In-Place Conditions

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

8.1.5.1 Density/Consistency

Density and consistency describe a physical property that reflects the relative resistance of a soil to penetration. The term “density” is commonly applied to coarse to medium-grained sediments (i.e., gravels, sands), whereas the term “consistency” is normally applied to fine-grained sediments (i.e., silts, clays). There are separate standards of measure for both density and consistency that are used to describe the properties of a soil.

The density or consistency of a soil is determined by observing the number of blows required to drive a 1 3/8-inch (35 mm) diameter split barrel sampler 18 inches using a drive hammer weighing 140 lbs. (63.5 kilograms [kg]) dropped over a distance of 30 inches (0.76 meters). Record the number of blows required to penetrate each 6 inches of soil in the field boring log during sampling. The first 6 inches of penetration is considered to be a seating drive; therefore, the blow count associated with this seating drive is recorded, but not used in determining the soil density/consistency. The sum of the number of blows required for the second and third 6 inches of penetration is termed the “standard penetration resistance,” or the “N-value.” The observed number of blow counts must be corrected by an appropriate factor if a different type of sampling device (e.g., Modified California Sampler with liners) is used. For a 2 3/8-inch inner diameter (I.D.) Modified California Sampler equipped with brass or stainless-steel liners and penetrating a cohesionless soil (sand/gravel), the N-value from the Modified California Sampler must be divided by 1.43 to provide data that can be compared to the 1 3/8-inch diameter sampler data.

For a cohesive soil (silt/clay), the N-value for the Modified California Sampler should be divided by a factor of 1.13 for comparison with 1 3/8-inch diameter sampler data.

Drive the sampler and record blow counts for each 6-inch increment of penetration until one of the following occurs:

- A total of 50 blows have been applied during any one of the three 6-inch increments; a 50-blow count occurrence shall be termed “refusal” and noted as such on the boring log.
- A total of 150 blows have been applied.
- The sampler is advanced the complete 18 inches without the limiting blow counts occurring, as described above.

If the sampler is driven less than 18 inches, record the number of blows per partial increment on the boring log. If refusal occurs during the first 6 inches of penetration, the number of blows will represent the N-value for this sampling interval. Table 8-5 8-5 and Table 8-6 present representative descriptions of soil density/consistency vs. N-values.

Table 8-5: Measuring Soil Density with a California Sampler – Relative Density (Sands, Gravels)

Description	Field Criteria (N-Value)	
	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.43 factor
Very Loose	0–4	0–6
Loose	4–10	6–14
Medium Dense	10–30	14–43

Description	Field Criteria (N-Value)	
	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.43 factor
Dense	30–50	43–71
Very Dense	> 50	> 71

Table 8-6: Measuring Soil Density with a California Sampler – Fine Grained Cohesive Soil

Description	Field Criteria (N-Value)	
	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.13 factor
Very Soft	0–2	0–2
Soft	2–4	2–4
Medium Stiff	4–8	4–9
Stiff	8–16	9–18
Very Stiff	16–32	18–36
Hard	> 32	> 36

For undisturbed fine-grained soil samples, it is also possible to measure consistency with a hand-held penetrometer. The measurement is made by placing the tip of the penetrometer against the surface of the soil contained within the sampling liner or Shelby tube, pushing the penetrometer into the soil a distance specified by the penetrometer manufacturer, and recording the pressure resistance reading in pounds per square foot (psf). The values are as follows (Table 8-7):

Table 8-7: Measuring Soil Consistency with a Hand-Held Penetrometer

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

Consistency can also be estimated using thumb pressure using Table 8-8.

Table 8-8: Measuring Soil Consistency Using Thumb Pressure

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will penetrate soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

8.1.5.2 Cementation

Cementation is used to describe the friability of a soil. Cements are chemical precipitates that provide important information as to conditions that prevailed at the time of deposition, or conversely, diagenetic effects that occurred following deposition. Seven types of chemical cements are recognized by Folk (1980). They are as follows:

- Quartz – siliceous

- Chert – chert-cemented or chalcedonic
- Opal – opaline
- Carbonate – calcitic, dolomitic, sideritic (if in doubt, calcareous should be used)
- Iron oxides – hematitic, limonitic (if in doubt, ferruginous should be used)
- Clay minerals – if the clay minerals are detrital or have formed by recrystallization of a previous clay matrix, they are not considered to be a cement. Only if they are chemical precipitates, filling previous pore space (usually in the form of accordion-like stacks or fringing radial crusts) should they be included as “kaolin-cemented,” “chlorite-cemented,” etc.
- Miscellaneous minerals – pyritic, collophane-cemented, glauconite-cemented, gypsiferous, anhydrite-cemented, baritic, feldspar-cemented, etc.

The degree of cementation of a soil is determined qualitatively by utilizing finger pressure on the soil in one of the sample liners to disrupt the gross soil fabric. The three cementation descriptors are as follows:

- Weak – friable; crumbles or breaks with handling or slight finger pressure
- Moderate – friable; crumbles or breaks with considerable finger pressure
- Strong – not friable; will not crumble or break with finger pressure

8.1.5.3 Structure

This variable is used to qualitatively describe physical characteristics of soil that are important to incorporate into hydrogeological and/or geotechnical descriptions of soil at a site. Appropriate soil structure descriptors are as follows:

- Granular – spherically shaped aggregates with faces that do not accommodate adjoining faces
- Stratified – alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness
- Laminated – alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness
- Blocky – cohesive soil that can be broken down into small angular or subangular lumps that resist further breakdown
- Lensed – inclusion of a small pocket of different soil, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soil are present, the soil being described can be termed homogeneous if the description of the lenses is included
- Prismatic or Columnar – particles arranged about a vertical line, ped is bounded by planar, vertical faces that accommodate adjoining faces; prismatic has a flat top; columnar has a rounded top
- Platy – particles are arranged about a horizontal plane

8.1.5.4 Other Features

- Mottled – soil that appears to consist of material of two or more colors in blotchy distribution
- Fissured – breaks along definite planes of fracture with little resistance to fracturing (determined by applying moderate pressure to sample using thumb and index finger)
- Slickensided – fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)

8.1.6 Development of Soil Description

Develop standard soil descriptions according to the following examples. There are three principal categories under which all soil can be classified. They are described below.

8.1.6.1 Coarse-grained Soil

Coarse-grained soil is divided into sands and gravels. A soil is classified as a sand if over 50 percent of the coarse fraction is "sand-sized." It is classified as a gravel if over 50 percent of the coarse fraction is composed of "gravel-sized" particles.

The written description of a coarse-grained soil shall contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); grain size of coarse fraction; Munsell color and color number; moisture content; relative density; sorting; angularity; other features, such as stratification (sedimentary structures) and cementation, possible formational name, primary USCS classification, secondary USCS classification (when necessary), and approximate percentages of minor constituents (i.e., sand, gravel, shell fragments, rip-up clasts) in parentheses.

Example: POORLY-SORTED SAND WITH SILT, medium- to coarse-grained, light olive gray, 5Y 6/2, saturated, loose, poorly sorted, subrounded clasts, SW/SM (minor silt with approximately 20 percent coarse-grained sand-sized shell fragments, and 80 percent medium-grained quartz sand, and 5 percent to 15 percent ML).

8.1.6.2 Fine-grained Soil

Fine-grained soil is further subdivided into clays and silts according to its plasticity. Clays are rather plastic, while silts have little or no plasticity.

The written description of a fine-grained soil should contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); Munsell color; moisture content; consistency; plasticity; other features, such as stratification, possible formation name, primary USCS classification, secondary USCS classification (when necessary), and the percentage of minor constituents in parentheses.

Example: SANDY LEAN CLAY, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70 percent fines, 30 percent sand, with minor amounts of disarticulated bivalves [about 5 percent]).

8.1.6.3 Organic Soil

For highly organic soil, describe the types of organic materials present as well as the type of soil constituents present using the methods described above. Identify the soil as an organic soil, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soil usually has a dark brown to black color and may have an organic odor. Often, organic soils will change color, (e.g., from black to brown) when exposed to air. Some organic soils will lighten in color significantly when air-dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

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

8.3 Rock Classification

The purpose of rock classification is to thoroughly describe the physical and mineralogical characteristics of a specimen and to classify it according to an established system. The generalized rock classification system described below was developed because, unlike the USCS for soils, there is no universally accepted rock classification system. In some instances, a more detailed and thorough rock classification system may be appropriate. Any modifications to this classification system, or the use of an alternate classification system should be considered during preparation of the site work plan. Both the TO Manager and the QA Manager or Technical Director must approve any modifications to this classification system, or the use of another classification system.

Describing rock specimens on a common basis is essential so that rocks described by different site geologists are comparable. Site geologists describing rock specimens as a part of investigative activities must use the classification system described herein, or if necessary, another more detailed classification system. Use of a common classification system provides the most useful geologic database for all present and future subsurface investigations and remedial activities.

In order to provide a more consistent rock classification between geologists, a rock classification template has been designated as shown in **Error! Reference source not found.**. The template includes classification of rocks by origin and mineralogical composition. When classifying rocks, all site geologists shall use this template.

The site geologist shall describe the rock specimen and record the description in a boring log or logbook. The items essential for classification include (i.e., metamorphic foliated):

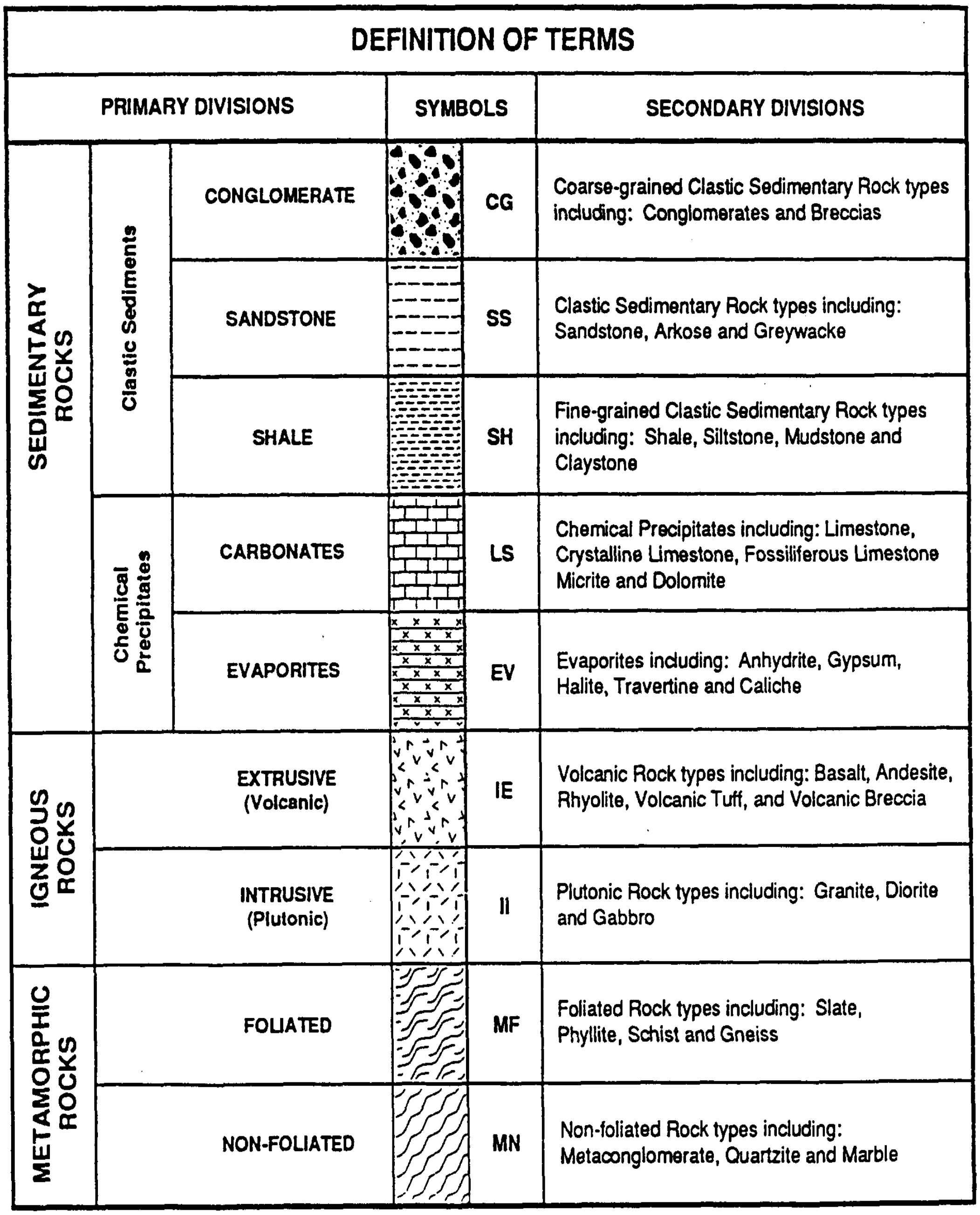
- Classification Name (i.e., schist)
- Color
- Mineralogical composition and percent
- Texture/Grain size (i.e., fine-grained, pegmatitic, aphlitic, glassy)
- Structure (i.e., foliated, fractured, lenticular)
- Rock Quality Designation (sum of all core pieces greater than two times the diameter of the core divided by the total length of the core run, expressed as a percentage)
- Classification symbol (i.e., MF)

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

9.0 Quality Control and Assurance

None

Figure 8-4: Rock Classification System



DEFINITION OF TERMS

PRIMARY DIVISIONS			SYMBOLS		SECONDARY DIVISIONS
SEDIMENTARY ROCKS	Clastic Sediments	CONGLOMERATE		CG	Coarse-grained Clastic Sedimentary Rock types including: Conglomerates and Breccias
		SANDSTONE		SS	Clastic Sedimentary Rock types including: Sandstone, Arkose and Greywacke
		SHALE		SH	Fine-grained Clastic Sedimentary Rock types including: Shale, Siltstone, Mudstone and Claystone
	Chemical Precipitates	CARBONATES		LS	Chemical Precipitates including: Limestone, Crystalline Limestone, Fossiliferous Limestone Micrite and Dolomite
		EVAPORITES		EV	Evaporites including: Anhydrite, Gypsum, Halite, Travertine and Caliche
IGNEOUS ROCKS		EXTRUSIVE (Volcanic)		IE	Volcanic Rock types including: Basalt, Andesite, Rhyolite, Volcanic Tuff, and Volcanic Breccia
		INTRUSIVE (Plutonic)		II	Plutonic Rock types including: Granite, Diorite and Gabbro
METAMORPHIC ROCKS		FOLIATED		MF	Foliated Rock types including: Slate, Phyllite, Schist and Gneiss
		NON-FOLIATED		MN	Non-foliated Rock types including: Metaconglomerate, Quartzite and Marble

10.0 Data and Records Management

10.1 Document soil classification information collected during soil sampling onto the field boring logs, field trench logs, and into the field notebook. Copies of this information shall be sent to the **TO Manager** for the project files.

10.2 Field notes will be kept during coring activities in accordance with SOP 3-03 – Recordkeeping, Sample Labeling, and Chain of Custody. The information pertinent to soil classification activities includes chronology of events, sample locations (x,y,z), time/date, sampler name, methods (including type of core liner/barrel, if applicable), sampler penetration and acceptability, sample observations, and the times and type of equipment decontamination. Deviations to the procedures detailed in the SOP should be recorded in the field logbook.

11.0 Attachments or References

American Society for Testing and Materials (ASTM). 2000. *Standard Practice for Description and Identification of Soils (Visual, Manual Procedure)*. D 2488-00. West Conshohocken, PA.

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Author	Reviewer	Revisions (Technical or Editorial)
Robert Shoemaker Senior Scientist	Naomi Ouellette, Project Manager	Rev 0 – Initial Issue
Ken O'Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

Direct Push Sampling Techniques

Procedure 3-17

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) provides guidance on the use of direct push techniques.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM under the client contract.

1.3 This procedure shall serve as management-approved professional guidance and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP; DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by both the Task Order (TO) Manager and the Quality Assurance (QA) Manager or Technical Director, and documented.

1.4 If there are procedures whether it be from AECOM, state and/or federal that are not addressed in this SOP and are applicable to direct push sampling then those procedures may be added as an appendix to the project-specific QAPP.

2.0 Safety

2.1 Field personnel shall perform work in accordance with the Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP). During monitoring well installation, subcontractors in direct contact with potentially contaminated media shall wear the proper personal protective equipment (PPE) as outlined in the APP/SSHP. Failure to comply will result in disciplinary action.

2.2 If circumstances warrant, a real-time immediate response instrument, such as a Miniram Dust Monitor, organic vapor analyzer, HNu, Thermo, Draeger or Sensidyne tubes, or explosimeter, should be used to monitor the work area. When real/time instrument response exceeds the permissible exposure limit, personnel shall don the appropriate PPE and alternate control measures to ensure personnel safety. If safe control measures are not achievable, field activities shall be discontinued immediately. Company-specific APP/SSHPs offer guidelines on air surveillance and on selection of PPE. In addition, the site-specific APP/SSHP includes an air monitoring program and suggested PPE.

2.3 In addition to the aforementioned precautions and depending upon the type of contaminant expected, employ the following safe work practices:

Particulate, Metal Compounds, or PFAS/PFOS

1. Avoid skin contact and/or incidental ingestion of soil.
2. Wear protective clothing, steel-toed boots, powderless Nitrile gloves with non-water-repellent protective leather gloves, safety glasses, and hearing protection as warranted.

VOCs

1. Avoid breathing constituents venting from holes by approaching upwind, and/or by use of respiratory protection.
2. Pre-survey the area with a flame ionization detector (FID) or photoionization detector (PID) prior to sampling.
3. If monitoring results indicate organic vapors that exceed action levels as specified in the site-specific APP/SSHP, sampling activities may need to be conducted in Level C protection. At a

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

minimum, skin protection will be required by use of gloves and Tyvek or other media that is protective against the media being encountered.

Flammable or Explosive Conditions

1. Monitor explosive gases as continuously as possible using an explosimeter and oxygen meter.
2. Place all ignition sources upwind or crosswind of the borehole.
3. If explosive gases exceed the designated action levels as specified in the site-specific APP/SSHP, cease operations and evaluate conditions.

Physical Hazards Associated with Soil Sampling

1. To avoid possible back strain associated with sample collection, use the large muscles of the legs, not the back, when retrieving soil samplers.
2. Stay clear of all moving equipment, and avoid wearing loose fitting clothing.
3. To avoid slip/trip/fall hazards, be wary of open trenches, pits, or holes.
4. Be aware of restricted mobility due to PPE.
5. To avoid hand, wrist, arm, shoulder, and back trauma due to the use of slide hammers or hand augers, rotate sampling among field personnel

3.0 Terms and Definitions

3.1 Direct push techniques are methods for subsurface sampling or monitoring that involve the application of downward pressure (usually supplied through hydraulic means) without the benefit of cutting tool rotation to enter soil. A variety of systems are available under several trade names, such as GeoProbe®. Equipment may be skid-mounted, trailered, or mounted directly on the frame of a vehicle.

4.0 Interferences

4.1 Potential interferences could result from cross-contamination between samples or sample locations. Minimization of the cross contamination will occur through the following:

- The use of clean sampling tools at each location as necessary.
- Avoidance of material that is not representative of the media to be sampled.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The TO Manager is responsible for ensuring that these standard direct push technique procedures are followed during projects conducted under the ER Program and that a qualified individual conducts or supervises the projects. A qualified individual for subsurface sampling or monitoring using direct push techniques is defined as a person with a degree in geology, hydrogeology, or geotechnical/civil engineering with at least 1 year of experience supervising soil boring construction using conventional drilling or direct push techniques. The TO Manager or designee is responsible for ensuring that all personnel involved in direct push sampling techniques shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1c (DON 2007).

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Site Supervisor (SS)** is responsible for ensuring that all field personnel follow these procedures.

5.2.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.2.5 The **Field Personnel** and/or **SS** are responsible for directly supervising the direct push sampling activities to ensure that they are conducted according to this procedure, and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

In addition to those materials provided by the subcontractor, the project **SS/Field Personnel** will require:

- Boring Logs;
- Spoons or scoops;
- Sample kit (bottles, labels, custody records and tape, cooler, wet ice), if laboratory analysis is required;
- Sample collection pan;
- Folding rule or tape measure;
- Polyethylene plastic sheeting;
- Utility knife;
- Equipment decontamination materials (as described in SOP 3-06, *Equipment Decontamination*);
- Health and safety equipment (as required by APP/SSHP); and
- Non-water-repellent field project notebook/pen.

7.0 Procedure

Direct push techniques may be used as a cost-effective alternative to conventional drilling techniques for obtaining subsurface soil and groundwater samples and for monitoring subsurface conditions.

7.1 Method Selection

Base the decision to use direct push techniques on: (1) their ability to achieve the required information at the required level of quality control and (2) their cost-effectiveness compared to conventional drilling methods. Major limitations of direct push techniques are their inability to penetrate rock or cobbles and a shallow maximum depth of penetration. The capabilities of direct push systems vary significantly among vendors. Consider these differences in capabilities when evaluating the method for a subsurface exploration program.

Use direct push techniques to obtain groundwater samples for confirmatory analyses only if the screen placement method protects the screen from clogging during installation and allows the installation of a sand-pack around the exterior of the well screen.

7.2 Inspection of Equipment

Inspect direct push equipment prior to use for signs of fluid leakage, which could introduce contaminants to the soil. If, at any time during equipment operation, fluid is observed leaking from the rig, cease operations and immediately repair or contain the leak. Collect, containerize, and label soil and other materials affected by the leak for proper disposal (see SOP 3-05, *IDW Management*).

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

7.3 Preparation of Work Site

Inspect the work site prior to commencing operations to ensure that no overhead hazards exist that could impact the direct push equipment, and the work area should cleared and/or marked by the local underground utility locating service (e.g., DigSafe). In addition, clear locations planned for subsurface exploration using either geophysical methods and/or hand excavate locations to a depth of 2 to 3 feet prior to soil penetration, unless it is certain (by virtue of subsurface clearing activities) that no utilities or other hazardous obstructions will be encountered in the first 2 to 3 feet. Hand excavation may be waived when it is not practical.

Locate the direct push rig so that it is downslope from the penetration point, if the work is to be performed on a grade. Locate the rig downwind or crosswind of the penetration point, if possible. Cover the area surrounding, and in the vicinity of, the penetration point with plastic. Establish required exclusion zones using plastic tape or cones to designate the various areas.

7.4 Equipment Decontamination

To avoid cross-contamination, thoroughly decontaminate equipment used for direct push exploration and sampling as described in SOP 3-06, *Equipment Decontamination*. Decontaminate sampling tools and downhole equipment between each sampling event and between penetration points. At a minimum, steam clean or wash and rinse the equipment. Collect, containerize, and label all wash and rinse water for proper disposal. Clean equipment (e.g., drive rods and samplers) shall not come into contact with contaminated soils or other contaminated materials. Keep equipment on plastic or protect it in another suitable fashion. Store push rods and other equipment removed from a hole on plastic sheeting until properly decontaminated.

7.5 Soil Sampling

This SOP assumes that the subcontractor will perform sampling; therefore, detailed procedures regarding sample acquisition are not provided. Vendors of direct push equipment offer a variety of sampling systems designed specifically for their equipment. Both continuous and discreet soil samples may be obtained using sampling equipment similar to that described in Procedure 3-21, *Surface and Subsurface Soil Sampling*. The preferred methods for soil sampling using direct push techniques use stainless steel split-tube samplers that are driven through the horizon to be sampled. Use plastic sample tubes (e.g., Macro-Core Samplers) only for screening purposes or, in the case of confirmatory sampling, if samples will not be analyzed for volatile organic compounds (VOCs) or semivolatile organic compounds (SVOCs).

7.6 Groundwater Sampling

Direct push vendors offer numerous methods for obtaining groundwater samples. Key differences among methods involve: (1) the maximum well diameter achievable; (2) the ability to protect the well screen from exposure to contaminated overburden soils during installation; (3) the ability to install packing around the screen; (4) flexibility in the size, materials of construction, and design of well screens; and (5) the ability to convert sampling points into permanent monitoring wells. The limitations and abilities of a given system must be thoroughly understood and matched to the needs of the project before committing to the collection of groundwater samples using direct push techniques.

Use direct push techniques only to collect screening samples unless it is confirmed that the system:

1. Effectively protects the well screen from exposure to contaminated overburden soils during installation
2. Allows the installation of effective packing around the well screen
3. Allows the well screen to be effectively sealed against the downward infiltration of overlying groundwater or surface precipitation
4. Is constructed of materials compatible with the intended sampling and analysis goals of the project

5. Allows the use of a well screen properly sized and slotted for the needs of the project

Additional information on the collection of groundwater samples can be found in SOP 3-14 Monitoring Well Sampling.

It is the responsibility of the **TO Manager** to evaluate and determine the appropriateness of direct push systems prior to committing to their use on any project involving groundwater sampling. As part of this evaluation, it is recommended to obtain concurrence from regulatory authorities in advance for the method selection.

7.7 Borehole Abandonment

Methods for abandoning boreholes created with direct push systems will vary among vendors. Coordinate the desired method for abandonment with the vendor in the planning stages of the project to ensure proper abandonment.

Some direct push boreholes will close naturally as the drive rods and sampling tools are withdrawn. This may occur in loose, unconsolidated soils, such as sands. Close all boreholes using one of the procedures described in this procedure, unless natural caving precludes such closure.

The three methods for closing direct push boreholes are:

1. Add granulated or pelletized bentonite and hydrate in layers, proceeding from the bottom of the hole to the surface.
2. Pour premixed cement/water (or cement/water/bentonite) mixture into the hole.
3. Fill the entire hole with granular or pelletized bentonite and hydrate by means of a previously emplaced water tube that is gradually withdrawn as water is supplied to the bentonite.

The second method is recommended. For shallow holes less than 10 feet in depth, pour a cement/water/bentonite mix directly into the opening using a funnel. For deeper holes, use a conductor (tremie) pipe to carry the grout mix to the far reaches of the borehole. Lower the conductor pipe to within 2 inches of the bottom and gradually withdraw it as grout is added, keeping the lower end of the pipe submerged in grout at all times.

The recommended grout mixture for well abandonment is 7 to 9 gallons of water per 94-pound bag of Portland cement, with 3 percent to 5 percent by weight of powdered bentonite added to the mixture. Commercial products, such as Volcay are acceptable with pre-approval of the **TO Manager**.

Seal boreholes to within 0.5 to 2.0 feet of the surface. Inspect the abandoned borehole after 24 hours to ensure that grout shrinkage does not occur. If significant shrinkage has occurred, re-grout the borehole. Fill the remaining portion of the hole with local topsoil or appropriate paving materials.

8.0 Quality Control and Assurance

8.1 Collection of representative samples will be ensured through adherence to the procedures in this SOP and the sampling strategy outlined in the QAPP. The field quality control samples identified in the QAPP must be collected. These samples may include field duplicates, equipment rinsate blanks, trip blanks, and matrix spike/matrix spike duplicates

9.0 Records, Data Analysis, Calculations

9.1 Various forms are required to ensure that adequate documentation is made of the sample collection activities. These forms may include:

- Boring logs;
- Non-water-repellent field logbook;
- Sample collection records;

- Chain-of-custody forms; and
- Shipping labels.

9.2 Boring logs (Attachment 1) will provide visual and descriptive information for samples collected at each soil boring and are often the most critical form of documentation generated during a soil sampling program.

9.3 The field logbook is kept as a general log of activities and should not be used in place of the boring log.

9.4 Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes.

9.5 Shipping labels are required is sample coolers are to be transported to a laboratory by a third party (courier service).

10.0 Attachments or References

10.1 Attachment 1 – Boring Log

10.2 Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

10.3 SOP 3-05, *IDW Management.*

10.4 SOP 3-06, *Equipment Decontamination.*

10.5 SOP 3-21, *Surface and Subsurface Soil Sampling.*

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)
Ken O’Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

Attachment 1
Boring Log

Boring ID:

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Project Name:	**Drilling Company:**	**Type of Surface Material:**
Project Number:	**Drilling Method:**	**Patching Material:**
Date Started Drilling:	**Rig Type:**	**Drilling Water Level:**
Date Finished Drilling:	**Core Size:**	**Boring Total Depth (bgs):**
Physical Location:		**Logged By:**

(Note: bgs = below ground surface)

Depth Range	Re covery ft/ft	PID (ppm)	Moisture Content	GA Class.	USCS	GA Class: Garfield Avenue Sites classification & Modified Unified Soil Clasiffication System	
						Ground Surface Cover and Thickness:	**Sample name & #:**
0-1							
1-2							
2-3							
3-4							
4-5							
5-6							
6-7							
7-8							
8-9							
9-10							
10-11							
11-12							
12-13							
13-14							
14-15							
15-16							
16-17							
17-18							
18-19							
19-20							

Stratigraphic Unit Intervals:		**Comments:**
1.)	**5.)**	
2.)	**6.)**	
5.)	**6.)**	

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Operation and Calibration of a Photoionization Detector

Procedure 3-20

1.0 Purpose and Scope

1.1 Purpose and Applicability

1.1.1 This standard operating procedure (SOP) describes the procedures that will be followed by field staff for operation and calibration of a photoionization detector (PID). The PID is primarily used by AECOM personnel for safety and survey monitoring of ambient air, determining the presence of volatiles in soil and water, and detecting leakage of volatiles.

1.1.2 PIDs routinely used by field personnel include the Photovac Microtip, Thermoelectron 580EZ, MiniRAE 2000, and MiniRae 3000. Personnel responsible for using the PID should first read and thoroughly familiarize themselves with the instrument instruction manual.

1.2 Principle of Operation

1.2.1 The PID is a non-specific vapor/gas detector. The unit generally consists of a hand-held probe that houses a PID, consisting of an ultraviolet (UV) lamp, two electrodes, and a small fan which pulls ambient air into the probe inlet tube. The probe is connected to a readout/control box that consists of electronic control circuits, a readout display, and the system battery. Units are available with UV lamps having an energy from 9.5 electron volts (eV) to 11.7 eV.

1.2.2 The PID analyzer measures the concentration of trace gas present in the atmosphere by photoionization. Photoionization occurs when an atom or molecule absorbs a photon of sufficient energy to release an electron and become a positive ion. This will occur when the ionization potential of the molecule (in electron volts (eV) is less than the energy of the photon. The source of photons is an ultraviolet lamp in the probe unit. Lamps are available with energies ranging from 9.5 eV to 11.7 eV. All organic and inorganic vapor/gas compounds having ionization potentials lower than the energy output of the UV lamp are ionized and the resulting potentiometric change is seen as a positive reading on the unit. The reading is proportional to the concentration of organics and/or inorganics in the vapor.

1.2.3 Sample gases enter the probe through the inlet tube and enter the ion chamber where they are exposed to the photons emanating from the UV lamp. Ionization occurs for those molecules having ionization potentials near to or less than that of the lamp. A positive- biased polarizing electrode causes these positive ions to travel to a collector electrode in the chamber. Thus the ions create an electrical current which is amplified and displayed on the meter. This current is proportional to the concentration of trace gas present in the ion chamber and to the sensitivity of that gas to photoionization.

1.2.4 In service, the analyzer is first calibrated with a gas of known composition equal to, close to, or representative of that to be measured. Gases with ionization potentials near to or less than the energy of the lamp will be ionized. These gases will thus be detected and measured by the analyzer. Gases with ionization potentials greater than the energy of the lamp will not be detected. The ionization potentials of the major components of air, i.e., oxygen, nitrogen, and carbon dioxide, range from about 12.0 eV to 15.6 eV and are not ionized by any of the lamps available. Gases with ionization potentials near to or slightly higher than the lamp are partially ionized, with low sensitivity.

1.3 Specifications

1.3.1 Refer to the manufacturer's instructions for the technical specifications of the instrument being used. The operating concentration range is typically 0.1 to 2,000 ppm isobutylene equivalent.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP). Work will also be conducted according to the Task Order (TO) Quality Assurance Project Plan (QAPP) and/or direction from the **Site Safety and Health Officer (SSHO)**.

2.2 Only PIDs stamped Division I Class I may be used in explosive atmospheres. Refer to the project APP/SSHP for instructions pertaining to instrument use in explosive atmospheres.

3.0 Terms and Definitions

None.

4.0 Interferences

4.1 Regardless of which gas is used for calibration, the instrument will respond to all analytes present in the sample that can be detected by the type of lamp used in the PID.

4.2 Moisture will generate a positive interference in the concentration measured for a PID and is characterized by a slow increase in the reading as the measurement is made. Care must be taken to minimize uptake of moisture to the extent possible. Refer to the manufacturers' instructions for care, cleaning, and maintenance.

4.3 Uptake of soil into the PID must be avoided as it will compromise instrument performance by blocking the probe, causing a positive interference, or dirtying the PID lamp. Refer to the manufacturers' instructions for care, cleaning, and maintenance.

4.4 The user should listen to the pitch of the sampling pump. Any changes in pitch may indicate a blockage and corrective action should be initiated.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **TO Manager** is responsible for ensuring that the operation and calibration activities comply with this procedure. The **TO Manager** is responsible for ensuring that all personnel involved in the operation and calibration shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Site Supervisor (SS)** is responsible for ensuring that all operation and calibration activities are conducted according to this procedure.

5.2.4 All **Field Personnel** are responsible for the implementation of this procedure.

6.0 Equipment and Supplies

- Calibration Gas: Compressed gas cylinder of isobutylene in air or similar stable gas mixture of known concentration. The selected gas should have an ionization potential similar to that of the vapors to be monitored, if known. The concentration should be at 50-75% of the range in which the instrument is to be calibrated;
- Regulator for calibration gas cylinder;

- Approximately 6 inches of Teflon® tubing;
- Tedlar bag (optional);
- Commercially-supplied zero grade air (optional);
- "Magic Marker" or “Sharpie” or other waterproof marker;
- Battery charger;
- Moisture traps;
- Spare lamps;
- Manufacturer’s instructions; and
- Field data sheets or logbook/pen.

7.0 Procedure

7.1 Preliminary Steps

7.1.1 Preliminary steps (battery charging, check-out, calibration, maintenance) should be conducted in a controlled or non-hazardous environment.

7.2 Calibration

7.2.1 The PID must be calibrated in order to display concentrations in units equivalent to ppm. First a supply of zero air (ambient air or from a supplied source), containing no ionizable gases or vapors is used to set the zero point. A span gas, containing a known concentration of a photoionizable gas or vapor, is then used to set the sensitivity.

7.2.2 Calibrate the instrument according to the manufacturer’s instructions. Record the instrument model and identification number, the initial and adjusted meter readings, the calibration gas composition and concentration, and the date and the time in the field records.

7.2.3 If the calibration cannot be achieved or if the span setting resulting from calibration is 0.0, then the lamp must be cleaned (Section 7.4).

7.3 Operation

7.3.1 Turn on the unit and allow it to warm up (minimum of 5 minutes). Check to see if the intake fan is functioning; if so, the probe will vibrate slightly and a distinct sound will be audible when holding the probe casing next to the ear. Also, verify on the readout display that the UV lamp is lit.

7.3.2 Calibrate the instrument as described in Section 7.2, following the manufacturer’s instructions. Record the calibration information in the field records.

7.3.3 The instrument is now operational. Readings should be recorded in the field records.

7.3.4 When the PID is not being used or between monitoring intervals, the unit may be switched off to conserve battery power and UV lamp life; however, a “bump” test should be performed each time the unit is turned on and prior to taking additional measurements. To perform a bump test, connect the outlet tubing from a Tedlar bag containing a small amount of span gas to the inlet tubing on the unit and record the reading. If the reading is not within the tolerance specified in the project plan, the unit must be recalibrated.

7.3.5 At the end of each day, recheck the calibration. The check will follow the same procedures as the initial calibration (Section 7.2) except that no adjustment will be made to the instrument. Record the information in the field records.

7.3.6 Recharge the battery after each use (Section 7.4).

7.3.7 When transporting, ensure that the instrument is packed in its stored condition in order to prevent damage.

7.4 Routine Maintenance

7.4.1 Routine maintenance associated with the use of the PID includes charging the battery, cleaning the lamp window, replacing the detector UV lamp, replacing the inlet filter, and replacing the sample pump. Refer to the manufacturer's instructions for procedures and frequency.

7.4.2 All routine maintenance should be performed in a non-hazardous environment.

7.5 Troubleshooting Tips

7.5.1 One convenient method for periodically confirming instrument response is to hold the sensor probe next to the tip of a magic marker. A significant reading should readily be observed.

7.5.2 Air currents or drafts in the vicinity of the probe tip may cause fluctuations in readings.

7.5.3 A fogged or dirty lamp, due to operation in a humid or dusty environment, may cause erratic or fluctuating readings. The PID should never be operated without the moisture trap in place.

7.5.4 Moving the instrument from a cool or air-conditioned area to a warmer area may cause moisture to condense on the UV lamp and produce unstable readings.

7.5.5 A zero reading on the meter should not necessarily be interpreted as an absence of air contaminants. The detection capabilities of the PID are limited to those compounds that will be ionized by the particular probe used.

7.5.6 Many volatile compounds have a low odor threshold. A lack of meter response in the presence of odors does not necessarily indicate instrument failure.

7.5.7 When high vapor concentrations enter the ionization chamber in the PID the unit can become saturated or "flooded". Remove the unit to a fresh air environment to allow the vapors to be completely ionized and purged from the unit.

8.0 Quality Control and Assurance

8.1 The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific QAPP.

8.2 Calibration of the PID will be conducted at the frequency specified in the project plan. In the absence of project-specific guidance, calibration will be performed at the beginning of each day of sampling and will be checked at the end of the sampling day or whenever instrument operation is suspect. The PID will sample a calibration gas of known concentration. The instrument must agree with the calibration gas within ±10%. If the instrument responds outside this tolerance, it must be recalibrated.

8.3 Checks of the instrument response (Section 7.5) should be conducted periodically and documented in the field records.

9.0 Records, Data Analysis, Calculations

Safety and survey monitoring with the PID will be documented in a bound field logbook, or on standardized forms, and retained in the project files. The following information is to be recorded:

- Project name and number;
- Instrument manufacturer, model, and identification number;
- Operator's signature;

- Date and time of operation;
- Calibration gas used;
- Calibration check at beginning and end of day (meter readings before adjustment);
- Span setting after calibration adjustment;
- Meter readings (monitoring data obtained);
- Instances of erratic or questionable meter readings and corrective actions taken; and
- Instrument checks and response verifications – e.g., battery check, magic marker response (Section 7.5) or similar test.

10.0 Attachments or References

United States Environmental Protection Agency. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM). USEPA, Region 4, SESD, Enforcement and Investigations Branch, Athens, GA. November 2001.

Author	Reviewer	Revisions (Technical or Editorial)
Robert Shoemaker Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)
Ken O’Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Surface and Subsurface Soil Sampling Procedures

Procedure 3-21

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the procedures for soil sampling. The procedure includes surface and subsurface sampling by various methods using hand auguring, test pit, direct-push, sonic drilling, and split-spoon equipment.

1.2 For project specific information (e.g., sampling depths, equipment to be used, and frequency of sampling), refer to the Quality Assurance Project Plan (QAPP), which takes precedence over these procedures. Surface soil sampling, typically considered to be up to two feet below ground surface by United States Environmental Protection Agency (USEPA) standards, is typically accomplished using hand tools such as shovels or hand augers. Test pit samples are considered subsurface samples, although normally collected via hand tools similar to surface soil sampling or by excavation machinery. Direct-push and split-spoon sampling offer the benefit of collecting soil samples from a discrete or isolated subsurface interval without the need of extracting excess material above the target depth. These methods dramatically reduce time and cost associated with disposal of material from soil cuttings when compared to test pit sampling. In addition, direct-push, sonic drilling, and split-spoon sampling methods can obtain samples at targeted intervals greater than 15 feet in depth, allowing for discrete depth soil sampling while speeding up the sampling process. Direct-push methods work best in medium to fine-grained cohesive materials, such as medium to fine sands, silts, and silty clay soils. Sonic drilling sampling works well in all types of soil and bedrock. Split-spoon sampling works well in all types of soil but is somewhat slower than direct-push and sonic drilling methods. With the exception of volatile organic compounds (VOCs) samples, the soil sample interval is composited so that each sample contains a homogenized representative portion of the sample interval. Due to potential loss of analytes, samples for VOC analysis are not composited. Samples for chemical analysis can be collected by any of the above-mentioned sampling methods, as disturbed soil samples. Undisturbed samples are best collected with direct push or by Shelby Tube (not covered in this SOP). They are collected, sealed, and sent directly to the laboratory for analysis without homogenizing.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Accident Prevention Plan (APP)/Site Safety and Health Plan. Work will also be conducted according to the Task Order (TO) QAPP and/or direction from the **Site Safety and Health Officer (SSHO)**.

2.2 Before soil sampling commences, appropriate entities (e.g. DigSafe, local public works departments, company facilities) must be contacted to assure the anticipated soil sampling locations are marked for utilities, including electrical, telecommunications, water, sewer, and gas.

3.0 Terms and Definitions

None.

4.0 Interferences

4.1 Low recovery of soil from sampling equipment will prevent an adequate representation of the soil profile and sufficient amount of soil sample. If low recovery is a problem, the hole may be offset and re-advanced, terminated, or continued using a larger diameter sampler.

4.2 Asphalt in soil samples can cause false positive results for hydrocarbons. To ensure samples are free of asphalt, do not collect samples that may contain asphalt. If the collection of samples potentially containing asphalt is unavoidable, note the sampling depths at which the presence of asphalt are suspected.

4.3 Instrumentation interferences addressed in SOPs for Calibration of the Photoionization Detector (PID), Headspace Screening for Total Volatile Organics, and Equipment Decontamination must also be considered.

4.4 Cross contamination from sampling equipment must be prevented by using sampling equipment constructed of stainless steel that is adequately decontaminated between samples.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **TO Manager** is responsible for ensuring that soil sampling activities comply with this procedure. The TO Manager is responsible for ensuring that all personnel involved in soil sampling shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Site Supervisor (SS)** is responsible for ensuring that all soil sampling activities are conducted according to this procedure.

5.2.4 All **Field Personnel** are responsible for the implementation of this procedure.

6.0 Equipment and Supplies

The depth at which samples will be collected and the anticipated method of sample collection (direct-push, split-spoon, hand auger, shovel, or test pits) will be presented in the QAPP. The following details equipment typically needed for soil sampling, based on the various methods. See the QAPP for specific detail of equipment and supply needs.

6.1 Depending on the nature of suspected contamination, field screening instrumentation may be used for direct sampling. Appropriate instrumentation and calibration standards should be available. If volatile organic contaminants are suspected and a PID will be used, refer to the equipment and instrumentation listed in SOP 3-20 Operation and Calibration of a Photoionization Detector. Equipment in this SOP includes but is not limited to:

- PID/FID;
- Calibration gas; and
- Tedlar® gas bags (for calibration).

6.2 If field screening methods include jar headspace screening for volatile organics, refer to the equipment and procedure in SOP 3-19 Headspace Screening for Total VOCs. Equipment in this SOP includes but is not limited to:

- Clean soil (“drillers jars”) jars;
- HDPE sample jars for PFAS/PFOS samples; and
- Aluminum foil for non-PFAS/PFOS sampling.

6.3 Appropriate decontamination procedures must be followed for sampling equipment. Refer to SOP 3-06 Equipment Decontamination. Equipment in this SOP includes but is not limited to:

- Alconox® or Liquinox®;
- Isopropyl Alcohol;
- Deionized Ultra-Filtered (DIUF) Water (confirmed PFAS-free);
- Plastic buckets or washbasins;
- Brushes; and
- Polyethylene sheeting.

6.4 The following general equipment is needed for all soil sampling, regardless of method:

- Stainless steel bowls;
- Stainless steel trowels;
- Appropriate sample containers for laboratory analysis;
- Personal Protective Equipment (PPE);
- Non-water-repellent logbook;
- Cooler and ice for preservation; and
- Stakes and flagging to document sampling location.

6.5 The following additional equipment is needed for volatile organic sampling:

- Electronic pan scale and weights for calibration; and
- Syringes or other discrete soil core samplers.

6.6 The following additional equipment may be needed for surface and test pit soil sampling:

- Hand Auger

6.7 The following additional equipment may be needed for soil sampling from direct push and/or split-spoon equipment:

- Tape measure or folding carpenter’s rule for recording the length of soil recovered.

Note: All subsurface drilling equipment will be provided and maintained by the subcontractor.

7.0 Procedure

7.1 General Soil Sampling Procedure for All Soil Sampling Methods

7.1.1 Record the weather conditions and other relevant on-site conditions.

7.1.2 Select the soil sampling location, clear vegetation, if necessary, and record the sampling location identification number and pertinent location details.

7.1.3 Verify that the sampling equipment is properly decontaminated, in working order, and situated at the intended sampling location.

7.1.4 Place polyethylene sheeting on the ground and assemble all necessary sampling equipment on top of it. Cover surfaces onto which soils or sampling equipment will be placed (i.e., tables with polyethylene sheeting).

7.1.5 Follow the appropriate procedures listed below for either surface, split-spoon, sonic drilling, direct push, or test pit sample collection (7.2, 7.3, 7.4, 7.5, and 7.6, respectively).

7.1.6 Collect soil samples according to procedures listed in Section 7.7 depending on project specific analyses.

7.1.7 Record date/time, sample ID, and sample descriptions in the field logbook or field form. A sketch or description of the location may also be recorded so the sample location can be re-constructed, especially if the location will not be recorded using global positioning satellite (GPS) equipment.

7.1.8 Immediately label the sample containers and place them on ice, if required for preservation. Complete the chain-of-custody form(s) as soon as possible.

7.1.9 Dispose of all excess excavated soil in accordance with the QAPP.

7.1.10 If required, mark the sample location with a clearly labelled wooden stake or pin flag. If the location is on a paved surface, the location may be marked with spray paint.

7.1.11 Decontaminate the sampling equipment according to SOP 3-06 Equipment Decontamination.

7.2 Surface Sampling

7.2.1 The criteria used for selecting surface soil locations for sampling may include the following:

- Visual observations (soil staining, fill materials);
- Other relevant soil characteristics;
- Site features;
- Screening results;
- Predetermined sampling approach (i.e., grid or random); and
- Sampling objectives as provided in the QAPP.

7.2.2 The following procedures are to be used to collect surface soil samples. Surface soils are considered to be soils that are up to two feet below ground surface, though state regulations and project objectives may define surface soils differently; therefore, the QAPP should be consulted for direction on the depth from which to collect the surface soil samples. Sampling and other pertinent data and information will be recorded in the field logbook and/or on field forms. Photographs may be taken as needed or as specified in the QAPP.

1. Gently scrape any vegetative covering until soil is exposed. Completely remove any pavement.
2. Remove soil from the exposed sampling area with a stainless-steel trowel, hand auger, or shovel. Put soils within the sampling interval in a stainless-steel bowl for homogenizing. Monitor the breathing zone and sampling area as required in the APP/SSHP.
3. For VOC analyses, collect representative soil samples directly from the recently-exposed soil using a syringe or other soil coring device (e.g., TerraCore®, EnCore®). Follow procedures in Section 7.7.1 for VOC sampling.
4. Collect sufficient soil to fill all remaining sample jars into a stainless-steel bowl. Homogenize the soil samples to obtain a uniform soil composition which is representative of the total soil sample collected according to the following procedure:
    a) Remove all rocks and non-soil objects using a stainless-steel spoon or scoop.

b) Form a cone shaped mound with the sample material, then flatten the cone and split the sample into quarters.

c) Use the stainless-steel spoon/scoop to mix the quarter samples that are opposite.

d) After mixing the opposite quarters, reform the cone shaped mound.

e) Repeat this procedure a minimum of five (5) times, removing any non-soil objects and breaking apart any clumps.

7.3 Split-Spoon Sampling

7.3.1 At each boring location, the frequency and depth of split-spoon samples will be determined from the QAPP. Split-spoon samples may be collected continuously, intermittently, or from predetermined depths.

7.3.2 Split-spoon samplers shall be driven into undisturbed soil by driving the spoon ahead of the drill augers/casing. In cohesive soils, or soils where the borehole remains open (does not collapse), two split-spoon samples may be taken prior to advancing the augers/casing.

7.3.3 After split-spoons are retrieved, open the split-spoon and measure the recovery of soil. If a PID will be used for screening, immediately scan the recovered sample for VOCs using the PID. Scan the recovered soil boring by making a hole in the soil with a decontaminated trowel and placing the PID inlet very close to the hole. Be very careful not to get soil on the tip of the PID. Take PID readings every 6 inches along the split-spoon and/or in any areas of stained or disturbed soil. Record the highest PID reading and the depth at which it was observed along with all other pertinent observations. If required in the QAPP, VOC and headspace samples should be collected (see Section 7.7.1) prior to logging the sample.

7.3.4 If headspace screening for VOCs is required in the QAPP, collect a soil sample (as defined in the QAPP) and perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.

7.3.5 Soils collected using the split-spoon sampler will be logged by the field representative using the procedure required in the QAPP.

7.3.6 Collect the remainder of the sample volume required into a stainless-steel bowl. Homogenize the soil so the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.

7.3.7 The QAPP may specify that intervals to be sent to the laboratory be determined by visual observation and/or highest PID screening or headspace results, which can only be determined once the boring is complete. In this instance, a VOC sample should be collected at each interval. The remainder of the soil from that interval will be set aside in a clearly labelled stainless steel bowl covered with polyethylene sheeting. Once the boring has been completed and the sample interval has been determined, the remainder of the soil can be homogenized according to Section 7.2 and submitted for laboratory analysis.

7.3.8 Once a boring is complete and all required samples have been collected, the boring must be completed as specified in the QAPP (e.g., completed as a monitoring well, backfilled with bentonite, etc.).

7.4 Sonic Drilling Sampling

7.4.1 At each boring location, the frequency and depth of sonic drilling samples will be determined from the QAPP.

7.4.2 Sonic drilling methods, also known as vibratory drilling, use an eccentrically oscillating drill head to produce high-frequency vibratory energy that is then transmitted down a drill string to a core barrel to quickly advance through the subsurface. Sonic drilling utilizes a double-cased system using an inner core barrel and a larger override casing. This ensures that the borehole is continuously cased to the total depth, minimizing the potential for borehole collapse and providing the means to alter casing diameters to telescope through semi-confining units to prevent downhole cross contamination.

7.4.3 Upon retrieval of the core barrel, place the tubular plastic sleeve (confirmed PFAS-free) with sealed bottom over the bottom of the core barrel. The core barrel will then be vibrated, causing the soil sample to be extruded into the sleeve. Place the sleeve on the work surface (i.e. PFAS-free plastic covered table or ground). Open the sleeve and measure the recovery of soil.

7.4.4 If a PID will be used for screening, immediately scan the recovered sample for VOCs using the PID. Scan the recovered soil boring by making a hole in the soil with a decontaminated trowel and placing the PID inlet very close to the hole. Be very careful not to get soil on the tip of the PID. Take PID readings every 6 inches along the soil core and/or in any areas of stained or disturbed soil. Record the highest PID reading and the depth at which it was observed along with all other pertinent observations. If required in the QAPP, VOC and headspace samples should be collected (see Section 7.7.1) prior to logging the sample.

7.4.5 If headspace screening for VOCs is required in the QAPP, collect a soil sample (as defined in the QAPP) and perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.

7.4.6 Soils collected using sonic drilling will be logged by the field representative using the procedure required in the QAPP.

7.4.7 Collect the remainder of the sample volume required into a stainless-steel bowl. Homogenize the soil so the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.

7.4.8 The QAPP may specify that intervals to be sent to the laboratory be determined by visual observation and/or highest PID screening or headspace results, which can only be determined once the boring is complete. In this instance, a VOC sample should be collected at each interval. The remainder of the soil from each interval will be set aside. Once the boring has been completed and the sample interval has been determined, the remainder of the soil can be homogenized according to Section 7.2 and submitted for laboratory analysis.

7.4.9 Once a boring is complete and all required samples have been collected, the boring must be completed as specified in the QAPP (e.g., completed as a monitoring well, backfilled with bentonite, etc.).

7.5 Direct Push Sampling

At each boring location, the frequency of direct-push samples will be determined from the QAPP. Typically, samples with direct-push equipment are collected in 4-foot (ft) intervals, but smaller (e.g., 2 ft) and larger (e.g., 5 ft) intervals are also possible.

1. Sample using Macro-Core samplers with acetate liners to obtain discrete soil samples at the depths specified in the QAPP.
2. Cut open the acetate liner. If required in the QAPP, immediately scan the recovered soil boring for VOCs using a PID by making a hole in the soil with a decontaminated trowel and placing the PID inlet very close to the hole. Be very careful not to get soil on the tip of the PID. Take PID readings every 6 inches along the split-spoon and/or in any areas of stained or disturbed soil. Record the highest PID reading and the depth at which it was observed along with all other pertinent observations. VOC and headspace samples, if required in the QAPP should be collected (see Section 7.7.1) prior to logging the sample.
3. If required in the QAPP, collect a soil sample (as defined in the QAPP) and perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.
4. Soils collected using the direct-push sampler will be logged by the by the field representative using the procedure required in the QAPP.
5. Collect the remainder of the sample into a stainless-steel bowl. Homogenize the soil collected so that the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.

6. Once a boring is complete and all required samples have been collected, the boring must be completed as specified in the QAPP (e.g., completed as a monitoring well, backfilled with bentonite, etc.).

7.6 Test Pit Sampling

7.6.1 Excavate the test pit to the desired depth.

7.6.2 Using the excavator bucket, collect soil samples as specified in the QAPP. Collect a sample and perform screening analyses as required by the QAPP. If VOCs contamination is suspected, perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.

7.6.3 Collect the sample from center of the bucket to avoid potential contamination from the bucket.

7.6.4 VOC samples should also be collected from an undisturbed section soil in the excavator bucket. The top layer of exposed soil should be scraped away just prior to collecting the VOC samples.

7.6.5 Collect the remainder of the sample volume required into a stainless-steel bowl. Homogenize the soil so the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.

7.6.6 Dispose of all excavated soil according to the QAPP.

7.7 Sample Collection Methods

7.7.1 Volatile Organics Sampling

For soils collected for analyses of volatile organics, including Volatile Petroleum Hydrocarbons (VPH) or other purgeable compounds, a closed system is maintained. From collection through analysis, the sample bottles are not opened. The bottle kit for a routine field sample for these analyses will typically include three 40-mL VOA vials and one soil jar. Two 40-mL VOA vials will contain either 5 mL reagent water or 5 mL sodium bisulfate and magnetic stir bars (i.e., low level vials). The third VOA vial will contain 15 mL methanol with no magnetic stir bar (i.e., high level vial). These vials are usually provided by the laboratory and are pre-weighed, with the tare weight recorded on the affixed sample label. No additional sample labels are affixed to the VOA vials, as addition of a label would alter the vial weight. All information is recorded directly on the sample label using an indelible marker. The soil jar is provided for percent solids determination. For VOC or VPH analyses, samples are collected prior to sample homogenization. Collect the VOC sample in accordance with the procedure described below.

1. Determine the soil volume necessary for the required sample weight, typically 5 grams:
    a) Prepare a 5 mL sampling corer (e.g., Terra Core®) or cut-off plastic syringe.
    b) Tare the sampler by placing it on the scale and zeroing the scale.
    c) Draw back the plunger to the 5-gram mark or 5mL (5cc) mark on cut-off syringe and insert the open end of the sampler into an undisturbed area of soil with a twisting motion, filling the sampler with soil. Note the location of the plunger with respect to the milliliter (cc) or other graduation printed on the sampler.
    d) Weigh the filled sampler and remove or add soil until the desired weight is obtained. Note the location of the plunger which corresponds to this weight. Do not use this sample for laboratory analysis.
2. Once the required soil volume has been determined, pull the plunger back to this mark and hold it there while filling the syringe for each sample.
3. Collect 5 grams of soil using the cut-off syringe or Terra Core® sample device. Extrude the 5-grams of soil into one of the low level 40-mL VOA vials. Quickly wipe any soil from the threads of the VOA vial with a clean Kimwipe® and immediately close the vial. It is imperative that the

threads be free from soil or other debris prior to replacing the cap on the vial in order to maintain the closed system necessary for the analysis.

4. Gently swirl the vial so that all of the soil is fully wetted with the preservative.
5. Fill the other low level 40 mL VOA vial in this manner.
6. Repeat the process for the high-level VOA vials, only for the high-level VOA vial three 5-gram aliquots (i.e., 15 grams total) should be extruded into the high-level VOA vial.

   NOTE: Depending on the laboratory, some high-level VOA vials only contain 5 mL or 10 mL of methanol. If this is the case, either 5 grams total or 10 grams total, respectively, should be extruded into the high-level VOA vial. In other words, the mass of soil in grams should be identical to the volume of methanol in mL (i.e., 1:1 ratio of soil to methanol).
7. Collect any additional QC sample collected (e.g., field duplicate, MS, and MSD) in the same manner as above.
8. Fill the 4-oz glass jar with soil from the same area for percent moisture determination.

7.7.2 Soil Sampling Method (All other analyses except VOC/VPH)

When all the required soil for a sampling location has been obtained, the soil can be homogenized as described in section 7.2. Collect sufficient volume to fill all of the remaining sample containers at least ¾ full for all other analyses. Homogenize the soil in a decontaminated stainless-steel bowl, removing rocks, sticks, or other non-soil objects and breaking apart any lumps of soil prior to filling the remaining sample containers.

NOTE: Soil samples must contain greater than 30% solids for the data to be considered valid.

8.0 Quality Control and Assurance

8.1 Sampling personnel should follow specific quality assurance guidelines as outlined in the QAPP. Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements outlined in the QAPP typically suggest the collection of a sufficient quantity of field duplicate, field blank, and other samples.

8.2 Quality control requirements are dependent on project-specific sampling objectives. The QAPP will provide requirements for equipment decontamination (frequency and materials), sample preservation and holding times, sample container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

9.0 Records, Data Analysis, Calculations

All data and information (e.g., sample collection method used) must be documented on field data sheets, boring logs, or within site logbooks with permanent ink. Data recorded may include the following:

- Weather conditions;
- Arrival and departure time of persons on site;
- Instrument type, lamp (PID), make, model and serial number;
- Calibration gas used;
- Date, time and results of instrument calibration and calibration checks;
- Sampling date and time;
- Sampling location;
- Samples collected;
- Sampling depth and soil type;
- Deviations from the procedure as written; and
- Readings obtained.

10.0 Attachments or References

SOP 3-06, *Equipment Decontamination*

SOP 3-19, *Headspace Screening for Total VOCs*

SOP 3-20, *Operation and Calibration of a Photoionization Detector*

Author	***Reviewer***	***Revisions (Technical or Editorial)***
Robert Shoemaker, PMP Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)
Ken O’Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)
Robert Shoemaker, PMP Senior Scientist	Josh Millard, PG, CPG	Rev 2 – Addition of Sonic Drilling Methods (January 2020)

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM’s internal PFAS sampling guidance supersedes materials and methods described in SOPs.

Water Quality Parameter Testing

Procedure 3-24

1.0 Purpose and Scope

1.1 The purpose of this document is to define the standard operating procedure (SOP) for use water quality parameter testing for groundwater or surface water sampling. This SOP describes the equipment, field procedures, materials, and documentation procedures necessary to complete this task. Specific information regarding coring locations can be found in the associated Quality Assurance Project Plan (QAPP).

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM under the client contract.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review. If there are procedures whether it be from AECOM, state and/or federal that are not addressed in this SOP and are applicable to surface water sampling then those procedures may be added as an appendix to the project specific QAPP.

1.4 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the **Task Order (TO) Manager** or **Program Quality Manager**. Deviations to this SOP will be documented in the field records.

2.0 Safety

2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first surface water sampling location. All **field sampling personnel** responsible for sampling activities must review the project-specific Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP), paying particular attention to the control measures planned for the sampling tasks. Conduct preliminary area monitoring to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor and liquid phase through the use of respirators and disposable clothing.

2.2 In addition, observe standard health and safety practices according to the project-specific APP/SSHP. Suggested minimum protection during well sampling activities includes protective eyewear, powder-free nitrile gloves, rubberized steel-toed boots, and an American National Standards Institute-standard hard hat. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on evaluation for PFAS and on the contaminant concentrations.

2.3 Daily safety briefs will be conducted at the start of each working day before any work commences. These daily briefs will be facilitated by the **Site Safety Officer (SSO)** or designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the APP/SSHP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.

2.4 The health and safety considerations for the work associated with surface water sampling include:

- Proper selection of personal protective equipment for work around water bodies (e.g., personal flotation devices [PFDs]), as specified in the project-specific APP/SSHP.

NOTE: SOPs have been updated for PFAS sampling activities; however, AECOM's internal PFAS sampling guidance supersedes materials and methods described in SOPs.

- Appropriate health and safety protocols for working in a boat (if applicable), as specified in the project-specific APP/SSHP.
- Proper lifting techniques when retrieving surface water samplers, large muscles of the legs should be used, not the back.
- Stay clear of all moving equipment and avoid wearing loose fitting clothing.
- To avoid slip/trip/fall hazards as a result of working on wet surfaces, wear work boots/work boot covers with textured soles.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended), and in cases of extreme cold, wear fitted insulated clothing

3.0 Terms and Definitions

3.1 **Barometric Pressure (BP)**: The density of the atmosphere, which varies according to altitude and weather conditions.

3.2 **Conductivity/Specific Conductance**: A measure of the ability of water to pass electrical current, which increases with the amount of dissolved ionic substances (i.e., salts). Conductivity is inversely related to the resistance of a solution and is measured in units of mhos per centimeter (mhos/cm) (inverse ohms/cm, Siemens/cm). The conductivity of water increases with increasing temperature. Specific Conductance is corrected for 25 degrees Celsius (°C); for this reason, it is best to record Specific Conductance. If Conductivity is recorded, the temperature of the sample MUST recorded.

3.3 **Dissolved Oxygen (DO):** The amount of oxygen present in water and available for respiration. DO is typically measured in milligrams per liter (mg/L). Oxygen is less soluble in warm and salty waters, so the instrument compensates the apparent percent saturation for changes in temperature and conductivity. Most probes measure the current resulting from the electrochemical reduction of oxygen (at a gold cathode) diffusing through a selective membrane. Because oxygen is being removed from the sample to perform the measurement, sample flow is required to prevent false low readings due to depletion of oxygen in the solution in front of the probe. Optical DO probes do not remove oxygen from the sample and are less affected by salts. The common range of DO in groundwater is 0.0 to 3.0 mg/L. Measurements outside of this range suggest that the meter may not be operating correctly.

3.4 **Nephelometric Turbidity Unit (NTU):** The measurement of light passing through a sample based on the scattering of light caused by suspended particles.

3.5 **Potential of Hydrogen (pH):** A measure of acidity and alkalinity of a solution using a logarithmic scale on which a value of 7 represents neutrality, lower numbers indicate increasing acidity, and higher numbers are increasingly basic.

3.6 **Oxidation-Reduction Potential (ORP):** Also known as redox or eH, ORP is a measurement of the potential for a reaction to occur, which generally indicates the oxygen status of a sample. The probe consists of a platinum electrode, the potential of which is measured with respect to a reference electrode that rapidly equilibrates with the potential of the sample solution. A positive value indicates that oxygen is present. A negative value indicates an anaerobic environment or reducing condition. For this reason, negative ORP readings should be associated with DO readings of less than 0.5 mg/l; with negative ORP readings the water may exhibit a sulfur odor or gray color. Positive ORP readings should be associated with DO readings greater than 0.5 mg/L and lack of sulfur odors. Because of the complex relationship between ORP and temperature, no compensation is attempted; it is thus best to report both the ORP and temperature of a water sample.

3.7 **Total Dissolved Solids:** A measure of the quantity of materials in water that are either dissolved or too small to be filtered.

3.8 **Turbidity:** Measure of the clarity of water in NTUs. Potable water typically has NTU values between 0.0 and 0.3 NTUs, depending on the state or regulatory program.

4.0 Interferences

4.1 During field testing, water quality data that is documented from field testing equipment may be influenced by certain outside factors that are unrelated to the actual site water quality. Such parameters and equipment include the following:

4.2 **pH Meters:** Coatings of oils, greases, and particles may impair the electrode's response. Pat the electrode bulb dry with lint-free paper or cloth and rinse with de-ionized water. For cleaning hard-to-remove films, use isopropyl alcohol very sparingly so that the electronic surface is not damaged.

Poorly buffered solutions with low specific conductance (less than 200 microsiemens per centimeter) may cause fluctuations in the pH readings. Equilibrate electrode by immersing in several aliquots of sample before taking pH.

4.3 **Dissolved Oxygen**: Dissolved gases (e.g., hydrogen sulfide, halogens, sulfur dioxide) are a factor with the performance of DO probes. The effect is less pronounced on optical DO meters. Meter type and potential interferences should be considered based on potential sulfate/sulfide or nitrate/nitrite reducing environments.

Exposure of the sample to the atmosphere will cause elevated DO measurements.

4.4 **Turbidity Meter**: If the weather is warm and humidity is high, condensation may collect on the cuvet.

To avoid this, allow the sample to warm and dry the outside of the cuvet before making the measurement. One method used to accomplish this is to place the cuvet against one’s body (armpits work well).

4.5 **Temperature**: Sample temperature will change rapidly when there are significant differences between the sample and ambient air.

5.0 Training and Qualifications

5.1 Qualifications and Training

5.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **TO Manager** is responsible for ensuring that field activities comply with this procedure. The TO Manager or designee shall review all surface water sampling forms on a minimum monthly basis. The TO Manager is responsible for ensuring that all field sampling personnel involved in water quality parameter testing shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Field Manager** is responsible for ensuring that all field sampling personnel follow these procedures.

5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure. Minimum qualifications for field sampling personnel require that one individual on the field team shall have a minimum of 6 months of experience with water quality parameter testing.

5.2.5 The **field sampler and/or task manager** is responsible for directly supervising the surface water sampling procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected during sampling. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the **Program Quality Manager** and then documented in the field logbook and associated report or equivalent document.

6.0 Equipment and Supplies

6.1 The following equipment list contains materials that may be needed in carrying out the procedures outlined in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- QAPP
- Maps/Plot plan
- Non-water-repellent logbook
- Site description forms
- Pump (Peristaltic, Portable Bladder, Submersible)
- Polyethylene bladders (for portable bladder pumps)
- Bladder pump controller (for portable bladder pumps)
- Air compressor (for portable bladder pumps)
- Nitrogen cylinders (for portable bladder pumps)
- 12-volt power source
- Polyethylene inlet and discharge tubing
- Silicone tubing appropriate for peristaltic pump head
- HDPE bailer appropriately sized for well
- Disposable bailer string (polypropylene)
- Individual or multi-parameter water quality meter(s) with flow-through cell to measure temperature, pH, specific conductance, dissolved oxygen (DO), oxidation reduction potential (ORP), and/or turbidity
- Turbidity meter
- Teflon-free water level meter
- Oil/water interface probe

6.2 **Equipment/Apparatus**: Field personnel shall consult the site QAPP to review the equipment requirements for the sampling procedures to be followed during the sampling effort. The specific apparatus and materials required will depend on the water quality parameters being monitored. **Table 1** shows the common equipment used in water quality parameter testing.

Table 1
Water Quality Parameter Testing — Common Equipment

Water quality Parameter Instrument	Calibration Standards Required	Other Equipment
pH Meter	Yes - 2- or 3-Point Standards depending on groundwater range. Calibration must cover the range to be measured. If samples are above or below typical buffer standards (4, 7 and 10), special order buffers that fall outside groundwater pH range.	Container or flow thru cell for holding sample
Specific Conductance	Yes	Container or flow thru cell for holding sample
ORP Meter	Yes	Container or flow thru cell for holding sample
Turbidity Meter	Yes	Container or flow thru cell for holding sample
DO	No	Container or flow thru cell for holding sample
Thermometer	No	Container or flow thru cell for holding sample
Flow Rate	No	Container or flow thru cell for holding sample

Notes:
ORP = Oxidation Reduction Potential
DO = Dissolved Oxygen

7.0 Calibration or Standardization

7.1 Instrument or Method Calibration

Most monitoring instruments require calibration before use, and this calibration must be conducted in the field under the ambient climatic conditions that will be present during field sampling. Calibration of monitoring instruments shall be performed in accordance with the manufacturer's specifications and recorded in the provided form in Attachment 1. Site-specific instrument calibration requirements should be specified in the QAPP. The following minimum calibration requirements apply to the various types of meters used to gather water quality measurements.

Initial Calibration (IC): Before use, the instrument or meter electronics are adjusted (manually or automatically) to a theoretical value (e.g., DO saturation) or a known value of a calibration standard. An IC is performed in preparation for the first use of an instrument or if a calibration verification does not meet acceptance criteria.

Initial Calibration Verification (ICV): The instrument or meter calibration is checked or verified directly following IC by measuring a calibration standard of known value as if it were a sample and comparing the measured result to the calibration acceptance criteria for the instrument/parameter. If an ICV fails to meet acceptance criteria, immediately recalibrate the instrument using the applicable initial calibration procedure or remove it from service.

Continuing Calibration Verification (CCV): After use, the instrument or meter calibration is checked or verified by measuring a calibration standard of known value as if it were a sample and comparing the measured result to the calibration acceptance criteria for the instrument/parameter.

7.2 Calibration Checks

Calibration checks are conducted by measuring a known standard. They must be completed after calibration and should be performed at least one other time (i.e., after lunch) and anytime suspect measurements are encountered. Table 2 provides general acceptance ranges to be used during calibration checks. If a meter is found to be outside of the acceptance range, the meter must be recalibrated. If the meter remains out of range, the project manager and/or the supplier of the meter should be contacted to determine alternative measures.

Table 2
Calibration Check Acceptance Limits

Parameter	Acceptance Criteria
Dissolved Oxygen	±0.3 mg/L of the theoretical oxygen solubility
Oxidation-Reduction Potential	±10 mv from the theoretical standard value at that temperature
pH	±0.2 Standard pH Units
Specific Conductance	±5% of the standard
Turbidity	0.1 to 10 NTU: ±10% of the standard 11 to 40 NTU: ±8% of the standard 41 to 100 NTU: ±6.5% of the standard

Notes:
Mg/L = milligrams per liter
Mv = millivolts
NTU = nephelometric turbidity units

7.3 Possible and Suspected Ranges

The concentration for each parameter range should be known so that concentrations outside of the range can be noted. Table 3 presents the maximum range of the parameter in groundwater. The table also presents the suspected range. Measurements outside of the maximum/minimum range should be considered in error and the measurement method should be checked. Concentrations outside the normal range should be treated as suspect but may be the result of contaminant impact. For example, a pH of 2.0 would be out of the normally suspected range for groundwater but not at a site impacted with an acid.

Table 3
Minimum and Maximum Result Ranges

Parameter	Units	PossibleMin	Possible Max	Normal Min	Normal Max	Notes
Dissolved Oxygen	mg/L	0.0	14.6 (0°C) 10.1 (15°C) 8.3 (2°C)	0.0	5	The colder the sample, the higher the DO reading. DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron and/or gray color. DO less than 1 mg/L, ORP negative, may have <u>sulfur odor, sulfide, ferrous iron and/or gray color.</u>
pH	SU	0	14	5	9	pH values exceeding 10 could indicate grout contamination

Parameter	Units	Possible Min	Possible Max	Normal Min	Normal Max	Notes
ORP	mv					DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron and/or gray color. DO less than 1 mg/L, ORP negative, may have sulfur odor, sulfide, ferrous iron and/or gray color.
Specific Conductance	µS/cm			varies	varies	
Temperature	°C	0	100	5	30	
Turbidity	NTU	0	Greater than 1,000	0	Greater than 1,000	50 NTU or greater suggests cloudiness.

Notes:
mg/L = milligrams per liter
°C = degrees Celsius
DO = dissolved oxygen
SU = standard units
ORP = oxidation reduction potential
Mv = millivolts
mS/cm =micro Siemens per cm
NTU = nephelometric turbidity units

7.4 Field Instruments and Calibration Criteria

The calibration acceptance criteria for each instrument are summarized in Table 4 along with special considerations related to each field instrument.

Table 4
Calibration check Acceptance Limits

Parameter	Acceptance Criteria
Dissolved Oxygen	±0.3 mg/L of the theoretical oxygen solubility
Oxidation-Reduction Potential	±10 mv from the theoretical standard value at that temperature.
pH	±0.2 Standard pH Units
Specific Conductance	±5% of the standard
Turbidity	0.1 to 10 NTU: ±10% of the standard 11 to 40 NTU: ±8% of the standard 41 to 100 NTU: ±6.5% of the standard

Notes:
Mg/L = milligrams per liter
mv = millivolts
NTU = nephelometric turbidity units

7.4.1 pH Meters

For the most accurate of pH measurements, pH meters should receive a three-point calibration. However, if a two-point calibration will bracket the groundwater pH of the site, a two-point calibration is acceptable. Three-point calibrations typically include calibrating to solutions of pH 7.00, 4.00, and 10.00. If groundwater pH is outside the calibration range of the solution standards, special buffers must be ordered to bracket the pH. Some meters will report the slope of the calibration and this may be used in checking the meter calibration (refer to the meter's manual). When performing an ICV, the result must be within +/- 0.2 pH units of the stated buffer value.

pH meters should be calibrated across the range of values to be measured. The maximum and minimum calibration solutions shall be outside the range of anticipated values. For example, if the expected range is between 7.50 and 9.00, the 7.00 and the 10.00 standard should be used for calibration. Perform the IC using at least two buffers, and always use the pH 7.00 buffer first. A reading that is above the maximum (or below the minimum) calibration standard is an estimate only and is not valid. This condition requires obtaining a new standard that is above (or below) the reported value, depending on the measurement.

A percent slope of less than 90 percent indicates a bad electrode that must be changed or repaired. If percent slope cannot be determined, or the manufacturer's optimum specifications are different, follow the manufacturer’s recommendation for maintaining optimum meter performance.

7.4.2 Specific Conductivity Meters

For IC, when the sample measurements are expected to be 00 microsiemens per centimeter (µS/cm) or greater, use two standard potassium chloride (KCl) solutions that bracket the range of expected sample conductivities. Calibrate the instrument with the first standard. Verify the calibration of the instrument with the second standard, bracketing the range of expected sample values.

If the instrument can be calibrated with more than one standard, choose additional calibration standards within the range of expected sample values.

When the sample measurements are expected to be less than 100 µS/cm, a lower bracket is not required, but one standard (KCl) solution that is within the range of expected measurements must be used for the IC and the ICV.

Accept the calibration if the meter reads within +/- 5 percent of the value of any calibration standard used to verify the calibration.

Most field instruments read conductivity directly. Record all readings and calculations in the calibration records.

For CCV, check the meter with at least one KCl standard with a specific conductance in the range of conductivity measured in environmental samples. The reading for the calibration verification must also be within +/- 5 percent of the standard value.

If new environmental samples are encountered outside the range of the IC, verify the instrument calibration with two standards bracketing the range of sample values. If these calibration verifications fail, recalibrate the instrument.

7.5 Dissolved Oxygen Meters

Before calibrating, check the probe membrane for bubbles, tears, or wrinkles. These conditions require replacement of the membrane in accordance with the manufacturer’s directions.

If the meter provides readings that are off-scale, will not calibrate, or drift, check the leads, contacts, etc., for corrosion and/or short circuits. These conditions require replacement maintenance in accordance with the manufacturer’s directions.

Most DO meters must be calibrated based on an environment of 100 percent humidity and a known elevation and barometric pressure (BP).

For 100 percent humidity, place the probe in the calibration container with a moist towel and allow the probe to remain, undisturbed, for 10 to 20 minutes.

The IC is an air calibration at 100% saturation. Before use, verify the meter calibration in water-saturated air to make sure it is properly calibrated and operating correctly. Make a similar verification at the end of the day or sampling event. Follow the manufacturer’s instructions for your specific instrument. Allow an appropriate warm up period before IC. Wet the inside of the calibration chamber with water, pour out the excess water (leave a few drops), wipe any droplets off the membrane/sensor and insert the sensor into the chamber (this ensures 100 percent humidity). Allow adequate time for the DO sensor and the air inside the calibration chamber to equilibrate. Once the probe/calibration chamber is stable at ambient temperature, check the air temperature and determine from the DO versus temperature table (see Attachment 2) what DO should measure. The acceptance criterion for DO ICV is +/- 0.3 mg/L.

Use the same procedure as above for CCV.

7.6 ORP Meters

Verify electrode response before use in the field.

Equilibrate the standard solution to the temperature of the sample. The standard solution is based on a 25°C temperature; however, the calibration solution standard's value will require adjustment based on the temperature.

Immerse the electrodes and gently stir the standard solution in a beaker (or flow cell).

Turn the meter on, placing the function switch in the millivolt (mv) mode.

Let the electrode equilibrate and record the reading to the nearest millivolt. The reading must be within ±10 mv from the theoretical redox standard value at that temperature. If not, determine the problem and correct it before proceeding. Switch to temperature display and read the value.

Record the mv reading and temperature in the field notebook or in form. Rinse the electrode with distilled water and proceed with the sample measurement, unless using a flow cell. If a flow cell is used, rinse between sample locations.

7.7 Turbidity Meters

Perform an initial calibration using at least two primary standards.

If the instrument cannot be calibrated with two standards, calibrate the instrument with one standard and verify with a second standard.

Perform an ICV by reading at least one primary standard as a sample. The acceptance criterion for the ICV depends on the range of turbidity of the standard value:

1. Standard Value = 0.1 to 10 NTU: the response must be within 10 percent of the standard;
2. Standard Value = 11 to 40 NTU: the response must be within 8 percent of the standard;
3. Standard Value = 41 to 100 NTU: the response must be within 6.5 percent of the standard; and
4. Standard Value greater than 100 NTU: the response must be within 5 percent of the standard.

Determining the Values of Secondary Standards: Use only those certified by the manufacturer for a specific instrument. Secondary standards may be used for CCVs.

To initially determine the value of a secondary standard, assign the value that is determined immediately after an ICV or verification with primary standards. This is done by reading the secondary standard as a sample. This result must be within the manufacturer's stated tolerance range and +/- 10 percent of the assigned standard value. If the +/- 10 percent criterion is not met, assign this reading as the value of the standard. If the reading is outside the manufacturer's stated tolerance range, discard the secondary standard.

CCV: Perform a CCV using at least one primary or secondary standard. The calibration acceptance criteria are the same as those for an ICV.

8.0 Procedures

8.1 Purpose

The procedures will vary depending on parameters being measured, method of sampling, and the method of measurement used. The information here is a general guidance and the site-specific documents and manufacturer manuals supersede these procedures.

8.2 Cautions

Improper use of water quality testing equipment could result in equipment damage or compromised sampling results. Personnel should be trained to operate the test equipment being used for a field operation and should be trained in the proper techniques for collecting and logging water quality parameters. Personnel should also be able to recognize problems with test equipment and have someone available for basic troubleshooting and repair.

8.3 Direct Measurements

Direct measurements with meters are the most common methods and can be accomplished by placing a sample in a container with the probe or by allowing the water to flow past the probe in a flow cell. The use of a flow-through cell improves measurement quality by allowing the constant flow of water over the probes and reduces interaction of the sample with the atmosphere. Sample cups should be avoided. The quantity of samples, timing, and methodology should be described in the project QAPP.

Following calibration of required probes, connect the bottom flow-cell port to the discharge line of the pump. Connect the top port to a discharge line directed to a bucket to collect the purge water. Allow the flow cell to completely fill. As the water flows over the probe, record the measurements. Continue to record the measurements at regular intervals, as specified in the QAPP.

When the ambient air temperatures are much higher or lower than the temperature of the water sample, it is best to keep the length of tubing between the wellhead and the flow cell as short as possible to prevent heating or cooling of the water. Tubing and flow-through cell should not be exposed to direct sunlight, particularly in the summer, if at all possible, to avoid heating of water samples.

8.4 Data Acquisitions, Calculations, and Data Reduction

8.4.1 Specific Conductivity Correction Factions

If the meter does not automatically correct for temperature (i.e., read Specific Conductivity) record Conductivity and adjust for temperature upon returning to the office. The following equation can be used to convert Conductivity to Specific Conductivity.

$$K = \frac{(Km)(C))}{1 + 0.0191(\mathrm{T} - 25)}$$

Where:

K = Conductivity in µmhos/cm at 25°C

Km = Measured conductivity in µmhos/cm at T degrees Celsius

C = Cell constant

T = Measured temperature of the sample in degrees Celsius;

If the cell constant is 1, the formula for determining conductivity becomes:

$$K = \frac{(Km)}{1 + 0.0191(\mathrm{T} - 25)}$$

8.4.2 Percentage Difference Calculation

For evaluating slope of readings from either a flow cell or a sample cup.

$$\%Difference = \frac{(Highest\ Value - Lowest\ Value)}{(Highest\ Value)}\ x\ 100$$

8.4.3 Convert mm mercury (mmHG) to inches mercury (inHG)

$$mmHG = inHG\ x\ 25.4$$

8.4.4 True Barometric Pressure

For Converting BP obtained from a public domain source that is expressed in BP at sea level to BP at the subject site.

$$TrueBP = (BP) - \frac{(2.5\ x\ [Local\ Altitude])}{100}$$

Where: BP is in mmHG and Local Altitude is in feet

Example: BP at Site A is 30.49 inHG and elevation is 544 feet, calculate TrueBP

Convert inHG to mmgHG:

mmHG = 30.49 inHG x 25.4 = 774.4 mmHG

Calculate TrueBP:

TrueBP = (774.4 mmHG) – [2.5*(544/100)] = 774.4-13.6 = 760.mmHG.

9.0 Quality Control and Assurance

9.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific QAPP. The goal of the QA program should be to ensure precision, accuracy, representativeness, completeness, and comparability in the project sampling program.

9.2 Quality Control (QC) requirements for sample collection are dependent on project-specific sampling objectives. The project-specific QAPP will provide requirements for sample preservation, holding times, container types, as well as various QC samples such as trip blanks, field blanks, equipment blanks, and field duplicates.

10.0 Data and Records Management

10.1 Field notes will be kept during sampling activities in accordance with *SOP 3-03 – Recordkeeping, Sample Labeling, and Chain of Custody*. During the completion of sampling activities, fill out the sample logbook and transmit forms to the TO Manager for storage in project files.

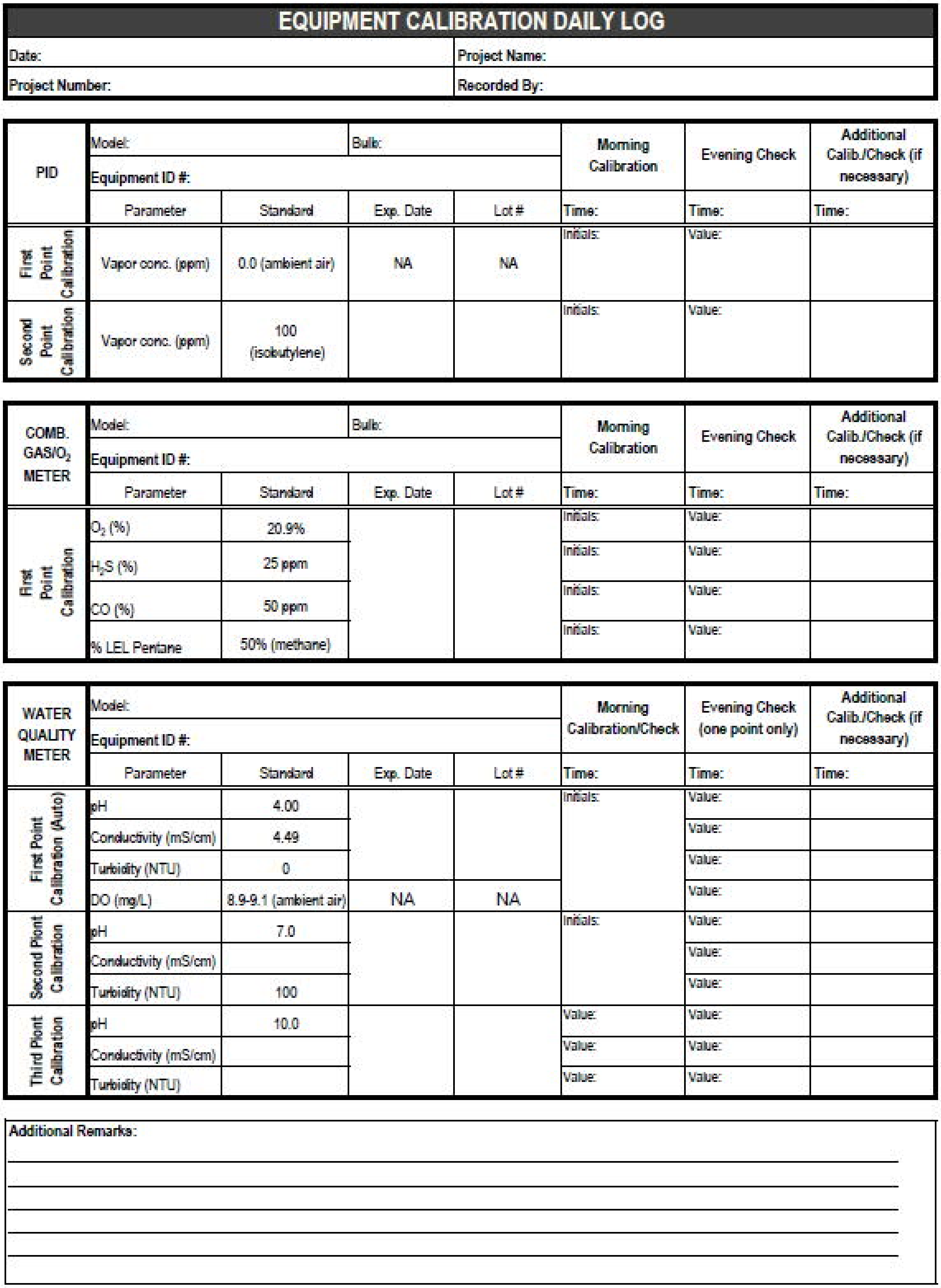
10.2 Deviations to the procedures detailed in the SOP should be recorded in the field logbook.

11.0 Attachments or References

Attachment 1: Example Field Instrument Calibration Form
Attachment 2: Solubility of Oxygen at Given Temperatures
Attachment 3: Example Field Data Form

Author	Reviewer	Revisions (Technical or Editorial)
Robert Shoemaker Senior Scientist	Naomi Ouellette, Project Manager	Rev 0 – Initial Issue
Amanda Martin Engineer	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)

Attachment 1
Example Field Instrument Calibration Form



EQUIPMENT CALIBRATION DAILY LOG	
Date:	Project Name:
Project Number:	Recorded By:

PID	Model:		Bulb:		Morning Calibration	Evening Check	Additional Calib./Check (if necessary)
	Equipment ID #:						
	Parameter	Standard	Exp. Date	Lot #	Time:	Time:	Time:
First Point Calibration	Vapor conc. (ppm)	0.0 (ambient air)	NA	NA	Initials:	Value:	
Second Point Calibration	Vapor conc. (ppm)	100 (isobutylene)			Initials:	Value:	

COMB. GAS/O_2 METER	Model:		Bulb:		Morning Calibration	Evening Check	Additional Calib./Check (if necessary)
	Equipment ID #:						
	Parameter	Standard	Exp. Date	Lot #	Time:	Time:	Time:
First Point Calibration	O_2 (%)	20.9%			Initials:	Value:	
	H_2S (%)	25 ppm			Initials:	Value:	
	CO (%)	50 ppm			Initials:	Value:	
	% LEL Pentane	50% (methane)			Initials:	Value:	

WATER QUALITY METER	Model:				Morning Calibration/Check	Evening Check (one point only)	Additional Calib./Check (if necessary)
	Equipment ID #:						
	Parameter	Standard	Exp. Date	Lot #	Time:	Time:	Time:
First Point Calibration (Auto)	pH	4.00			Initials:	Value:	
	Conductivity (mS/cm)	4.49				Value:	
	Turbidity (NTU)	0				Value:	
	DO (mg/L)	8.9-9.1 (ambient air)	NA	NA		Value:	
Second Piont Calibration	pH	7.0			Initials:	Value:	
	Conductivity (mS/cm)					Value:	
	Turbidity (NTU)	100				Value:	
Third Piont Calibration	pH	10.0			Value:	Value:	
	Conductivity (mS/cm)				Value:	Value:	
	Turbidity (NTU)				Value:	Value:	

Additional Remarks:

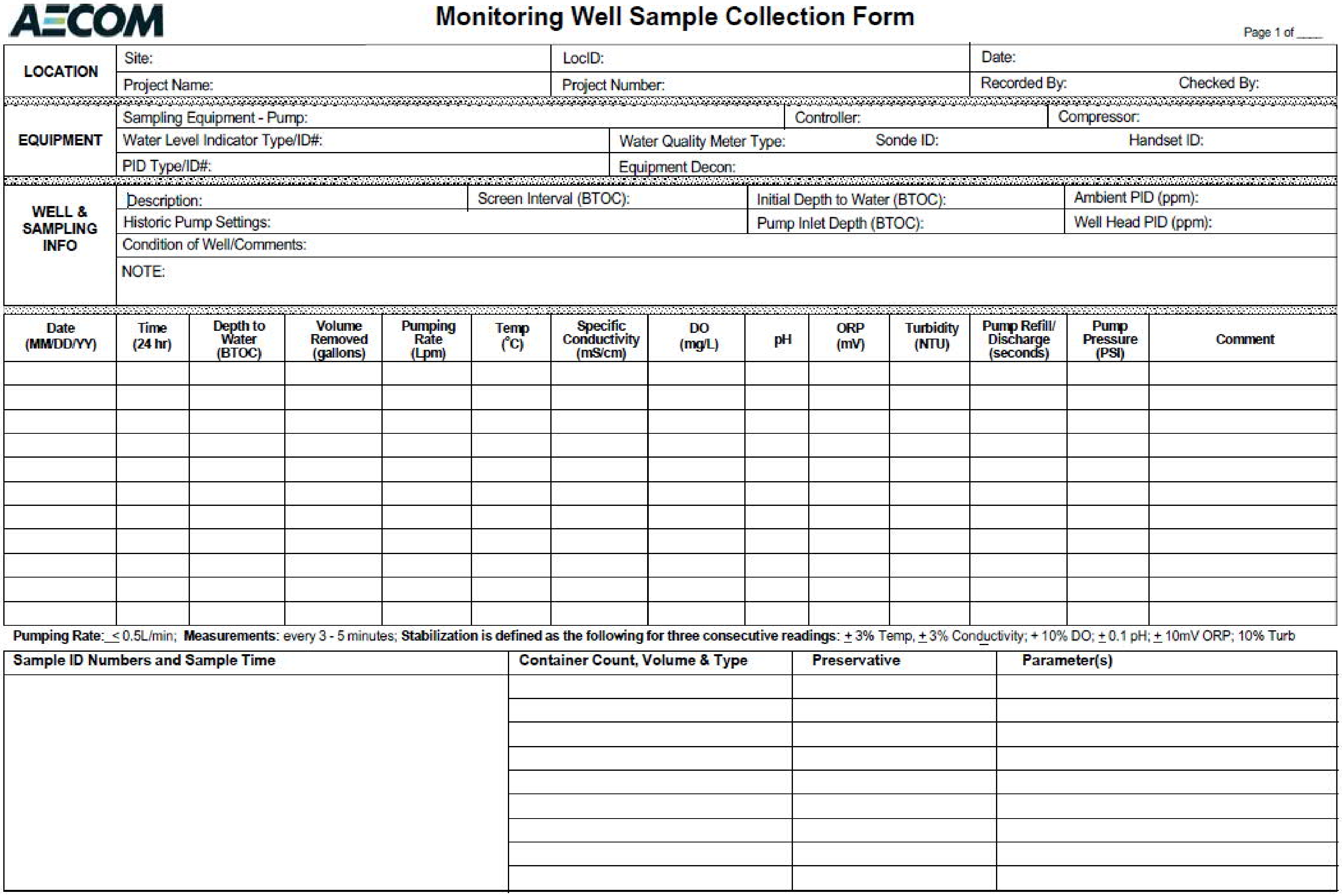
Attachment 2
Solubility of Oxygen at Given Temperatures

Field Measurement of Dissolved Oxygen

Solubility of Oxygen in Water at Atmospheric Pressure			
Temperature	**Oxygen Solubility**	**Temperature**	**Oxygen Solubility**
°C	**mg/L**	**°C**	**mg/L**
0.0	14.621	26.0	8.113
1.0	14.216	27.0	7.968
2.0	13.829	28.0	7.827
3.0	13.460	29.0	7.691
4.0	13.107	30.0	7.559
5.0	12.770	31.0	7.430
6.0	12.447	32.0	7.305
7.0	12.139	33.0	7.183
8.0	11.843	34.0	7.065
9.0	11.559	35.0	6.950
10.0	11.288	36.0	6.837
11.0	11.027	37.0	6.727
12.0	10.777	38.0	6.620
13.0	10.537	39.0	6.515
14.0	10.306	40.0	6.412
15.0	10.084	41.0	6.312
16.0	9.870	42.0	6.213
17.0	9.665	43.0	6.116
18.0	9.467	44.0	6.021
19.0	9.276	45.0	5.927
20.0	9.092	46.0	5.835
21.0	8.915	47.0	5.744
22.0	8.743	48.0	5.654
23.0	8.578	49.0	5.565
24.0	8.418	50.0	5.477
25.0	8.263		

Notes:
The table provides three decimals to aid interpolation
Under equilibrium conditions, the partial pressure of oxygen in air-saturated water is equal to that of the oxygen in water saturated
°C = degrees Celsius
mg/L = milligrams per liter

Attachment 3
Example Field Data Form



AECOM

Monitoring Well Sample Collection Form

Page 1 of ____

LOCATION	Site:	LocID:	Date:
	Project Name:	Project Number:	Recorded By: Checked By:

EQUIPMENT	Sampling Equipment - Pump:	Controller:	Compressor:
	Water Level Indicator Type/ID#:	Water Quality Meter Type: Sonde ID:	Handset ID:
	PID Type/ID#:	Equipment Decon:	

WELL & SAMPLING INFO	Description:	Screen Interval (BTOC):	Initial Depth to Water (BTOC):	Ambient PID (ppm):
	Historic Pump Settings:		Pump Inlet Depth (BTOC):	Well Head PID (ppm):
	Condition of Well/Comments:			
	NOTE:			

Date (MM/DD/YY)	Time (24 hr)	Depth to Water (BTOC)	Volume Removed (gallons)	Pumping Rate (Lpm)	Temp (°C)	Specific Conductivity (mS/cm)	DO (mg/L)	pH	ORP (mV)	Turbidity (NTU)	Pump Refill/ Discharge (seconds)	Pump Pressure (PSI)	Comment

Pumping Rate: ≤ 0.5L/min; **Measurements:** every 3 - 5 minutes; **Stabilization is defined as the following for three consecutive readings:** ± 3% Temp, ± 3% Conductivity; + 10% DO; ± 0.1 pH; ± 10mV ORP; 10% Turb

Sample ID Numbers and Sample Time	Container Count, Volume & Type	Preservative	Parameter(s)

Grab Groundwater Sampling Techniques

Procedure 3-37

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) defines the procedures for collecting grab-groundwater samples from temporary well points installed using direct push or other drilling.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM under the client contract.

1.3 As guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by both the **Task Order (TO) Manager** and the **Program Quality Manage**r and documented.

1.4 If there are procedures whether it be from AECOM, state and/or federal that are not addressed in this SOP and are applicable to direct push sampling then those procedures may be added as an appendix to the project-specific Quality Assurance Project Plan (QAPP).

2.0 Safety

2.1 **Field Personnel** shall perform work in accordance with the Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP). During grab groundwater collection, subcontractors in direct contact with potentially contaminated media shall wear the proper personal protective equipment (PPE) as outlined in the APP/SSHP. Failure to comply will result in disciplinary action.

3.0 Terms and Definitions

3.1 Grab groundwater collection techniques are designed to collect screening-level groundwater data in an efficient manner such that informed field decisions can be made when delineating contaminant plumes, inferring source areas, and identifying other potential soil sample locations and/or locations for permanent monitoring well installation.

4.0 Interferences

4.1 Contaminants that are known to adsorb to particulates, such as metals, PCBs, etc., will be impacted by elevated turbidity (i.e., >25 Nephelometric Turbidity Units [NTU]). For grab groundwater samples with turbidity above 25 NTU, AECOM will collect filtered using a 0.45-micron field filter as well as unfiltered samples.

4.2 Gas bubbles present in discharge tubing during purging and sampling are a problem: Their presence indicates off-gassing from groundwater or poor purging connections in the airline or groundwater tubing. Sunlight can exacerbate this problem when low pumping rates are used. Check connections at the surface. If bubbles persist, check connections at the pump. During purging and sampling, observe the flow of groundwater in the sample tubing and keep the tubing filled with groundwater, removing all air pockets and bubbles, to the extent possible. Gas bubbles may be reduced by increasing flow, if possible, and keeping tubing shaded.

4.3 Pump tubing lengths above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The **TO Manager** is responsible for ensuring that these standard grab groundwater collection procedures are followed during projects conducted under the Program and that a qualified individual conducts or supervises the projects.

5.2.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.

5.2.3 The **Site Supervisor (SS)** is responsible for ensuring that all **Field Personnel** follow these procedures.

5.2.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.2.5 The **Field Personnel** and/or **SS** are responsible for directly supervising the grab groundwater collection procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

6.1 Bladder Pump

The bladder pump system contains the following components: a pressurized cylinder of inert gas (typically nitrogen), a pump controller, air intake and discharge lines, and bladder pumps. The controller regulates total flow of nitrogen from the pressurized nitrogen cylinder to the pump assembly located in the well. AECOM typically samples one well per nitrogen cylinder. Note that if the bladder pumps are placed at the same depth in each well, multiple wells may be sampled simultaneously with one nitrogen cylinder or air compressor. In this case, a three-way cross splitter with quick-connect air line fittings is attached to the tubing connected to the nitrogen cylinder. Up to three controllers can then be connected to the nitrogen cylinder. If nitrogen cylinders are not available, air compressors may be used to power the bladder pumps.

The tubing bundle connected to the pump has three components: an air line with fittings to the pump and the controller, a sample line, and a support cable. For pumps that use nipple tubing connectors, the support cable may not be necessary. The sample line, through which the purge water is removed, must to be composed entirely of HDPE if samples for VOCs or PFAS are to be collected, depending on the project data quality objectives.

Temporary well points installed using direct push or other drilling methods are typically 1.5” or 1” in diameter. The diameter of the bladder pump should be sufficiently small (e.g., 0.850”, 0.675”, etc.) to allow for the easy deployment of the pump, associated tubing, and water level indicator.

6.2 Peristaltic Pump

Peristaltic pumps are not submerged in the well but remain outside of the well and function by pulling water to the surface. A peristaltic pump has a rotating pump head with stepless variable speed that compresses a short stretch of flexible Pharmaceutical-grade (e.g., Pharmed) silicone tubing to pull water up from the well using mechanical peristalsis. The sample water does not come into direct contact with the pump. HDPE tubing is connected to either end of the silicone tubing. The pumps typically used, the GeoPump or GeoPump II, by GeoTech, operate off an external 12 V battery or 120 V AC power source. Commercially available “JumpStart” 12-volt batteries are typically preferred since electrical hookup is typically not available; since they are safe, easy to carry, and easy to recharge; and since the potential contamination issues associated with use of a generator are avoided. Peristaltic pumps cannot be used when the depth to water is greater than 27 feet.

6.3 Tubing

HDPE tubing is preferred for all parameters. Pharmaceutical-grade (e.g., Pharmed) silicon tubing may be required to be used around the rotor head of the peristaltic pump, and, if necessary, as a connecting tubing to the flow-through cells. Inner tubing diameter should be kept to the smallest size possible to reduce the generation of air pockets during low flow. Tubing typically used with the peristaltic pumps is HDPE of
1/4-inch outside diameter, and 3/16-inch inner diameter.

6.4 Electronic water level indicator: Solinst Model 101 or similar

Inner casing diameter and pump diameter should be considered in selecting a water level indicator that will fit into the well with the pump. A smaller diameter probe will be required for temporary well points. Electronic water level indicators will be confirmed Teflon-free with the vendor.

6.5 Flow controllers and compressed inert gases for submersible bladder pumps

QED Model MP-10 Flow controller and nitrogen gas are typically used unless nitrogen is an analyte of interest. Portable air compressors may be used in place of compressed gas (e.g., QED Well Wizard).

6.6 Power Source

Marine battery, battery pack, compressed gas, portable air compressor, and a flow-controller are typically used.

6.6.1 Bladder Pumps

For bladder pump operation, the cylinders of inert compressed gas or portable air compressors function with the flow controller as the power source, although the flow controller does require batteries.

6.6.2 Peristaltic Pumps

The peristaltic pumps typically used by AECOM require an external 12-volt battery or 120-volt AC power source. Commercially available 12-volt batteries designed for jump-starting a car battery (“JumpStart” or similar) are preferred since electrical hookup is typically not available; since they are safe, easy to carry, and easily rechargeable; and since the potential contamination issues associated with use of a generator are avoided.

6.7 Turbidity Meter

LaMotte 2020 turbidity meter, or similar model.

7.0 Procedure

7.1 Pre-Sampling Activities

Place polyethylene sheeting on the ground and assemble all necessary sampling equipment on top of it. This helps to prevent contamination of the sampling equipment by the ground surface, reduces wear on the sampling equipment, and reduces the likelihood that contaminated purge water will spill onto the ground surface.

Prior to beginning sampling activities, measure the depth to water and total depth using the water level indicator and determine the amount of water in the temporary well point. Record this information in the field logbook. If the depth to water is greater than 27 feet, a bladder pump will have to be used.

Wells should be inspected for the presence of LNAPL. Wells with LNAPL cannot be sampled using bladder pumps or peristaltic pumps and must be sampled with a bailer.

All non-dedicated down-well measuring devices will be thoroughly decontaminated before sampling and between monitoring locations.

7.2 Purging the Temporary Well Point

Connect all the lines to the pump. Carefully lower the pump (bladder pump) or tubing (peristaltic pump) to the desired sampling depth. Take care to minimize disturbance and contact with the well walls. Secure the pump or tubing once the desired depth is achieved, typically the midpoint of the screened interval. Attach the water discharge line to a 5-gallon purge bucket or carboy using a squeeze clamp or similar device. Connect the pump the power source (i.e., battery, pump controller and compressed gas cylinder or air compressor).

Start the flow controller and begin purging at the slowest rate possible.

- Note the purge start time.
- Collect all purge water in a bucket or carboy.
- Slowly increase the flow rate until discharge begins. The pump controller should be set to allow for adequate recharge such that a maximum flow rate with no drawdown is achieved and a smooth, laminar discharge flow is achieved.
- Measure the flow rate using a graduated cylinder and time piece and monitor the water level and pumping rate.

Once drawdown has stabilized and an acceptable flow rate established, begin monitoring turbidity every five minutes and continue monitoring flow rate and water level.

- If drawdown cannot be controlled during purging, collect the samples immediately.
- Purge the temporary well until a turbidity reading of 25 nephelometric turbidity units (NTU) is achieved or for 20 minutes, whichever occurs first.

7.3 Sampling

In keeping with convention, samples should be collected in order of decreasing volatility and reactivity so that the most volatile or reactive samples are collected first. The following are general guidelines.

- Gases (methane/ethane/ethene/hydrogen/CO_2)
- Volatile Organic Compounds (VOCs)
- Semivolatile Organic Compounds (SVOCs)
- Pesticides
- Polychlorinated biphenyls (PCBs)
- Dioxins/furans
- Metals
- PFAS

During sample collection, allow the water to flow directly into and down the side of the sample container without allowing the tubing to touch the inside of the sample container or lid, in order to minimize aeration and maintain sample integrity.

- If groundwater turbidity is above 25 NTU at the time of sampling, collect filtered and unfiltered samples using a 0.45-micron filter for analyses that may be impacted by the elevated turbidity (e.g., metals, PCBs).

8.0 Quality Control and Assurance

8.1 Collection of representative samples will be ensured through adherence to the procedures in this SOP and the sampling strategy outlined in the QAPP. The field quality control samples identified in the QAPP must be collected. These samples may include field duplicates, equipment rinsate blanks, trip blanks, and matrix spike/matrix spike duplicates.

9.0 Records, Data Analysis, Calculations

9.1 Various forms are required to ensure that adequate documentation is made of the sample collection activities. These forms may include:

- Non-waterproof field logbook;
- Sample collection records;
- CoC forms; and
- Shipping labels.

9.2 The field logbook is kept as a general log of activities and should not be used in place of the boring log.

9.3 CoC forms are transmitted with the samples to the laboratory for sample tracking purposes.

9.4 Shipping labels are required is sample coolers are to be transported to a laboratory by a third party (courier service).

Author	Reviewer	Revisions (Technical or Editorial)
Suzy Baird Project Scientist	Robert Shoemaker TO Manager	Rev 0 – Initial Issue (February 2013)
Ken O'Donnell, PG Geologist	Claire Mitchell, PE, PMP Senior Engineer	Rev 1 – PFAS sampling update (July 2019)