Final Quality Assurance Project Plan

PFAS Site Inspection
700 South 1600 East PCE Plume Site
Operable Unit 1
Salt Lake City, Utah

CONTRACT NO.: W912DQ-21-D-3004
DELIVERY ORDER NO.: W912DQ22F3063

U.S. Army Corps of Engineers
Kansas City District

Department of Veterans Affairs
Veterans Health Administration Salt Lake City Health Care System

January 2025

CDM Smith

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Acronyms and Abbreviations

ABS	absolute difference
ASC	analytical services coordinator
bgs	below ground surface
BS	Bachelor of Science
CDM Smith	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CPR	cardiopulmonary resuscitation
CSM	conceptual site model
DMP	data management plan
DQO	data quality objective
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
FD	field duplicate
ft	feet (or foot)
FTL	field team leader
HDPE	high-density polyethylene
IDW	investigation-derived waste
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LDPE	low-density polyethylene
LLCS	low-level LCS
LOQ	limit of quantitation
MCL	maximum contaminant level
MDL	method detection limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MPC	measurement and performance criteria
MRL	method reporting limit
MS/MSD	matrix spike/matrix spike duplicate
NA	not available
ng/L	nanograms per liter
NIS	nonextracted internal standard
NTU	nephelometric turbidity unit
OSHA	Occupational Safety and Health Administration
PA	preliminary assessment
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PCE	tetrachloroethene
PFAS	poly- and perfluoroalkyl substances
PM	project manager
PQLG	project quantitation limit goal
PTFE	polytetrafluoroethylene
PTL	project technical leader
QA	quality assurance

QAPP	quality assurance project plan
QC	quality control
QL	quantitation limit
RI	remedial investigation
RL	reporting limit
RPD	relative percent difference
RSD	relative standard deviation
RSL	regional screening level
S4VM	Stage 4 validation protocols
S2BVM	Stage 2 validation protocols
SHSO	site health and safety officer
SI	site inspection
SOP	standard operating procedure
TBD	to be determined
TCE	trichloroethene
UDEQ	Utah Department of Environmental Quality
UFP	Uniform Federal Policy
USACE	U.S. Army Corps of Engineers
VA	Veterans Administration
VAMC	Veterans Affairs Medical Center
°C	degrees Celsius
%	percent
%R	percent recovery
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to

Revision Tracking Table

Revision Number	Date	Section(s) Revised	Summary of Changes

QAPP Worksheets #1 & 2: Title and Approval Page

(Uniform Federal Policy [UFP] Quality Assurance Project Plan [QAPP] Manual Section 2.1)

Contract Name/Number: W912DQ-21-D-3004

Task Order/Modification Number: W912DQ22F3063

Period of Performance: July 2023 – July 2025

Title: Quality Assurance Project Plan for Site Inspection, 700 South 1600 East PCE Plume Superfund Site

Signature_____ Date 1-24-2025

CDM Smith Project Technical Leader (PTL): Neil Smith

Signature_____ Date 1-24-2025

CDM Smith Project Manager (PM): Kara Fincham

Signature_____ Date 1-24-2025

CDM Smith Quality Assurance (QA) Specialist: Robert Alexander

Signature BAKER.KATHY.THERESIA.1231266875 Digitally signed by BAKER.KATHY.THERESIA.1231266875 Date: 2025.01.27 08:31:46 -06'00' Date_____

U.S. Army Corps of Engineers (USACE) PM: Kathy Baker

Signature SHANNON SMITH Digitally signed by SHANNON SMITH Date: 2025.01.27 08:08:09 -07'00' Date_____

Veterans Administration (VA) Program Manager: Shannon Smith

Signature ZANE KOZAREC Digitally signed by ZANE KOZAREC Date: 2025.01.27 08:27:32 -07'00' Date_____

VA QA Officer: Zane Kozarec

Letters of concurrence will be provided by EPA and UDEQ and included as appendices to the final QAPP.

This QAPP will be reviewed annually and updated, as necessary, by the VA and revised at least every 5 years.

Dates and Titles of Plans and Reports from Relevant Investigations and Companion Documents

CDM Smith. 2022a. *Final Remedial Investigation Report, Operable Unit 1*. 700 South 1600 East PCE Plume, Salt Lake City, Utah. Prepared for USACE.

CDM Smith. 2022b. *Contractor Quality Control Plan*. 700 South 1600 East PCE Plume, Salt Lake City, Utah. Prepared for USACE.

EPA. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. EPA/540/G-89/004.

EPA. 2000. *EPA Quality Manual for Environmental Programs*. EPA CIO 2105-P-01-0

EPA. 2002. *Guidance for Quality Assurance Project Plans*. QA/G-5. EPA/240/R-02/009.

EPA. 2005. *Uniform Federal Policy for Quality Assurance Project Plans*. Final, Version 1.

EPA. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*. EPA QA/G-4.

EPA. 2009. *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*. EPA/540/R-08/005.

EPA. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Optimized UFP-QAPP Worksheets*.

EPA. 2015. *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*. Office of Solid Waste and Emergency Response Publication 9200.2-154.

EPA. 2016. *Federal Facility Agreement Under CERCLA Section 120 for the 700 South 1600 East PCE Plume Site*.

EPA. 2020a. *National Functional Guidelines for Inorganic Superfund Methods Data Review*. EPA 542-R-20-006.

EPA. 2020b. *National Functional Guidelines for Organic Superfund Methods Data Review*. EPA 540-R-20-005.

EPA. 2023. *Quality Assurance Project Plan Standard*. Directive No: CIO 2105-S-02.1.

EPA. 2024. *Regional Screening Levels (RSLs) – User's Guide*.

Intergovernmental Data Quality Task Force. 2005. *Uniform Federal Policy for Quality Assurance Project Plans*. U.S. Department of Defense, EPA, and U.S. Department of Energy. DTIC ADA 427785. EPA-505-B-04-900A.

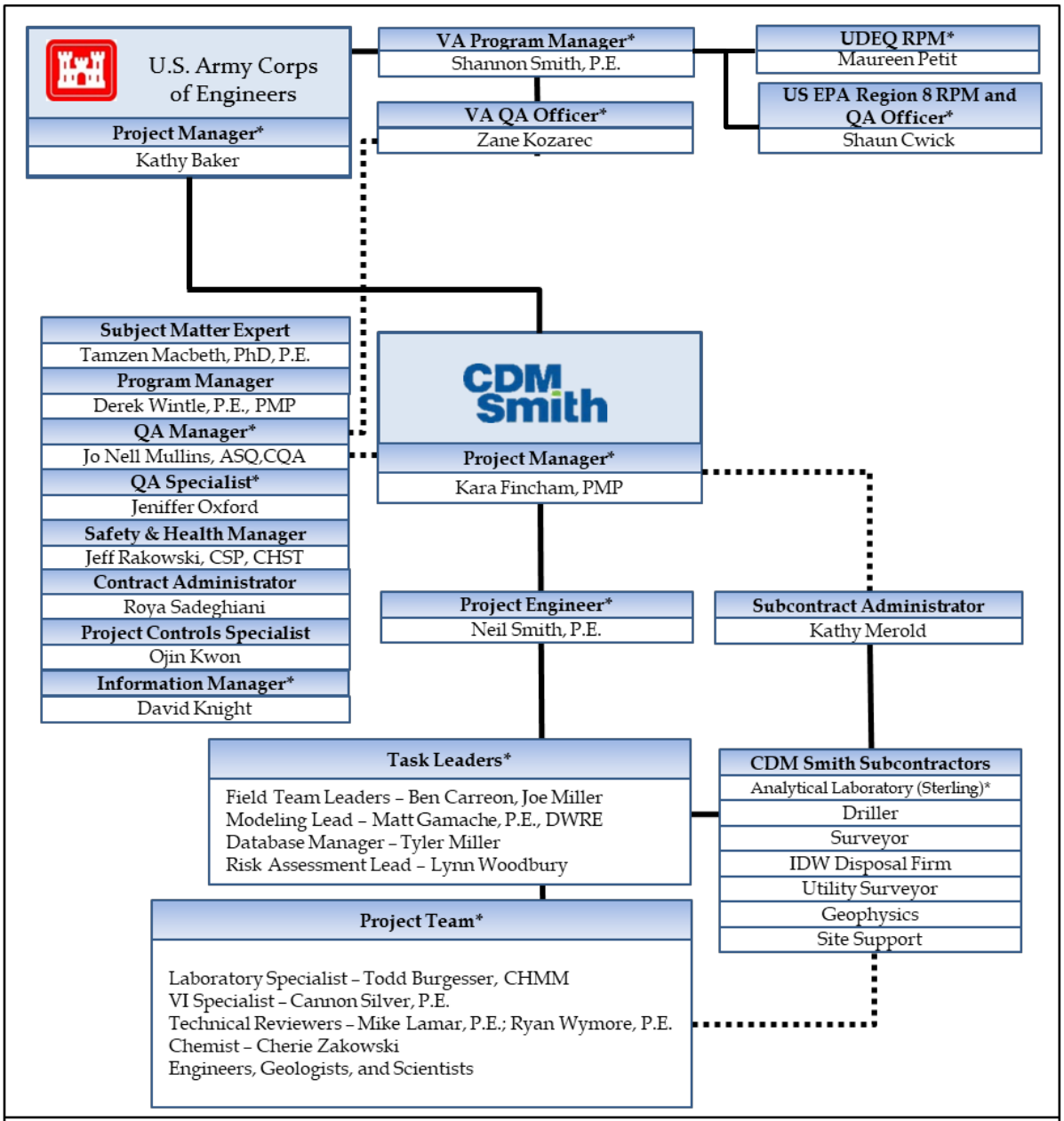
USACE. 2005. *Guidance for Evaluating Performance Based Chemical Data*. Engineer Manual 200-1-10.

VA. 2024. Preliminary Assessment for PFAS, Salt Lake City Veterans Affairs Medical Center, Salt Lake City, Utah.

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

(UFP-QAPP Manual Sections 2.3 and 2.4)

This QAPP will be distributed to Kathy Baker (USACE PM), Shannon Smith (VA Program Manager), and all other key project personnel identified with an asterisk in the project organization chart presented on the page that follows.



Legend

= Line of Authority
= Line of Communication
* = QAPP Recipient
ASQ = American Society for Quality
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CHMM = Certified Hazardous Materials Manager
CHST = Construction Health and Safety Technician
CQA = Certified Quality Auditor
CSP = Certified Safety Professional
DWRE = Diplomate, Water Resource Engineer
IDW = investigation-derived waste
P.E. = Professional Engineer
P.G. = Professional Geologist
PhD = Doctor of Philosophy
PMP = Project Management Professional
RPM = remedial project manager
TBD = to be determined
UDEQ = Utah Department of Environmental Quality
U.S. EPA = U.S. Environmental Protection Agency
VA = Veterans Administration

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Project Organization Chart
700 South 1600 East PCE Plume OU1

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

(UFP-QAPP Manual Sections 2.3.2–2.3.4)

The personnel list has been limited to the main points of contact from CDM Smith, who are responsible for implementing this QAPP.

Organization: CDM Smith

Project Personnel	Project Title/Responsibilities	Education/Experience	Specialized Training/Certifications	Signature/Date
Kara Fincham	**PM** – Coordinate the work effort with USACE and VA. Responsible for the technical scope and content, schedule adherence, subcontract management, and financial management of the project. Primary point of contact for USACE and VA.	Bachelor of Science (BS), Environmental Science. Over 25 years of experience in remediation, environmental sampling, and project management.	Project Management Professional, Hazardous Waste Operations and Emergency Response (HAZWOPER) 40-Hour Training and 8-Hour Supervisor Training	
Neil Smith	**PTL** – Provide technical direction and delivery of the project. Coordinate production of project deliverables and serves as technical leader for project documents.	BS, Civil Engineering; Master of Science, Environmental Engineering. Over 20 years of experience in site characterization, remedial technology design and managing large complex federal Superfund sites.	Professional Engineer HAZWOPER 40-Hour Training and 8-Hour Supervisor Training	
Cherie Zakowski	**Project chemist and analytical services coordinator (ASC)** – Lead data validation task, coordinate with laboratories, and manage chain-of-custody form preparation and sample shipping.	BS, Biology; BS, Environmental Studies and Human Ecology; Master of Science, Environmental Science with an Emphasis in Toxicology. Over 35 years of experience in laboratory sample coordination, data evaluation, and project management.	HAZWOPER 40-Hour Training and 8-Hour Supervisor Training	
Lynn Woodbury	**Risk assessor** – Lead the toxicology and risk assessment.	BS, Biology; Master of Science, Environmental Science. Over 25 years of experience conducting human health risk assessments.		

Project Personnel	Project Title/Responsibilities	Education/Experience	Specialized Training/Certifications	Signature/Date
Jeniffer Oxford	**QA specialist** – Oversee quality activities on the project, complete any quality assessments assigned, and facilitate corrective action.	BS, Natural Sciences. Over 35 years of experience in QA support, data validation, and laboratory coordination.	HAZWOPER 40-Hour Training, Certified Inorganic and Organic Data Validator	
Ben Carreon	**Field team leader (FTL)** – Oversee field implementation of the QAPP.	BS, Civil Engineering. Over 10 years of experience in site characterization and field investigations.	Professional Engineer, HAZWOPER 40-Hour Training and 8-Hour Supervisor Training, Occupational Safety and Health Administration (OSHA) 30-Hour Construction Safety, first aid, cardiopulmonary resuscitation (CPR)	
Joe Miller	**Alternate FTL** – Oversee field implementation of the QAPP.	BS, Geology; Master of Science, Geology. Over 15 years of experience in site characterization and field investigations.	Professional Geologist HAZWOPER 40-Hour Training and 8-Hour Supervisor Training, OSHA 30-Hour Construction Safety, first aid, CPR	
Todd Burgesser	**Laboratory specialist** – Support the ASC in laboratory coordination in accordance with QAPP documentation.	BS, Biological Sciences. Over 35 years of experience in industrial hygiene, project management, field investigations, and laboratory methods.	Certified Hazardous Materials Manager, HAZWOPER 40-Hour Training and 8-Hour Supervisor Training, OSHA 10-Hour Construction Safety Training	
Jeff Rakowski	**Health and Safety Manager** – Oversee adherence to health and safety requirements.	BA, Geography. Over 18 years of experience	Certified Safety Professional; Construction H&S Technician	
Sampling Team	**Field team** – Collect field samples and perform field tasks, including sample shipping, in accordance with QAPP documentation.	Field personnel will have education and experience in data collection and sampling techniques relevant to this QAPP.	HAZWOPER 40-Hour Training and Supervisor 8-Hour Training, OSHA 30-Hour Construction Safety Training (as needed), first aid, CPR	

Organization: Subcontracted Laboratory (Sterling Labs)

Personnel/Organization	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date
Olga Karplyuk	**PM** – Oversee laboratory analytical performance and confirm all laboratory protocols are followed to verify analytical results meet QA requirements for aqueous and soil samples.	BS, Earth and Environmental Science, 2 years of experience managing federal laboratory projects		

Organization: USACE and VA

Personnel/Organization	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date
Kathy Baker	**USACE Project Manager**	BS, Geology, BS, Chemistry; Master of Science in Geology. Over 11 years of experience in hazardous waste site characterization and remediation. Over 16 years in Project Management including Superfund Programs.		
Shannon Smith	**VA CERCLA Program Manager**	BS, Civil Engineering; Master of Science, Environmental Engineering. Over 25 years of experience in managing large complex federal Superfund sites		

QAPP Worksheet #6: Communication Pathways

(UFP-QAPP Manual Section 2.4.2)

Communication Driver	Organization and Responsible Entity	Name	Contact Information (Phone Number)	Contact Information (email)	Procedure (Timing, Pathways, Documentation)
Point of contact	CDM Smith PM	Kara Fincham	904-527-6716	finchamke@cdmsmith.com	The CDM Smith PM will send information about the project to the USACE and VA PMs.
Manage CDM Smith project team	CDM Smith PM	Kara Fincham	904-527-6716	finchamke@cdmsmith.com	The CDM Smith PM will communicate with the project team via email, telephone, and meetings. As necessary, meeting notes will be recorded and distributed to the team.
Manage field tasks	CDM Smith PM CDM Smith PTL CDM Smith FTL CDM Smith alternate FTL	Kara Fincham Neil Smith Ben Carreon Joe Miller	904-527-6716 303-383-2447 406-441-1454 303-383-2328	finchamke@cdmsmith.com SmithNL@cdmsmith.com carreonbs@cdmsmith.com millerjc@cdmsmith.com	Listed staff will communicate in person with the field team about planned sampling. If issues arise in the field, communication will be via telephone and email. The CDM Smith PTL and FTL will be the primary points of contact and perform daily and weekly quality control (QC) of field documents.
Perform field audit	CDM Smith QA specialist (or designee)	Jeniffer Oxford	212-377-4536	OxfordJM@cdmsmith.com	As determined in consultation with the CDM Smith PM, an audit of field activities may be performed to ensure the field team is following the requirements of this QAPP and the project Data Management Plan (DMP).

Communication Driver	Organization and Responsible Entity	Name	Contact Information (Phone Number)	Contact Information (email)	Procedure (Timing, Pathways, Documentation)
Document QAPP changes in the field	CDM Smith FTL CDM Smith alternate FTL CDM Smith PTL	Ben Carreon Joe Miller Neil Smith	406-441-1454 303-383-2328 303-383-2447	carreonbs@cdmsmith.com millerjc@cdmsmith.com SmithNL@cdmsmith.com	If the change is minor, listed staff will document the change in the field logbook and notify the CDM Smith PM and PTL. If the change is major, these staff will notify the PM immediately and complete a Minor Field Modification Form, and then send the form to the CDM Smith PTL and QA specialist for review. The PTL or PM will provide reviewed forms to the USACE PM and VA PM for their review. Notifications will also be sent to EPA and UDEQ.
Procure analytical services	CDM Smith PM CDM Smith ASC	Kara Fincham Cherie Zakowski	904-527-6716 720-264-1109	finchamke@cdmsmith.com ZakowskiCA@cdmsmith.com	Coordinate with subcontract laboratory, as necessary, including obtaining the laboratory's quality plan, certification(s), and SOPs from laboratories.
Facilitate database setup and information management planning	CDM Smith information manager (or designee)	David Knight	720-264-1120	KnightDL@cdmsmith.com	Prepare the database and coordinate with the CDM Smith PTL to ensure necessary information is captured. Communicate with the PTL or other technical staff to coordinate database exports.
Maintain official QAPP	CDM Smith PM	Kara Fincham	904-527-6716	finchamke@cdmsmith.com	Maintain and distribute the official, approved QAPP. Distribution will be by email. Copies will be kept in CDM Smith project files (i.e., ProjectWise and Microsoft Teams).

Communication Driver	Organization and Responsible Entity	Name	Contact Information (Phone Number)	Contact Information (email)	Procedure (Timing, Pathways, Documentation)
Initiate corrective actions	CDM Smith PM CDM Smith PTL CDM Smith QA specialist (or auditor)	Kara Fincham Neil Smith Jeniffer Oxford	904-527-6716 303-383-2447 212-377-4536	finchamke@cdmsmith.com SmithNL@cdmsmith.com OxfordJM@cdmsmith.com	The CDM Smith QA specialist or auditor initiates a corrective action request via email for identified issues immediately. The CDM Smith PM ensures corrective actions are completed and documentation of the resolution is maintained in CDM Smith project files.
Provide notification of analytical issues	CDM Smith ASC	Cherie Zakowski	720-264-1109	ZakowskiCA@cdmsmith.com	Notify the CDM Smith PM via email on any issues as they arise. Notify the CDM Smith FTL via phone of any sample collection/shipment issues. Notify subcontract laboratory PMs via email to initiate corrective action.
Report issues relating to analytical data quality, including ability to meet reporting limits (RLs) and requirements for data usability	Laboratory PM CDM Smith Chemist/ASC	Olga Karplyuk Cherie Zakowski	847-324-3348 720-264-1109	okarplyuk@thesterlinglab.com ZakowskiCA@cdmsmith.com	The CDM Smith ASC will communicate with subcontract laboratory PMs, as appropriate, and document the situation and its effect in a data quality report as appropriate. Subcontract laboratory PMs will elevate issues to the CDM Smith PM and ASC when necessary.

Communication Driver	Organization and Responsible Entity	Name	Contact Information (Phone Number)	Contact Information (email)	Procedure (Timing, Pathways, Documentation)
Shipping samples, clarifications and questions from laboratory, corrective actions	CDM Smith ASC	Cherie Zakowski	720-264-1109	ZakowskiCA@cdmsmith.com	Communicate with laboratories and the field team to coordinate sample shipments to laboratories. Any issues associated with sample shipments (e.g., chain-of-custody errors, hold time exceedances, unacceptable cooler temperature) and the associated corrective action (e.g., chain-of-custody corrections) will be communicated via email and documented in the QC summary report as appropriate.
Analytical problems/ procedures deviation	Laboratory PM	Olga Karplyuk	847-324-3348	okarplyuk@thesterlinglab.com	The laboratory will inform the CDM Smith ASC, as appropriate, if deviations from the assigned analytical protocol are required or if other analytical problems that affect the schedule or data quality are encountered. The situation and its effect on data quality will be documented in the laboratory report and the QC summary report as appropriate.

Communication Driver	Organization and Responsible Entity	Name	Contact Information (Phone Number)	Contact Information (email)	Procedure (Timing, Pathways, Documentation)
Initiate QAPP amendments	CDM Smith PM	Kara Fincham	904-527-6716	finchamke@cdmsmith.com	Initiate QAPP amendments in consultation with EPA and UDEQ project team and submit QAPP amendments for EPA approval before fieldwork. Inform the project team of changes and approvals and provide copies of QAPP amendments to personnel identified in QAPP Worksheets #3 & 5. Verify QAPP deviations are documented, as appropriate, and obtain EPA approval before they are implemented. QAPP amendments will appropriately incorporate approved minor field modifications.
QAPP amendments	VA PM	Shannon Smith	801-582-1565 x2021	shannon.smith92@va.gov	Review and approve QAPP amendments before they are implemented.
QAPP acceptance and communication to USACE, EPA, and the Utah Department of Environmental Quality (UDEQ)	EPA Remedial Project Manager UDEQ Remedial Project Manager	Shaun Cwick Maureen Petit	720-843-6569 385-391-8127	cwick.shaun@epa.gov mpetit@utah.gov	Accept the QAPP and notify the USACE PM and VA PM via email.
Major deviation from QAPP and notification to EPA and UDEQ	VA PM	Shannon Smith	801-582-1565 x2021	shannon.smith92@va.gov	If a major deviation from the QAPP occurs, the VA PM will notify EPA and UDEQ for consultation and to obtain concurrence with the change.
Site access	VA PM	Shannon Smith	801-582-1565 x2021	shannon.smith92@va.gov	Obtain written access to private property before performing field investigations on that property.

Communication Driver	Organization and Responsible Entity	Name	Contact Information (Phone Number)	Contact Information (email)	Procedure (Timing, Pathways, Documentation)
Site health and safety issues, including Stop Work due to safety concerns	CDM Smith site health and safety officer (SHSO)/FTL All on site personnel have Stop Work authority	Ben Carreon Joe Miller	406-441-1454 303-383-2328	carreonbs@cdmsmith.com millerjc@cdmsmith.com	Participate in daily health and safety meetings. If safety concerns are present at any time during work, all personnel on site have the authority to stop work and address health and safety issues. The field team will communicate with the CDM Smith PM, corporate health and safety manager (Jeff Rakowski, 732-590-4665), and other field staff as appropriate to address field safety concerns or issues
Emergencies	CDM Smith PM, field teams, USACE PM, and others	All on-site project personnel	All on-site project personnel		If an emergency occurs during field work, the field team will call local emergency response (911) and evacuate to a safe area. Once the immediate danger is avoided and any hurt individuals are cared for, the team will notify the CDM Smith PM and SHSO. The CDM Smith PM will communicate with the VA and USACE PMs. Other emergency situations will be communicated to all parties as soon as possible. CDM Smith's site health and safety plan also details emergency operations.
Regulatory Agency Interface	VA PM	Shannon Smith	801-582-1565 x2021	shannon.smith92@va.gov	The VA PM will be responsible for interface, information sharing, and communication with EPA and UDEQ during execution of the work.
Field Progress Reports	CDM Smith FTL CDM Smith alternate FTL CDM Smith PTL	Ben Carreon Joe Miller Neil Smith	406-441-1454 303-383-2328 303-383-2447	carreonbs@cdmsmith.com millerjc@cdmsmith.com SmithNL@cdmsmith.com	CDM Smith will prepare and submit progress reports of the activities and tasks that have been completed in the field

QAPP Worksheet #9: Project Planning Session Summary

(UFP-QAPP Manual Section 2.5.1 and Figures 9–12)

Dates of Planning Sessions: April 18, 2024

Location: Conference call

Purpose: Biweekly Progress Meeting and PFAS PA/SI Kickoff

Participants:

Name	Organization	Title/Role	Email
Shannon Smith	VA	Program Manager	shannon.smith92@va.gov
Wynn John	VA	Technical Manager	william.john@va.gov
Zane Kozarec	VA	Engineer/QA Officer	Zane.kozarec@va.gov
David Suchy	USACE	PM	david.suchy@usace.army.mil
Josephine Newton-Lund	USACE	PM	Josephine.M.Newton-Lund@USACE.army.mil
Neil Smith	CDM Smith	Engineer	smithnl@cdmsmith.com
Hans Johannes	CDM Smith	PM	johannesha@cdmsmith.com

- EPA sent a letter on April 18, 2024 conditionally agreeing to VA's request to perform a PA/SI as an initial step to investigate PFAS associated with the 700 South 1600 East PCE Plume.
- VA is initiating review of historical product use and researching past practices at the VAMC which may have used PFAS in support of the Preliminary Assessment.
- VA will prepare a UFP-QAPP to describe proposed sampling, limited to groundwater samples at existing wells, as part of the Site Inspection.

QAPP Worksheet #10: Conceptual Site Model

(UFP-QAPP Manual Section 2.5.2)

Site Overview

The site is in Salt Lake City, near the University of Utah and the front (west side) of the Wasatch Mountains. The Salt Lake City Veterans Affairs Medical Center (VAMC) operated a part-time dry cleaning operation in Building 7 that used tetrachloroethene (PCE) over a 6-year period in the late 1970s and early 1980s. During this period, dry cleaning residuals were disposed of into the sanitary sewer. Surface and near-surface releases of dry cleaning condensate in the Buildings 6 and 7 area on the VAMC campus and subsurface release through the sanitary sewer line defect in Sunnyside Park are the likely release mechanisms for PCE at the site.

PCE was first detected in 1990, during sampling in an irrigation well at the Mount Olivet Cemetery. Following this initial detection, multiple investigations were conducted by UDEQ and EPA, resulting in listing the site on the National Priorities List in 2013. A triparty Federal Facility Agreement was signed on November 7, 2016, by the VA, the State of Utah, and EPA, which regulated the site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The VA is currently evaluating remedial alternatives for the PCE plume at the site.

Per- and polyfluoroalkyl substances (PFAS) have chemical properties that make them useful in many commercial and industrial applications because they are heat resistant and can repel oil, grease, and water. PFAS have been manufactured for use in a wide variety of products, including firefighting foam, nonstick cookware, fiber and fabric stain protection applications, medical products, food packaging, and personal care products. During the dry cleaning process, PFAS from stain-protection-treated fabrics may leach into the dry cleaning waste stream, or stain-protection activities conducted during dry cleaning may add PFAS to the waste stream. PFAS have been used for coatings and coverings for medical equipment, filters and seals for tubing, X-ray film, barriers on hospital gowns and many other applications which could be a potential source of PFAS at the site. PFAS has also been used in some pharmaceuticals and packaging materials which were used at the site. The medical center janitorial staff uses a variety of Scotchgard cleaning products that contain PFAS. A more in-depth discussion of the potential historical uses of PFAS at the site is listed below. No prior PFAS sampling has been conducted at the site; this QAPP will describe the steps taken to perform a PFAS site inspection (SI).

The following sections describe the CSM, which is based on the CSM provided in the Remedial Investigation (RI) Report (CDM Smith 2022a) and adjusted to include PFAS. Figure 6-1 from the RI Report shows the PCE plume CSM and is included in Appendix C.

Physical Characteristics

The site is in an urban, mostly developed area near the University of Utah and the front of the Wasatch Mountains. The site is in a mixed commercial and residential area, and the major streets that bound the site include 500 South to the north, Michigan Avenue to the south, 1100 East to the west and Foothill Drive to the east. The Mount Olivet Cemetery, East High School, and the university of Utah athletics facilities, in addition to residential neighborhoods, are in the vicinity of the Site. The west of the SLC VAMC is a city park and recreation facility, University of Utah athletic fields and training buildings, elementary schools, and a residential community. Previously, a National Guard facility and a US Forest Service Fire Center were located west of the campus.

The site is located in the Wasatch Fault Zone, which separates the Salt Lake Valley from the Wasatch Mountains to the east. The site is bisected by the East Bench Segment of the Wasatch Fault (East Bench Fault) and the East Bench Fault Spur. The topography slopes to the west with a grade of 4 percent (%) until reaching the East Bench Fault, where it steepens to 10%. Seeps and springs are present alongside the scarp of the East Bench Fault. Figures 1-1 and 1-2 from the RI Report (CDM Smith 2022a) showing the site location and features are included in Appendix C.

The surficial geology is mapped as alluvial fan deposits and lacustrine deposits, grading from coarse grained on the east to finer grained to the west.

The closest surface water body is Red Butte Creek located to the east and south of the site, which flows to the southwest before traveling more westerly approximately 1,500 feet to the southwest of the site. The peak flow of Red Butte Creek occurs in late April through June because of snowmelt. Red Butte Creek is a losing stream as it flows across the primary and secondary recharge areas near the Wasatch Front, including the eastern portions of the site. Red Butte Creek receives surface water via both direct runoff and storm water discharges.

At the VAMC campus, groundwater was encountered generally from 185 to 200 feet (ft) below ground surface (bgs). Moving west and southwest, groundwater becomes shallower, with depth to groundwater at approximately 155 ft bgs to the west of the VAMC campus near Guardsman Way. In the residential area located approximately 4,000 ft downgradient from the VAMC campus boundary, shallow groundwater was encountered at approximately 15 ft bgs to above the ground surface (i.e., artesian conditions).

The local aquifer system includes groundwater flowing through perched (near the VAMC campus and Sunnyside Park only), unconfined shallow, and semiconfined deep aquifer systems. Surface discharge of groundwater occurs through seeps and springs located east of the East Bench Fault and are cumulatively a significant component of the local water balance. Figures 4-2 through 4-5 from the RI Report (CDM Smith 2022a) showing geologic features and potentiometric surface maps are included in Appendix C.

Groundwater elevation data provides information to define the four aquifer zones identified at the site: perched, shallow aquifer, intermediate aquifer, and deep aquifer zones. A silt/clay semiconfining unit is present between the shallow and deep aquifer zones. Flow directions are generally east to west. Vertical gradients are typically strongly downward near the VAMC campus and dissipate along the east to west groundwater flow path. The East Bench Fault Spur is not a significant impediment to groundwater flow. However, the head difference across the East Bench Fault is approximately 112 ft, likely occurring abruptly because of the fault acting as a semipermeable barrier to flow.

Hydraulic conductivity in the shallow aquifer zone generally ranges from 5 ft per day in the northeastern and southwestern areas of the site to 50 feet per day in the central area of the site. In the deep aquifer zone, there was no significant difference in hydraulic conductivities east and west of the East Bench Fault Spur.

Generally, the climate of the site is a semiarid continental climate with year-round rainfall. Summers are typically dry and hot. Winters are mild with precipitation from mid-latitude cyclones. The average temperatures range from approximately 28 degrees Fahrenheit (°F) in the coldest month of January to approximately 78°F in July, the hottest month in the year. The annual average temperature is approximately 52°F with an average daily temperature range of approximately 23°F. The average annual precipitation is approximately 21 inches per year.

Historical PFAS Usage

PFAS has yet to be sampled in environmental media at the site. Numerous activities, equipment, and materials used at the Salt Lake City VAMC site have been linked to PFAS as documented in the preliminary assessment (PA) (VA 2024). PFAS can be found in a variety of products used in the healthcare industry. The most common PFAS product is polytetrafluoroethylene (PTFE) as it is found within O-rings, gaskets, cardiovascular grafts, sutures, tubing, dialysis membranes, and other machines and diagnostic instruments (Henry et al., 2018). At the SLC VAMC, medical equipment is located in the hospital (Buildings 1 and 14) and in the medical research building (Building 2).

The Biomedical Engineering Department at the SLC VAMC maintains medical equipment and devices in use at the hospital. When medical equipment and devices have reached the end of their useful life, items are surplussed, recycled, or disposed of as solid waste. The Biomedical Engineering Department uses a variety of corrosion protection lubricants and pipe thread sealers that contain perfluoroalkylether and PTFE to maintain equipment; however, these products are not used on water lines nor wastewater lines and do not have a likely release route to the environment. Additionally, Medical Research (Building 2) currently uses an aerosol non-stick dry film lubricant that contains PTFE. Similarly, it is used on medical equipment with no likely release route to the environment.

Some pharmaceuticals and packaging materials are known to contain PFAS (e.g., Tambocor, Prozac, Celebrex, lquix Dexilant, Arava, Clinoril) (Hammel et al. 2022).

The Salt Lake City VAMC has an on-site compounding pharmacy in Building 1. The pharmacy primarily stores and dispenses medicines but can also compound custom medications to fit a patient's needs. The medical research building (Building 2) also stores and uses pharmaceuticals.

Unused or expired pharmaceuticals are managed as hazardous waste and incinerated at an off-site facility. Sink disposal or flushing of any pharmaceutical is not an approved disposal method and is against Salt Lake City VAMC policy.

PFAS is a component of both X-ray films and developing solutions. In films, PFAS functions to reduce friction, static electricity, and surface tension (Connecticut Department of Energy and Environmental Protection 2018); in developing solutions, it functions primarily as a surfactant. The SLC VAMC currently uses digital medium to complete all X-rays, but historically, X-ray film was used. X-ray film was developed within the radiology department within Building 1. The film was recycled for its silver content, while developing solution was depleted during the development process and small volumes were discharged to the sanitary sewer by the automated development equipment. X-ray film development ceased in 2007, when the SLC VAMC transitioned to a digital medium (McPherson 2024).

Medical center janitorial staff uses a variety of Scotchgard cleaning products that contain perfluorobutane sulfonic acid (PFBS) including pretreatment cleaner, floor finish, and extraction cleaner. These products may be used throughout the campus but are primarily used in the hospital (Buildings 1 and 14) and medical research buildings (Building 2). Usage of these specialty cleaners varies depending on the department. A tile floor finishing product is used about two times a month. Pretreatment and extraction cleaners for carpets are used more sparingly, about once a month (Smith 2024). Spent cleaning solutions are disposed of through the sanitary sewer (e.g., emptying mop buckets).

PFAS is also a common treatment for garments and uniforms used in healthcare settings because of its water- and stain-resistant properties. Stain-resistant materials (e.g., scrubs, gowns) laundered at the facility (Building 7) could have released residual PFAS chemicals into the wash water, which was discharged to the sanitary sewer system. Additionally, Scotchgard-brand detergents likely containing perfluorooctanesulfonic acid (PFOS) (pre-2000), PFBS, and other PFAS were used in the laundry service to remove stains. The SLC VAMC contracted with a commercial laundry facility in 2019 and all laundering stopped in Building 7. All laundering equipment has been removed and the building is being converted to storage and administrative space. The laundering of PFAS-containing materials may have had the potential to release PFAS to the environment via similar mechanisms as historical PCE releases at the site.

There are roughly 19 other buildings on the SLC VAMC campus that perform a variety of services both for patients and to support facility operations. The electrical shop (Building 6) uses a no-flash contact cleaner that contains PFAS. This product is used to clean energized equipment with no likely release pathway into the environment beyond the equipment housing structures. The machine shop (Building 6) uses an acoustic sealant that contains 3,3-dichloro-1,1,1,2,2-pentafluoropropane and 1,3-dichloro-1,1,2,2.3-pentafluoropropane. This sealant is used throughout

the facility but presents no likely release pathway. A gel guard aerosol with PTFE was historically used at the boiler plant (Building 7) and the grounds shop (Building 38). It is used as a lubricant and is sprayed on metals with no likely release pathway.

The VA does not have records of emergency response events that used aqueous film-forming foam (a common source of PFAS contamination) at the facility nor does the SLC VAMC operate a fire department (Treasure, 2024).

The hospital has a helicopter pad to facilitate patient transport. The helipad is located southwest of Building 14. There is no dedicated or specialized fire suppression equipment at the helipad, only a large ABC fire extinguisher. The VA does not have records or institutional knowledge of incidents where firefighting foam may have been used (Treasure, 2024). The VAMC does not have records or documentation of spills of materials containing PFAS at the site.

While historical uses of PFAS-containing materials have been evaluated at the VAMC campus, locations and processes which may have released PFAS to the environment have not been identified or investigated and represent a data gap in the CSM for PFAS at the site.

Potential Exposure Pathways

Possible PFAS exposure pathways are described in this section, with the purpose of focusing potential environmental media sampling. Each pathway represents a means by which hazardous substances may pose a threat to human health and/or the environment.

Groundwater: Hazardous substance migration to and within aquifers; potential threats to drinking water. Groundwater is considered a potential exposure pathway due to (1) past laundering processes at the facility that used and discharged wash water and dry cleaning residuals potentially containing PFAS to the sanitary sewer system, where releases to the subsurface may have occurred through defects in the sewer line, and (2) proximity to the municipal drinking water well owned by Salt Lake City Public Utilities (less than 0.5 miles downgradient and cross gradient to the facility), which has been offline since 2004.

Surface Water: Hazardous substance migration to surface water bodies; potential threats to drinking water supplies, human food chain and/or sensitive environments. Based on past and current processes at the facility, there is no evidence to support a release of PFAS to the facility's stormwater collection system from overland flow or flooding and discharge to Red Butte Creek nor does the site hydrogeology indicate a migration pathway from groundwater to surface water at the SLC VAMC. Therefore, surface water is not considered a potential exposure pathway through use as a drinking water source or sustainment of aquatic life.

Soil: Potential threat to people on or near the site who may encounter exposed wastes and/or impacted soil; includes both soil ingestion and dermal exposure. Based on past and current processes at the facility, there is no evidence to support a release of PFAS to the surrounding soils.

The SLC VAMC did not operate an on-site landfill. Also, there are no documented incidents where firefighting foam was used at the facility in an emergency, nor does the SLC VAMC have a fire department that might have trained using foam. Therefore, soil is not considered a potential exposure pathway for dermal or ingestion exposure.

Air: Hazardous substance transport in gaseous or particulate form; potential threats to people and/or sensitive environments. Based on past and current operations at the facility, there is no evidence to support a release of PFAS to the air; therefore, air migration is not considered a likely exposure pathway.

Because PFAS sampling has not been completed at the site, data gaps remain with regard to identification of complete or potentially complete exposure pathways for PFAS.

QAPP Worksheet #11: Project/Data Quality Objectives

(UFP-QAPP Manual Section 2.6.1)

Consistent with EPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA 2006), the seven-step process was followed to define data quality objectives (DQOs) for the SI. The DQOs serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the SI. The output from each step influences the choices that will be made later in the process.

Step 1: State the Problem

The U.S. Department of Veterans Affairs operated a part-time dry cleaning operation that used PCE over a 6-year period in the late 1970s and early 1980s. PCE -contaminated groundwater is present beneath the VAMC property, and in areas hydraulically downgradient that extend to the East Bench Fault area. The site has been designated as a Superfund site and EPA has requested the VA to investigate whether PFAS compounds are present in environmental media at the site. PFAS have not been documented to have been released at the site, but PFAS-containing chemicals have historically been used in activities that were conducted at the VAMC.

The utility of PFAS in consumer and industrial products has resulted in their ubiquity in the environment. PFAS are known to be persistent, bioaccumulative, toxic, and mobile, prompting the development of regulations including drinking water MCLs (EPA 2024). Although the VAMC has never manufactured PFAS or used high-purity PFAS in site activities, PFAS-containing products were used on-site (e.g., cleaning and laundering products, medical products and devices) as described in the PA (VA 2024). Environmental media at the VAMC have not yet been sampled for PFAS; therefore, the presence or absence of PFAS in environmental media at the site is unknown.

The PFAS regulatory landscape is rapidly evolving. At this time, federal and state guidance and screening levels are specific to drinking water. Groundwater is not currently used as a source of drinking water on-site. However, the most current drinking water RSLs developed by EPA will be used as comparison values during the SI.

Step 2: Identify the Goals of the Study

The overarching objective of the SI is to assess the presence or absence of PFAS in groundwater at the site; groundwater is the sole environmental medium at the site for which there is a potential exposure pathway. Groundwater samples will be collected from selected existing wells to evaluate the presence or absence of PFAS in groundwater at the site.

Specific study questions are as follows:

1. Are the PFAS compounds measured using EPA Method 1633 present at concentrations above the most current version of the applicable screening levels (MCLs or RSLs) in groundwater at the VAMC?

2. If PFAS compounds, quantified by Method 1633, are detected in groundwater above the applicable screening levels, can the detections be attributed to specific locations or operations at the VAMC that were identified during the PA as potentially using PFAS?

If PFAS detections are greater than the applicable screening levels, additional evaluations such as spatial evaluation and compositional evaluation of PFAS will be used to evaluate whether the types of detected PFAS compounds and concentrations may be attributable to sources at the VAMC campus that were identified during the PA. If these evaluations indicate that PFAS are potentially attributable to sources at the VAMC campus, then sampling of additional media such as soil near suspected release points may be warranted. If necessary, plans for additional environmental sampling would be developed with input from EPA and UDEQ. If PFAS are not detected in groundwater at concentrations above applicable screening levels, then no further investigation of PFAS is necessary in groundwater at this time.

Step 3: Identify the Information Inputs

To achieve the project goals, the information inputs listed in Exhibit 1 are needed.

Exhibit 1. Project Goals and Information Inputs

Project Goal	Information Inputs
Contaminant identification and distribution	• PFAS concentrations in groundwater measured using EPA Method 1633 • Georeferenced sample locations and monitoring well screen intervals
Evaluation of detected PFAS and potential source areas	• PFAS concentrations in groundwater and sample locations • PA findings

Step 4: Define the Boundaries

The SI will focus on the area within the PCE plume characterized during the site RI, as well as existing monitoring well locations proximal to areas on the VAMC campus that may have used PFAS-containing products in the past. Groundwater samples will be collected from wells within the PCE plume, near potential PFAS use areas, and upgradient of the PCE plume (for background levels). The target analytes for this investigation are the PFAS compounds quantified using EPA Method 1633. Groundwater samples will be collected during the spring or early summer of 2025.

Step 5: Develop the Analytic Approach

PFAS concentrations in groundwater will be quantified at each sampled well. If PFAS are detected in groundwater, concentrations will be evaluated spatially to identify whether PFAS in groundwater are close to areas at the VAMC campus that may have used PFAS-containing

products in the past. PFAS detections will also be compared to available most current RSLs/MCLs, as applicable, to contextualize the magnitude of any potential detections. PFAS concentrations at monitoring wells will be evaluated against concentrations in upgradient wells within the study area to identify locations where PFAS, if present, may be migrating from source areas or release points to groundwater.

Step 6: Specify Performance or Acceptance Criteria

Samples will be collected and analyzed in accordance with this UFP-QAPP. Project quantification limits for sample results must be equal to or less than the project screening levels (RSLs and MCLs) as specified in Worksheet #15. Data generated during the SI will be evaluated to determine whether they are usable for their intended purpose. This is accomplished by using specific data validation processes to verify that analytical results are within acceptable limits, and by evaluating the analytical control limits and the precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) parameters once laboratory data packages are received. If significant issues with the data are found, the results will be discussed with USACE, EPA, UDEQ, and the VA. The VA will then decide whether the total study error could cause them to make an incorrect decision (i.e., either a false negative or positive) based on the information collected.

Step 7: Develop the Detailed Plan for Obtaining Data

The technical approach and field procedures for completion of SI sampling activities is described in Worksheet #17. Standard operating procedures (SOPs) are included in **Appendix A**.

QAPP Worksheet #12: Measurement Performance Criteria for PFAS (Aqueous)

(UFP-QAPP Manual Section 2.6.2)

(EPA 2106-G-05 Section 2.2.6)

Matrix: Aqueous

Analytical Group: PFAS – Method 1633

Concentration Level: Low (nanograms per liter [ng/L])

Laboratory: Sterling Labs

Data Quality Indicator	QC Sample or Measurement Performance Activity	Measurement and Performance Criteria
Overall precision	Field duplicate (FD)	RPD less than or equal to (≤) 30% if both sample and duplicate concentrations greater than or equal to (≥) 5 RL, otherwise absolute difference (ABS) ≤ RL
Analytical accuracy and precision	Initial demonstration of precision and recovery standard	Varies by analyte – recoveries are detailed in Method 1633 Table 5; range is 21%–37% relative standard deviation (RSD) and 50–160 percent recovery (%R)
Analytical accuracy	Ongoing precision and recovery standard (OPR) = LCS	Varies by analyte – recoveries are detailed in SOP Table 5; range is 40% - 150%%R
Analytical accuracy	Low-level Ongoing precision and recovery standard (LLOPR) = Low Level LCS	Varies by analyte – recoveries are detailed in SOP Table 5; range is 40% - 150%%R
Analytical accuracy	Extracted internal standard (isotopically labeled compounds)	Varies by analyte – recoveries are outlined in SOP Table 5; range is 20% - 150%%R
Analytical accuracy	Nonextracted internal standard (NIS)	Limits are outlined in laboratory SOP 5 (30%–150%) of the averaged area of the ICAL standards
Overall accuracy/bias	Field or equipment blank	≤ RLs (i.e., meet RLs on Worksheet #15)
Overall accuracy/bias Analytical accuracy/bias	Field blank/laboratory method blank/instrument blank (IB)	≤⅓ MRL and less than (<) ½ the limit of quantitation (LOQ) (IB)
Analytical accuracy/bias	Instrument sensitivity check (ICS) at LOQ level	±30% of expected values as detected in SOP Table 5
Accuracy (preservation)	Temperature blank	0 to 6 degrees Celsius (°C)

Data Quality Indicator	QC Sample or Measurement Performance Activity	Measurement and Performance Criteria
Completeness	Data assessment	≥90%
Comparability	Data review – compare results from each round	Similar units (ng/L)
Sensitivity	Nondetect sample results are assessed during data assessment	Nondetect sample results meet project RL goals (PQLGs) on Worksheet #15 if applicable

QAPP Worksheet #13: Secondary Data Uses and Limitations

(UFP-QAPP Manual Section 2.7)

The table below summarizes the main types of secondary data that are available for the site.

Data Type	Sources	Data uses relative to current project	Factors affecting the reliability of data and limitations on data use
Geological data, Hydrogeological data, Analytical data	Historical data, related to groundwater levels and flow paths, collected at or near the site under federal or state direction and oversight. Data were evaluated and summarized in the RI Report (CDM Smith 2022a)	Support site characterization	No known limitations as described in the RI Report (CDM Smith 2022a). Data included in the RI were collected under approved QAPPs for the project.

QAPP Worksheets #14 & 16: Project Tasks and Schedule

(UFP-QAPP Manual Section 2.8.2)

The project tasks and estimated schedule for this SI follow. Dates are approximate and subject to change based on field conditions. This QAPP will be reviewed on an annual basis and updated, as necessary, by the VA and revised at least every 5 years.

- QAPP Finalization – February 2025
- Groundwater sampling and sample analysis – March 2025
- Data validation and reporting – April to June 2025
- IDW management and disposal – April to May 2025
- Draft SI report – August 2025
- Final SI report – December 2025

QAPP Worksheet #15: Screening Levels and Quantitation Limits for PFAS (Aqueous)

(UFP-QAPP Manual Section 2.6.2.3)

Matrix: Aqueous

Analytical Group: PFAS – Method 1633

Concentration Level: Low (ng/L)

Laboratory: Sterling Labs

Analyte	Chemical Abstracts Service Number	MCL (ng/L)	RSL (ng/L)	PQLG (ng/L)	Achievable Laboratory Limits	
					MDL (ng/L)	MRL (ng/L)
Perfluorobutanoic acid (PFBA)	375-22-4	--	1,800	1,800	0.48	6.4
Perfluoropentanoic acid (PFPeA)	2706-90-3	--	--	--	0.14	3.2
Perfluorohexanoic acid (PFHxA)	307-24-4	--	990	990	0.13	1.6
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	--	0.16	1.6
Perfluorooctanoic acid (PFOA)	335-67-1	4.0	0.0027	4.0	0.12	1.6
Perfluorononanoic acid (PFNA)	375-95-1	10*	5.9	5.9	0.09	1.6
Perfluorodecanoic acid (PFDA)	335-76-2	--	0.004	0.004	0.13	1.6
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	600	600	0.19	1.6
Perfluorododecanoic acid (PFDoA)	307-55-1	--	100	100	0.11	1.6
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	--	0.07	1.6
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	2,000	2,000	0.12	1.6
Perfluorobutanesulfonic acid (PFBS)	375-73-5	*	600	600	0.19	1.42
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	--	--	--	0.21	1.51
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	10*	39	10	0.23	1.46

Analyte	Chemical Abstracts Service Number	MCL (ng/L)	RSL (ng/L)	PQLG (ng/L)	Achievable Laboratory Limits	
					MDL (ng/L)	MRL (ng/L)
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	--	--	--	0.41	1.52
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4.0	0.2	4.0	0.22	1.48
Perfluorononanesulfonic acid (PFNS)	68259-12-1	--	--	--	0.20	1.54
Perfluorodecanesulfonic acid (PFDS)	335-77-3	--	--	--	0.14	1.54
Perfluorododecanesulfonic acid * (PFDoS)	79780-39-5	--	--	--	0.08	1.55
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	--	--	--	0.41	6
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	--	--	--	2.77	6.08
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	--	--	--	0.61	6.14
Perfluorooctanesulfonamide (PFOSA)	754-91-6	--	--	--	0.10	1.6
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	--	--	--	0.26	1.6
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	--	--	--	0.29	1.6
N-methyl perfluorooctanesulfonamide-acetic acid (NMeFOSAA)	2355-31-9	--	--	--	0.44	1.6
N-ethyl perfluorooctanesulfonamide-acetic acid (NEtFOSAA)	2991-50-6	--	--	--	0.29	1.6

Analyte	Chemical Abstracts Service Number	MCL (ng/L)	RSL (ng/L)	PQLG (ng/L)	Achievable Laboratory Limits	
					MDL (ng/L)	MRL (ng/L)
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	--	--	--	1.01	16
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	--	--	--	1.26	16
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	10*	1.5	1.5	0.41	3.2
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	--	0.15	3.02
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	--	--	--	0.11	3.2
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	--	--	--	0.12	3.2
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	--	--	--	0.45	3.2

If an MCL is set for the analyte, the screening level is the MCL, otherwise the screening level is the RSL for tap water. RSLs corresponding to an excessive lifetime cancer risk of 1×10^{-6} and a hazard quotient of 0.1 were used (EPA November 2024). Data will be evaluated against the most current versions of MCLs and/or RSLs.

* For mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS, the MCL is set at a hazard index of 1.

The PQLG is defined as the MCL if a numeric value is available. If a numeric MCL is not defined, the PQLG is defined as the RSL.

1

QAPP Worksheet #17: Sampling Design and Rationale

(UFP-QAPP Manual Section 3.1.1)

PFAS groundwater sampling will be performed at five monitoring well locations at the site, strategically selected to provide information about the presence or absence of PFAS chemicals throughout the aquifer system. At monitoring well locations with multiple screen intervals, all intervals will be sampled. The sampling is part of a SI to understand whether PFAS are present in the subsurface resulting from historical PFAS usage and discharge of PFAS-containing materials to the sanitary sewer. Figure 1 presents the proposed wells to be sampled for PFAS.

Building	Activities	MW location	Justification	Method
1 and 14	Use of cleaning supplies and former x-ray development equipment resulting in past and current disposal of residual PFAS to sanitary sewer	MW-30RA MW-30RB MW-30C	MW-30 is hydraulically downgradient from Buildings 1 and 14. Northwest property boundary; onsite monitoring closest to SLC-18	EPA 1633
2	Use of cleaning supplies resulting in disposal of residual PFAS to sanitary sewer	MW-05R	MW-05R is hydraulically cross gradient from Building 2. This well is also upgradient of the PCE plume and of potential release points near Building 7 and will be used as the upgradient comparison location for PFAS samples collected within the PCE plume.	EPA 1633
7	Dry-cleaning and laundry service resulting in historical disposal of residual PFAS to the sanitary sewer	MW-24 MW-29A MW-29B MW-29C	MW-24 is near the sewer line connection to Building 7, downgradient of the former dry cleaning operation and upgradient of the PCE plume MW-29 is near the identified break in the sewer line; a suspected source of PCE	EPA 1633
Western property boundary		MW-03RA MW-03RB MW-03RC MW-03RD	MW-03R is hydraulically downgradient of campus activities and where the highest concentration of PCE has been observed	EPA 1633

Information on each monitoring well location is provided below.

Sampling Location	Total Depth (feet below ground surface)	November 2022 Depth to Water (feet below ground surface)	Screened Interval (feet below ground surface)	Most Recent PCE Concentration (µg/L)[1]	Pump Inlet Depth (feet below ground surface)
MW-30RA	252	230.15	240 - 250	0.22 J	245
MW-30RB	294	233.09	280 - 290	0.21 J	285
MW-30C	329	232.69	317 - 327	0.28 J	317
MW-05R	230	216.68	198 - 228	< 1	222
MW-24	250	187.64	209.5 - 239.5	2.2	211
MW-29A	132	116.69	120 - 130	9.4	128
MW-29B	202	157.32	190 - 200	0.28 J	190
MW-29C	242	160.71	230 - 240	< 1	230
MW-03RA	223	189.84	215 - 220	27	215
MW-03RB	275	207.88	267 - 272	130	267
MW-03RC	315	207.85	307 - 312	3.5	307
MW-03RD	367	208.04	359 - 364	< 1	359

Notes:
1 – PCE Concentration data from November 2022 except MW-29C (June 2022), MW-29B (June 2021) and MW-05R (December 2020)
J – estimated value
< - PCE not detected above the reporting limit shown

PFAS Sampling Considerations

PFAS are ubiquitous and found in many consumer and industrial products. Because of their oil- and water-repellant properties, they can be found in certain groundwater sampling products. The following are the materials to be aware of for PFAS sampling efforts.

Allowable Equipment, Supplies, and Personal Protective Equipment

The following materials are appropriate for PFAS sampling:

- Silicone, which is widely used in the construction of sample tubing, groundwater bailers, tape, pluming paste, and pipe thread lubricants, is acceptable. The user should confirm these are silicon-based products before use.
- Nitrile, primarily for gloves, and other nitrile field products are also recommended.

- High-density polyethylene (HDPE) is commonly found in bottles, pipes, tubing, pump bladders, seals and gaskets.
- Polyvinyl chloride is commonly used to form pipes and fittings, bailers, and brushes.
- Polypropylene is commonly used for field fabrics, packaging, clothing, and others.
- Acetate products may be sample sleeves, liners, and filters.
- Stainless steel is common in many sampling materials including pumps.
- Masonite or aluminum clipboards are recommended.
- Cotton fabric clothing is recommended.
- Ballpoint pens and untreated paper are recommended.
- Decontamination detergents Alconox or Liquinox are acceptable.
- Laboratory-certified, PFAS-free water is recommended for equipment blanks and trip blanks.
- The laboratory will provide labels, custody seals, and appropriate forms/documentation for sample shipment.
- Bags of water ice are acceptable.
- The laboratory will provide insulated cooler(s) with sample containers along with PFAS-free water.

Additional materials may be acceptable if certified not to contain PFAS by an accredited organization.

Equipment, Supplies, and Professional Protective Equipment to Avoid

The following materials should be avoided during PFAS sampling to the extent practical, unless contact with the sample collection path is prevented.

- Polytetrafluoroethylene (PTFE), commonly known by its tradename Teflon. PTFE-containing materials should be avoided. Teflon has been widely used in environmental sampling equipment, including groundwater bailers, soil gas and groundwater sample tubing, sample pumps, and septa for volatile organic compound sample vials. Many traditional submersible and bladder pumps used in environmental sampling programs contain PTFE washers and/or low-density polyethylene (LDPE) bladders. These should be avoided in favor of pumps constructed with silicon seals and HDPE or other suitable bladder material. In cases where elimination of all PTFE-containing materials is unavoidable (for example, seals in complex mechanical equipment), ensure adequate purging is performed before sampling and equipment blanks are collected before sampling.

- Teflex (ETFE)- and Neoflon (PCTFE)-containing materials should not be used.
- LDPE-containing materials (e.g., sample tubing, bags, or containers used to transport samples) should be avoided.
- Passive diffusion bags and HydraSleeves constructed with LDPE should be avoided.
- Sampling equipment components and sample containers should not come in contact with aluminum foil.
- Water-resistant, waterproof, stain-treated clothing or shoes including Gore-Tex and Tyvek material should not be used.
- Handling or use of fabric softener and dryer sheets should be avoided (such as when laundering) before PFAS sampling.
- Paper products that are treated such as waterproof field books, plastic clipboards, binders, spiral hard cover notebooks, sticky notes, or glue materials should be avoided.
- Permanent marker pens such as Sharpie should not be used.
- Water that is not verified to be PFAS-free for trip and equipment blanks should be avoided. This includes drill rig water tanks.
- Decontamination soaps containing fluorosurfactants, such as Decon 90, should be avoided.
- Chemical ice packs (i.e., blue ice) should not be used.

Mobilization

Mobilization to the site will include identifying specific equipment and services necessary for field support, obtaining bids for services and procurement for equipment, and coordinating the delivery and set up of this equipment. Mobilization will also include coordination with subcontractors and services prior to the start of fieldwork.

Groundwater Sampling

Groundwater sampling from monitoring wells with dedicated pumps will be completed using a low-flow purging technique, as described in **CDM Smith SOP 1-12 Low-Stress (Low-Flow) Groundwater Sampling**. Sampling will be completed using PFAS-free bladder pumps with the intake placed at the center of the well screen for wells with fully submerged screen intervals. For wells with partially submerged screen intervals, the pump will be placed at the center of the saturated portion of the screen interval. The pump at MW-24 is placed near the top of the screen interval based on historical sampling at this well which indicated the highest PCE concentrations were present in the upper portion of the screen interval. For existing wells MW-03R and MW-29, sampling pumps will be placed at the top of the screen intervals because the construction of the Zone Isolation Sampling Technology (ZIST) wells precludes lowering a pump into the screen interval. ZIST pumps are constructed of stainless steel with nitrile seals and HDPE filters; therefore, will be acceptable for PFAS sampling. All wells proposed for sampling except for MW-03RA/B/C/D currently have Teflon-lined tubing which will be removed and replaced with HDPE tubing before sampling. During purging with the

pumps, water quality parameters (pH, dissolved oxygen, oxidation-reduction potential, temperature, specific conductance, and turbidity) will be measured with a flow-through multiparameter at 3- to 5-minute increments, continuing until stabilization criteria are met as described in **CDM Smith SOP 1-12**, modified to permit stabilization of turbidity when three consecutive readings are below 10 nephelometric turbidity units (NTUs) or are within ±10% for values greater than 10 NTUs. High turbidity has the potential to bias PFAS analytical results in water samples. During sampling, additional purging time will be conducted if necessary to lower the turbidity of the sample to below 10 NTU to the extent practical. If a sample does not achieve a turbidity of less than 10 NTU, additional evaluation of the data will be necessary to evaluate its usability to meet the project objectives. If low-flow sampling is unable to achieve turbidity below 10 NTU, alternative sampling approaches may be considered. All field parameters will be recorded on low-flow purge field forms, and samples will be collected after parameter stabilization.

Water Level Measurements

Groundwater level measurements will be collected with an electronic water level meter, or transducer in monitoring wells according to **CDM Smith SOP 1-6, Groundwater Level Measurement**. Prior to the start of groundwater sampling, groundwater level measurements will be collected from all wells on the VA campus and downgradient (west) to Guardsman Way.

Sample Packaging and Shipment

Sample packaging and shipment procedures are detailed in **CDM Smith SOP 2-1, Packaging and Shipping Environmental Samples**. Samples will be stored on ice immediately after collection and during sample shipment. Sample coolers will be delivered or shipped overnight to the contracted laboratory.

Equipment Calibration

Field equipment requiring calibration (e.g., photoionization detectors, water quality meters) will be calibrated before the start of work of each sampling day according to the manufacturer's instructions. The calibration information (equipment serial number, date, time of calibration, standards used, readings before and after calibration) will be recorded on the appropriate field form and/or field logbook per **CDM Smith SOP 4-1**, **Field Logbook Content and Control**. If equipment drift or malfunction occurs during sampling, field personnel will stop and recalibrate the instrument, as necessary. Equipment that fails to calibrate will be removed from service and replaced with properly functioning equipment. Equipment calibration is discussed further in **CDM Smith SOP 5-1, Control of Measurement and Test Equipment.**

Decontamination and IDW Management

Decontamination of drilling and sampling equipment will occur before and after each use to prevent cross contamination. Decontamination will consist of a rinse of equipment with deionized water with either Alconox or Liquinox followed by a triple rinse with lab-supplied PFAS-free water. Personnel conducting decontamination procedures will wear, at minimum, gloves, steel toe boots, and safety glasses or chemical splash goggles. Decontamination equipment and materials will be containerized in accordance with the investigation-derived waste (IDW) management

procedures outlined in the IDW Management Plan in Appendix D. Field personnel will follow the decontamination procedures outlined in **CDM Smith SOP 4-5, Field Equipment Decontamination at Nonradioactive Sites**, for different types of equipment used during the field program.

Liquid IDW generated during this investigation will be stored on site in polyethylene tanks. Representative samples of the liquid IDW in tanks will be collected using a disposable bailer or peristaltic pump. IDW generated during this investigation will be profiled and disposed at an offsite facility.

Field Documentation

The following types of documentation will be used to record field activities:

- Field Logbooks – Field personnel will record all daily activities in bound and prenumbered logbooks. The FTL will keep the master field logbook and will document field activities. The FTL will retain original field logbooks. After field activities are complete, field logbook pages will be scanned and uploaded to the project file. Field documentation procedures are described in **CDM Smith SOP 4-1, Field Logbook Content and Control.** The field team will not use waterproof field notebooks or permanent markers at the time of sampling to avoid potential cross contamination with PFAS compounds.

- Field Forms – Field data will be captured on hard copy field forms, to be checked in the field for completeness and accuracy and reviewed by an independent reviewer. Scanned field forms will be included in technical memoranda/reports that summarize field activities. Information captured in the appropriate field form does not need to be duplicated in the field logbook. However, the logbook should reference the activities completed and documented on field forms.

- Photographs – Photographs may be taken in the field to document sampling locations, lithology, collected samples, and field conditions. Any photographs taken will be documented in a photographic log that will include the date, location, photographer's name, and the direction the photographer was facing. Selected photographs will be used in reports as deemed necessary or appropriate. Photographic procedures are described in **CDM Smith SOP 4-2, Photographic Documentation of Field Activities.**

- Chain-of-Custody Forms – Chain-of-custody form procedures will document sample collection and possession. Chain-of-custody forms will be developed electronically and printed or completed in blue or black ink and will include the sample identifiers, the date and time of sample collection, and the requested analyses. The designated sampling team member will sign all chain-of-custody forms and custody seals. Custody seals will be applied to coolers before shipment. A copy of all chain-of-custody forms will be retained in the project file. Sample custody procedures are described in **CDM Smith SOP 1-2, Sample Custody.**

All sample labels will include, at minimum, the following information:

- Sample name/number
- Time and date of sample collection
- Site name and location
- Sample type and matrix
- Preservative
- Analysis method
- Sample nomenclature will consist of three components as follows:
  - Component 1 – Sample Location
    - *Example: MW30RA = Monitoring well MW-30RA*
    - *FD01 = Field duplicate #1; the parent sample will be noted on groundwater field sampling forms and in the field logbook*
    - *FB01 = field reagent blank #1*
    - *RB01 = equipment rinsate blank #1*
  - Component 2 – Sample Media
    - *GW = groundwater*
  - Component 3 – Sample Date (MMDDYY) (e.g., 030125, 042125)

  Examples are given below for each type of sample collection planned:

  - Normal groundwater sample collected from monitoring well MW-30RA on March 1, 2025 = *MW30RA-GW030125*
  - First groundwater field duplicate collected on March 1, 2025 = *FD01-GW030125*

QAPP Worksheet #18: Sampling Locations and Methods

(UFP-QAPP Manual Section 3.1.1 and 3.1.2)

Sampling locations are presented in **Figure 1**.

Building	Activities	Sampling location	Justification	Method
1 and 14	Use of cleaning supplies and former x-ray development equipment resulting in past and current disposal of residual PFAS to sanitary sewer	MW-30RA MW-30RB MW-30C	MW-30 is located hydraulically downgradient from Buildings 1 and 14. Northwest property boundary; onsite monitoring closest to SLC-18	EPA 1633
2	Use of cleaning supplies resulting in disposal of residual PFAS to sanitary sewer	MW-05R	MW-05R is hydraulically cross gradient from Building 2. This well is also upgradient of the PCE plume and of potential release points near Building 7 and will be used as the upgradient comparison location for PFAS samples collected within the PCE plume.	EPA 1633
7	Dry-cleaning and laundry service resulting in historical disposal of residual PFAS to the sanitary sewer	MW-24 MW-29A MW-29B MW-29C	MW-24 is near the sewer line connection to Building 7, downgradient of the former dry cleaning operation and upgradient of the PCE plume. MW-29 is near the identified break in the sewer line; a suspected source of PCE	EPA 1633
Western property boundary		MW-03RA MW-03RB MW-03RC MW-03RD	MW-03R is hydraulically downgradient of campus activities and where the highest concentration of PCE has been observed	EPA 1633
	Field Duplicate	To be determined	QA/QC Sample	EPA 1633
	Field Blank	To be determined	QA/QC Sample	EPA 1633
	Equipment Blank	To be determined	QA/QC Sample	EPA 1633

QAPP Worksheets #19 & 30: Sample Containers, Preservation, and Hold Times

(UFP-QAPP Manual Section 3.1.2.2)

Laboratory: Sterling Labs

Required Accreditations/Certifications: See Worksheets #4, 7 and 8 for laboratory accreditation and expiration dates

Sample Delivery Method: FedEx Next Day via cooler

Analyte	Matrix	Analytical Method	Container Requirements	Preservative	Analytical and Preparation Holding Times	Data Package Turnaround
PFAS	Aqueous	Method 1633	2 x 500 ml HDPE with polypropylene cap; 1 x 250 ml HDPE w/ polypropylene cap	0-6°C	28 days extraction if held at 0-6°C; Max 90 days if frozen < -20°C	21 days

Aqueous samples should be stored below 6°C and protected from light for the 28-day holding time.

QAPP Worksheet #20: Field QC Summary

(UFP-QAPP Sections 3.1.1 and 3.1.2)

Matrix	Analytical Group	FDs	Equipment Rinsate Blanks	Field Reagent Blanks
Water	PFAS	1 per 10 samples	1 per day	1 per day

PROCEDURE FOR COLLECTION OF FIELD QC SAMPLES

FDs: FDs are collected and analyzed to assess the overall precision of the field sampling technique. Duplicate samples of the same matrix will be collected at a rate of 10% (1 per 10 samples). These duplicates will be submitted "blind" to the laboratories by using sample numbers that differ from their associated environmental samples. Duplicate samples will be collected by alternately filling bottles/jars for the same analysis. FDs for groundwater will be collected by filling two sets of bottles for each analyte.

Field Blanks: Field blanks are used to evaluate potential for ambient background cross contamination of sampled groundwater and air. For groundwater field blanks, PFAS-free water supplied by the laboratory will be poured directly from its original container into laboratory-supplied sample containers for PFAS analysis. Field blanks will be collected at a frequency of 1 per day.

Equipment Rinsate Blanks: Field equipment blanks will be collected at a frequency of 1 per day. Rinsate blanks, otherwise called equipment blanks, are used to assess the effectiveness of equipment decontamination. Equipment blanks will be collected before the use of decontaminated equipment for sampling.

For aqueous samples, equipment blanks will be collected on reusable decontaminated sampling equipment by pouring demonstrated PFAS-free water over or through the decontaminated sampling device.

Cooler Temperature Indicators: One cooler temperature indicator or temperature blank will be placed in each cooler containing samples (solid and aqueous) being sent to the laboratory for analysis. The temperature blank will consist of a sample container filled with unpreserved water (potable or distilled). The container will be labeled "Temperature Blank" and dated.

QAPP Worksheet #21: Field SOPs

(UFP-QAPP Manual Section 3.1.2)

SOP Reference Number	Title and Revision Date	Originating Organization	SOP Option or Equipment Type (if SOP Provides Different Options)	Comments
1-2	Sample Custody, August 2020	CDM Smith	NA	
1-5	Groundwater Sampling Using Bailers, August 2020	CDM Smith	Polyethylene or stainless steel bailer if needed	
1-6	Groundwater Level Measurement, August 2020	CDM Smith	Electrical tape, pressure gauge, and transducer	
1-10	Field Measurement of Total Organic Vapors, February 2020	CDM Smith	Photoionization detector	
1-12	Low-Stress (Low-Flow) Groundwater Sampling	CDM Smith	NA	
2-1	Packaging and Shipping Environmental Samples, August 2020	CDM Smith	NA	
2-2	Guide to Handling Investigation-Derived Waste, August 2020	CDM Smith	NA	
4-1	Field Logbook Content and Control, August 2020	CDM Smith	NA	
4-2	Photographic Documentation of Field Activities, August 2020	CDM Smith	NA	
4-5	Field Equipment Decontamination at Nonradioactive Sites, March 2020	CDM Smith	NA	Acids and solvents will not be used
5-1	Control of Measurement and Test Equipment, August 2020	CDM Smith	NA	
	YSI Pro1030 Multiparameter Meter Manual	YSI	NA	
	LaMotte 2020t/I Turbidity Meter Manual	LaMotte	NA	

NA indicates no specific SOP options.

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

(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment	Activity	SOP Reference	Title or Position of Responsible Person	Frequency	Acceptance Criteria	Corrective Action
Multiparameter Water Quality Meter	Calibrate at the beginning of the day and check calibration at the end of the monitoring event with standards. Maintain, as needed, in the field; semiannually by supplier.	Manufacturer's specifications	FTL	Calibrate a.m., check p.m.	pH: ±0.2 pH units conductivity: ±10 microSiemens DO: ±0.1 milligrams per liter Temperature: ±0.2°C ORP: ±20 millivolts	Manually zero meter or service, as necessary, and recalibrate, return to rental company for replacement
Turbidity Meter	Calibration check at the beginning and end of the day. Maintenance performed, as needed, by supplier.	Manufacturer's specifications	FTL	Check a.m. and p.m.	±1 NTU or ±10% for turbidity greater than (>) 10 NTUs	Manually zero meter or service, as necessary, and recalibrate, return to rental company for replacement
RAE Systems MiniRAE 3000 organic vapor meter/ photoionization detector or equivalent with 10.6-electron-volt lamp	Calibrate at the beginning of each work day; check calibration at end of each day. Maintenance performed, as needed, by supplier.	CDM Smith SOP 1-10	FTL	Calibrate a.m., check p.m.	±10% of the calibrated value	Manually zero meter or service, as necessary, and recalibrate
Camera	Calibration, maintenance, testing, and inspection are not required for cameras used for photographic documentation.	NA	FTL	NA	NA	NA

QAPP Worksheet #23: Analytical SOPs

(UFP-QAPP Manual Section 3.2.1)

Analytical Method/SOP #	Analytical Laboratory	Title, Date, and URL (if available)	Definitive or Screening Data	Matrix/Analytical Group	SOP Option or Equipment Type	Modified for Project? Y/N
EPA 1633/ EMT-SOP-O-1633	Sterling Labs	Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solids, and Biosolid Samples by LC-MS/MS, Rev. 2, 10/5/2023	Definitive	Water/PFAS	Liquid chromatograph/mass spectrometry	N

QAPP Worksheet #24: Analytical Instrument Calibration

(UFP-QAPP Manual Section 3.2.2)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria[1]	Corrective Action	Person Responsible for Corrective Action	SOP Reference
Instruments used for analyses follow the calibration frequencies outlined in each method SOP						
LC/MS/MS	Initial Calibration (ICAL)	Before sample analysis	If RSD used, must be </= to 20% or RSE of the ICAL must be </= 20%.	Correct problem, then repeat ICAL.	Analyst or certified instrument technician	EMT-SOP-0-1633
	Retention Time (RT) window	After ICAL and at the beginning of analytical sequence. .	Use midpoint ICAL or opening CV/ CCV to verify RT within 0.4 minutes and isotopically labelled isotopes within 0.1 minute of associated EIS	Correct problem, then repeat ICAL.		EMT-SOP-0-1633
	Qualitative Identification Standard (available Branched and Linear isomer RT window confirmation)	At start of analysis prior to field samples containing available branched and linear isomers to confirm RT	All analytes must be within 0.4 minutes of predicted RT from midpoint of ICAL or opening CV (CCV)	Correct problem, then repeat ICAL.		EMT-SOP-0-1633
	Initial Calibration Verification (ICV)	After each ICAL and prior to analysis	Within 30% recovery, midpoint of ICAL	Correct problem, then repeat ICAL.		EMT-SOP-0-1633
	Calibration Verification (CV or CCV)	At the beginning and after every 10 samples, then to close analysis run	At mid-level of ICAL and must be within 30%	Correct problem, then repeat ICAL.		EMT-SOP-0-1633

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

(UFP-QAPP Manual Section 3.2.3)

Information is provided in the laboratory QA manuals and SOPs for laboratories that will be performing the analytical work (Appendix B).

Instrument/ Equipment	Maintenance Activity	Testing Activity Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Title/Position Responsible for Corrective Action	Reference
LC/MS/MS	Ensure unit is equilibrated	N/A	Daily	N/A	N/A	Analyst, Technical Manager, Supervisor, or Service tech.	EMT-SOP-O-1633
	Check drain, empty waste as needed	Visual Checks	As needed	N/A	N/A	Analyst, Technical Manager, Supervisor, or Service tech.	EMT-SOP-O-1633
	Check and clean cooling fan filters/ vents if getting dusted to ensure proper cooling air flow	N/A	Monthly	N/A	N/A	Analyst, Technical Manager, Supervisor, or Service tech.	EMT-SOP-O-1633
Thermometer	Per manufacturer instructions						

QAPP Worksheets #26 & 27: Sample Handling, Custody, and Disposal

(UFP-QAPP Manual Section 3.3)

Sampling Organization: CDM Smith

Laboratory: Sterling Labs; 509 North 3rd Avenue, Des Plaines, IL 60016

Method of Sample Delivery (shipper/carrier): FedEx

Number of Days from Reporting until Sample Disposal: Subcontract laboratory as specified in scope of work.

Activity	Organization and Title or Position of Person Responsible for the Activity	SOP Reference
Sample labeling	CDM Smith – FTL	CDM Smith SOP 1-2 and SOP 4-1 Sample nomenclature is described in Section 6.13 of the Treatability Study Work Plan
Chain-of-custody form completion	CDM Smith – FTL	CDM Smith SOP 1-2
Packaging	CDM Smith – FTL	CDM Smith SOP 2-1 for field samplers
Shipping coordination	CDM Smith – FTL, CDM Smith ASC	CDM Smith SOP 2-1
Sample receipt, inspection, and log-in	Laboratory custodian	Analytical scope of work and laboratory SOPs
Sample custody and storage	CDM Smith and laboratories	CDM Smith SOP 1-2 and analytical statement of work or laboratory QA manual
Sample disposal	Laboratory custodian	Laboratory SOPs

QAPP Worksheet #28: Analytical QC and Corrective Action for PFAS (Aqueous)

(UFP-QAPP Manual Section 3.4 and Tables 4, 5, and 6)

Matrix: Aqueous

Analytical Group: PFAS

Analytical Method/SOP Reference: Method 1633

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Project-Specific MPC
FD	1 per sample batch not >10 samples	None	Data assessor to inform PM if RPD or ABS exceeds MPC	Laboratory analyst/FTL	RPD ≤ 30% if both sample and duplicate concentration ≥5 times the RL, otherwise absolute difference (ABS) ≤ RL
Equipment blank	1 per decontamination event for nondisposable equipment/1 per day	< QL	Identify source and eliminate. Reanalyze blank and affected samples if sufficient sample remains. ASC will alert project team of repeated or widespread exceedances. The FTL will review field decontamination procedures and retrain samplers.	Laboratory analyst/CDM Smith ASC/FTL	≤ QL
Temperature blank	1 per cooler	≤ 6 °C	Inform field crew to use adequate coolant	Laboratory analyst/FTL	0 to ≤ 6 °C
Field blank	1 per sampling event	≤ ⅓ MRL	Sample results are invalid. Recollect and reanalyze samples	Laboratory analyst	≤ ⅓ MRL
Laboratory method blank	1 per sample batch not to exceed 10 samples	See laboratory SOP	Correct problem. If required, re-prepare and reanalyze with all QC samples and field samples processed with the contaminated blank.	Laboratory analyst	< LOQ, or less than 10% of any detection

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Project-Specific MPC
Instrument Blank	Daily prior to analysis and following highest standard, following each CCV, and following any sample with analytes exceeding ICAL range.	<½ LOQ	Calibration must be performed using a lower concentration standard for the high standard until the criteria are met.	Laboratory analyst	<½ LOQ
Extracted Internal Standard	Add to all ICAL standards, batch QC and field samples.	20 to 150%	Re-vial a fresh aliquot and reanalyze. If extraction standard recovery(ies) is still outside the QC limit(s), reanalyze the sample at a dilution. If extraction standard recovery(ies) is still outside the QC limit(s), reextract using a reduced sample volume. If extraction standard recovery(ies) is still outside the QC limit(s), narrate as a nonconformance and report the data.	Laboratory analyst	Limits outlined in laboratory SOP
Non-extracted Internal Standard	Add to all ICAL standards, batch QC and field samples.	>30% of the averaged area of the ICAL standards. Limits 30 to 150%.	Consult a supervisor to determine the appropriate course of action based on batch and sample results.	Laboratory analyst	30%–150% of the average areas measured during the initial calibration
OPR = LCS	One per preparatory batch.	40 to 150%	Re-extract and reanalyze samples as required. Contact client if required for consultation on additional measures need to be taken.	Laboratory analyst	40 to 150%
LLOPR = Low Level LCS	Prior to analyzing samples, one per prep batch	40 to 150%	Re-extract and reanalyze samples as required. Contact client if required for consultation on additional measures need to be taken.	Laboratory analyst	40 to 150%

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Project-Specific MPC
Initial demonstration of precision and recovery	For each matrix type, analyze four extracted replicate standards and a method blank	Compounds recoveries must fall into corresponding ranges in Table 5 of Method 1633	Repeat analyses of the four extracted replicate standards and method blanks until criteria is met.	Laboratory analyst	Recoveries listed in Table 5 of Method 1633
Instrument sensitivity check – at LOQ level	Daily, prior to sample analysis	±30% of expected value	Correct the problem and rerun instrument sensitivity check. If problem persists, repeat instrument calibration.	Laboratory analyst	±30% of expected value

QAPP Worksheet #29: Project Documents and Records

(UFP-QAPP Manual Section 3.5.1)

The DMP is presented in Appendix E.

Record	Generation	Verification	Storage Location/Archival
Sample Collection and Field Records			
Field logbooks	FTL/sampling team	PTL/FTL	Project file
Equipment calibration records	FTL/sampling team	PTL/FTL	Project file
Chain-of-custody forms	CDM Smith ASC	FTL	Project file
Field data collection forms (groundwater)	FTL/sampling team	PTL/FTL	Project file
Relevant correspondence	PTL/FTL/sampling team	PTL/FTL	Project file
Minor field modifications/deviations	FTL/sampling team	PM/PTL	Project file
Field surveillance checklists	FTL/sampling team	PTL/FTL	Project file
Field corrective action reports	FTL/sampling team	PTL/FTL	Project file
Photographs	FTL/sampling team	PTL/FTL	Project file
Health and safety forms, reports, training, and incident reports	FTL, PM, PTL, or safety and health manager	PM/PTL/safety and health manager	Project file
Project Assessments			
Field sampling audit plans, reports, and checklists	QA specialist	PTL/PM/QA specialist	Project file
Corrective action reports	QA specialist	PTL/PM/QA specialist	Project file
Analytical sample results	Laboratory	ASC	Project file
Data usability assessment report	ASC	PTL/PM/QA specialist	Project file
Subcontract laboratory QA plan	Laboratory	PTL/PM	Project file
QC audit reports	QA manager	QA manager/PTL/PM	Project file
Data validation reports	ASC	PTL/PM	Project file
Data package completeness checklist	ASC	PTL/PM	Project file
Validated data reports	ASC	PTL/PM	Project file

Record	Generation	Verification	Storage Location/Archival
Laboratory Records			
Sample receipt, custody, and tracking logs	Per laboratory QA manual	Per laboratory QA manual	Laboratory project file
Sample preparation logs	Per laboratory QA manual	Per laboratory QA manual	Laboratory project file
Corrective action reports	Per laboratory QA manual	ASC	Project file
Subcontract laboratory certifications	ASC	PM	Project file
Corrective action forms	Per laboratory QA manual	ASC	Project file
Data packages (case narratives, sample results, QC summaries, and raw data (detailed in CLP SOPs)	Per laboratory QA manual	Laboratory PM	Project file
Sample analysis run logs	Per laboratory QA manual	Per laboratory QA manual	Laboratory project file
Other Records			
Subcontract documents (contract, scopes of work, bid sheets), subcontract documents, and review forms	Subcontractor	PM	Project file

Note: Project records will be retained for a minimum of 10 years in accordance with CERCLA requirements.

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

(UFP-QAPP Manual Sections 4.1.1 and 4.1.2)

Sample results and QC data will be delivered to CDM Smith as an electronic data deliverable (EDD). Electronic copies of all CDM Smith project deliverables, including graphics, are maintained by project number in CDM Smith's data storage/management systems (ProjectWise). Electronic files are routinely backed up and archived. The final QAPP will be submitted to EPA electronically.

Data other than laboratory data include electronic field tool data, field logbooks, annotated maps, and access forms. Those data will be electronically scanned (as necessary) and stored in the project folder following each sampling event. Electronic copies will be stored indefinitely both at the local CDM Smith office and in CDM Smith's data storage/management system (ProjectWise). ProjectWise is a secure, cloud-based file management system and all files are subject to a rigorous maintenance and backup plan with backups completed daily.

Data will be collected under the supervision of an FTL experienced with the sampling methods and procedures. The FTL will observe new and junior-level staff, as appropriate, to verify they are using appropriate methods in accordance with the QAPP and relevant SOPs. The FTL will review logbook entries and completed field data collection forms to verify that observations and information are being recorded correctly. Any issues that are identified will be communicated to the field staff and promptly corrected; additional corrective action (e.g., rereading of planning documents, retraining on procedures) will be taken as needed. The FTL will communicate any field issues to the CDM Smith PM and QA specialist as appropriate.

Assessments:

Assessment Type	Responsible Party/ Organization	Number/Frequency	Estimated Dates	Assessment Documentation[1]	Deliverable Due Date
Field planning/ readiness review meeting	PM/CDM Smith	Once, prior to mobilization for each field sampling event, repeated if significant changes in the sampling program occur or if significant time has passed (i.e., a new season of sampling)	TBD	Field Planning Meeting Form and Readiness Checklists	Field Planning Meeting Form within 24 hours of meeting and stored in project files
Field deviations from work plan/QAPP	Field samplers, FTL/CDM Smith	Continuous during sampling event	TBD	Logbook (minor deviation), Minor Field Modification Form (major deviation)	FTL notifies PM within 24 hours of deviation
Health and safety audit	SHSO or qualified designee/CDM Smith	Once if warranted	TBD	Audit Checklist	Notify by phone immediately Report 1 week after audit

Assessment Type	Responsible Party/ Organization	Number/Frequency	Estimated Dates	Assessment Documentation[1]	Deliverable Due Date
Field data collection QC	FTL/CDM Smith	Daily checks of field sampling procedures, logbooks, chain-of-custody forms, and field data collection forms to verify field data and observations are collected and recorded correctly	Daily during sampling	None	FTL notifies PM and field staff immediately if issues are identified
Field surveillance	FTL or QA Staff/CDM Smith	Once during each field event	TBD	Field surveillance checklists	FTL or QA staff notifies PM and technical team immediately if issues are identified
Analytical sample receipt	PM/analytical laboratories	Daily, when samples are shipped and/or delivered to analytical laboratories	TBD	Sample check in form Email confirmation of sample receipt Laboratory report	Analytical PM notifies CDM Smith staff via email immediately if issues are identified
Deviations from the QAPP, data collection QC	FTL/CDM Smith	One comprehensive QA review	During reporting	Applicable report	QA specialist notifies technical team for corrections to be made prior to document submittal

[1] Assessment documentation provided under separate cover in the Contractor Quality Control Plan (CDM Smith 2022b)

Assessment Response and Corrective Action:

Assessment Type	Responsible for Responding to Assessment Findings	Assessment Response Documentation	Timeframe for Response	Responsible for Implementing Corrective Action	Responsible for Monitoring Corrective Action Implementation
Field planning/readiness review meeting	FTL/CDM Smith	Field planning meeting form and readiness checklists	Within one week of the meeting	PM and FTL	PM
Field deviations from work plan/QAPP	PM, FTL/CDM Smith	Logbook	Immediately to within 24 hours of deviation	PM and FTL	PM, FTL, QA specialist
Health and safety audit	PM, FTL/CDM Smith	Memorandum and checklist	Immediate corrective action required where possible;	PM and FTL	SHSO

Assessment Type	Responsible for Responding to Assessment Findings	Assessment Response Documentation	Timeframe for Response	Responsible for Implementing Corrective Action	Responsible for Monitoring Corrective Action Implementation
			otherwise as specified on the corrective action notice		
Field data collection QC	PM, FTL/CDM Smith	Logbook, chain-of-custody forms, and field forms	Immediate corrective action required where possible; otherwise as specified on the corrective action notice	PM and FTL	PM, FTL, QA specialist
Field surveillance	PM, FTL/CDM Smith	Field surveillance checklist	Immediate corrective action required where possible; otherwise as specified on the corrective action notice	PM and FTL	PM, FTL, QA specialist
Analytical sample receipt	ASC, FTL/CDM Smith	Email, Quality Control Report	Immediately to within 24 hours of deviation	ASC and FTL	PM, ASC, QA specialist
Deviations from the QAPP, data collection QC	PM, FTL/CDM Smith	Applicable report	Prior to document submittal	PM and FTL	PM, FTL, QA specialist

QA updates will be provided to the CDM Smith PM whenever quality problems are encountered. Field staff will note any minor quality problems in the logbook and major deviations will be noted on a Minor Field Modification Form. CDM Smith's PM will inform the project QA specialist via email upon encountering major quality issues that cannot be immediately corrected. CDM Smith grants every employee stop work authority if quality or health and safety issues are observed. The USACE PM and their designee also has stop work authority.

QAPP Worksheet #34: Data Verification and Validation Inputs

(UFP-QAPP Manual Section 5.2.1 and Table 9)

Below are the inputs that will be used during data verification and validation. Inputs include planning documents, field records, and laboratory records. Data verification is a check that all specified activities involved in collecting and analyzing samples have been completed and documented and that the necessary records (objective evidence) are available to proceed to data validation. Data validation is the evaluation of conformance to stated requirements, including those in the contract, methods, SOPs, and the QAPP.

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)
Planning Documents/Records			
1	Approved QAPP	X	
2	Contract	X	
3	Field SOPs	X	
4	Laboratory SOPs	X	
Field Records			
5	Field logbooks	X	X
6	Equipment calibration records	X	X
7	Chain-of-custody forms	X	X
8	Sample location and feature Global Positioning System data	X	
9	Drilling/boring logs	X	X
10	Field data collection forms	X	X
11	Relevant correspondence	X	X
12	Minor Field Modification Forms/deviations	X	X
13	Field surveillance checklists	X	X
14	Field corrective action reports	X	X
Analytical Data Package			
15	Cover sheet (laboratory identifying information)	X	X
16	Case narrative	X	X
17	Internal laboratory chain-of-custody forms	X	X

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)
18	Sample receipt records	X	X
19	Sample chronology (i.e., dates and times of receipt, preparation, and analysis)	X	X
20	Communication records	X	X
21	Project-specific performance testing sample results (if applicable)	X	X
22	RL establishment and verification	X	X
23	Standards traceability	X	X
24	Instrument calibration records	X	X
25	Definition of laboratory qualifiers	X	X
26	Results reporting forms	X	X
27	QC sample results	X	X
28	Laboratory corrective action reports	X	X
29	Raw data	X	X
30	EDDs	X	X

QAPP Worksheet #35: Data Verification Procedures

(UFP-QAPP Manual Section 5.2.2)

Records Reviewed	Requirement Documents	Process Description	Responsible Person, Organization
QAPP	QAPP, SOPs	All planning documents will be available to reviewers to allow reconciliation with planned activities and objectives	All data users
Field logbook	QAPP, CDM Smith SOP 4-1	Data verification includes the following steps: ▪ Field records are present and complete for each day of field activities ▪ All planned samples, including field QC samples, were collected and sample collection locations were documented ▪ Meteorological data were provided for each day of field activities ▪ Changes/exceptions were documented and reported in accordance with requirements ▪ Required field monitoring was performed and results documented	Daily – FTL At conclusion of field activities – FTL
Field data collection forms and calibration logs	QAPP, CDM Smith SOP 5-1, CDM Smith SOP 3-5	▪ Calibration logs are completed and calibration meets the criteria in Worksheet #22 ▪ All field data collection forms are filled out completely and accurately ▪ All relevant observations and notes are included, and field forms/notes are scanned and stored electronically at the conclusion of field activities	Daily – FTL At conclusion of field activities – FTL
Chain-of-custody forms	QAPP, CDM Smith SOP 1-2	▪ Completeness and correctness of chain-of-custody forms ▪ Examine entries for consistency with the field logbook ▪ Check that appropriate methods and sample preservation have been recorded ▪ Required volume of sample was collected and sufficient sample volume is available for QC samples (e.g., matrix spike/matrix spike duplicate [MS/MSD]) ▪ All required signatures and dates are present and no transcription errors	Daily – FTL At conclusion of field activities – project chemist/ASC
Laboratory deliverable	QAPP	▪ Laboratory deliverable contains all records specified in the QAPP ▪ Sample receipt conditions are recorded and documented ▪ Missing/broken sample containers noted and reported according to plan ▪ Data package includes the contaminants of concern and results were provided for all collected samples ▪ Laboratory narrative describes all QC exceptions ▪ Required notifications were provided to project personnel as specified in the QAPP	Before release – laboratory quality manager Upon receipt by CDM Smith – project chemist/ASC

Records Reviewed	Requirement Documents	Process Description	Responsible Person, Organization
		▪ Necessary signatures and dates are present	
EDDs	QAPP, SOPs, laboratory QA manual	Required fields and format conform to the format specified in the laboratory contract and DMP	Upon receipt – CDM Smith project chemist/ASC

QAPP Worksheet #36: Data Validation Procedures

(UFP-QAPP Manual Section 5.2.2)

CDM Smith data validators will validate 100% of definitive subcontract laboratory data using the criteria establish in the analytical methods, the final QAPP, and *Guidance on Environmental Data Verification and Data Validation* (EPA 2002) for qualification to be applied when QC limits are exceeded. The data validator will be independent of the sampling team and of the analytical laboratory. The QAPP criteria are used during validation in conjunction with the EPA NFGs for any specific criteria limits. Analytical methods are used during validation if method specific QC elements are not thoroughly discussed in the EPA National Functional Guidelines and/or the QAPP, and if applicable. Stage 4 validation protocols (S4VM) will be used for 10% of the laboratory data, and the remaining 90% of data will be validated using Stage 2b validation protocols (S2BVM). Validated data will be assessed for usability as described in Worksheet #37. Data assessment and validation will determine whether collected data can be used as intended.

Individual data validation reports are prepared for each sample delivery group (SDG). The validation report provides information on the following items as applicable per method: SDG number; laboratory; media; sample collection date; methods; sample names; laboratory identifier; guidance documents; PARCCS elements (precision: FDs, MS/MSDs, LCS/laboratory control sample duplicates (LCSDs), laboratory duplicates; accuracy: MS, LCS, method blanks, field blanks, calibrations, tuning, surrogates, internal standards; representativeness: sampling procedure and design criteria, holding times, precision criteria, contaminant of concern documentation; comparability: analytical procedures and methods followed; completeness: data usability; sensitivity: MDLs, RLs). All QC elements that are outside of required criteria are discussed in the reports along with the qualifier required and the associated samples. An EDD from the laboratory is updated for each SDG with the appropriate qualifier if required. The EDD is then loaded into the project-specific EQuIS database. A QC summary report as identified in Worksheet #37 is then prepared that discusses all data quality items from the data validation performed as well as all PARCCS related items for the sampling activities. The individual data validation reports are an appendix to this QC summary report.

The data validation process is summarized in the table that follows.

Validation Input	Description	Responsible for Validation
Frequency	Review data at 10% S4VM and 90% S2BVM levels.	Data validator
SOPs	Verify the sampling methods/procedures outlined in QAPP were followed, and any deviations were noted/approved. Determine potential impacts from noted/approved deviations of DQOs.	FTL, PTL, QA specialist
Chain-of-custody forms	Examine chain-of-custody forms against the QAPP and laboratory contract requirements (e.g., analytical methods, sample identification). Examine traceability of data from sample collection to generation of project reported data, including sampling dates and times, sample IDs, and QC sample information.	Data validator

Validation Input	Description	Responsible for Validation
Laboratory data package	Examine laboratory data packages against the QAPP and laboratory contract requirements, and against chain-of-custody forms (e.g., holding times, sample handling, analytical methods, sample identification, data qualifiers, QC samples). Determine potential impacts from noted/approved deviations on DQOs.	Data validator
Laboratory data package	Verify analytical procedures were followed. Corrective actions will be taken and documented, when applicable, per specific methods. Deviations will be documented. Data will be qualified in accordance with the EPA National Functional Guidelines (inorganic and organic) (EPA 2020a, 2020b) when QC limits are exceeded.	Data validator, ASC
FDs	Compare results of FD (or replicate) analyses with RPD criteria.	Data validator, ASC
Methods	Verify records support implementation of the SOP for sampling and analysis.	
Data narrative	Determine deviations from methods identified in the QAPP and their impact.	
Project quantitation limit	Verify PQLGs are achieved as established in the QAPP, whenever feasible, for the established methods.	
QC sample assessment	A summary of QC samples and results will be verified for measurement performance criteria and assessed for completeness.	

QAPP Worksheet #37: Data Usability Assessment

(UFP-QAPP Manual Section 5.2.3, including Table 12)

This worksheet documents procedures that will be used to perform the data usability assessment. The data usability assessment is performed at the conclusion of data collection activities, using the outputs from data verification and data validation. The assessment will consider any quality issues identified and documented throughout the data collection cycle (e.g., minor field modifications). It is the data interpretation phase, which involves a qualitative and quantitative evaluation of environmental data to determine whether the project data are of the right type, quality, and quantity to support the decisions that need to be made.

Appropriate CDM Smith personnel that may include the PM, risk assessor, QA officer, project chemist, and other applicable project team members will prepare the data usability assessment.

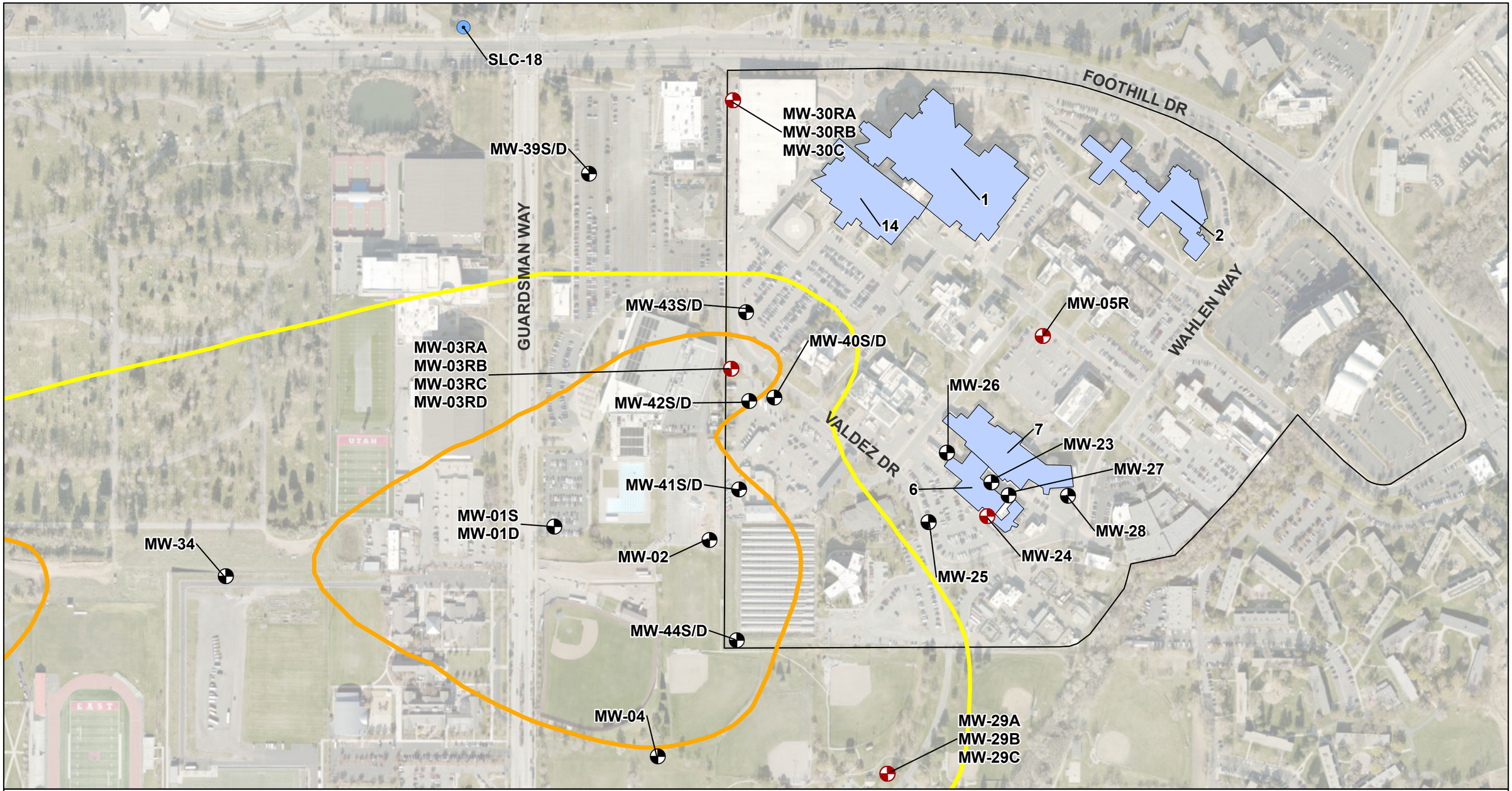
Qualification for QC exceedances will be performed using the analytical methods, the QAPP for control limits, and as directed in the National Functional Guidelines validation guidance when QC limits are exceeded.

Step 1	***Review the project's objectives and sampling design:*** The DQOs defined in Worksheet #11 will be reviewed to make sure they are still applicable. The sampling design will be reviewed for consistency with stated objectives.
Step 2	***Review the data verification and data validation outputs:*** Available QA reports, including the data validation reports, and database exports will be reviewed. Deviations will be reviewed from planned activities (e.g., number and locations of samples, holding time exceedances, damaged samples, and SOP deviations) and their impacts on the data usability. Implications of unacceptable QC sample results will be evaluated.
Step 3	***Verify the assumptions of the selected statistical method:*** Underlying assumptions for selected statistical methods will be verified (if documented in the QAPP) to see if they are valid, where applicable. Common assumptions include the distributional form of the data, independence of the data, dispersion characteristics, homogeneity, etc. Depending on the robustness of the statistical method, minor deviations from assumptions usually are not critical to statistical analysis and data interpretation. If serious deviations from assumptions are discovered, then another statistical method may need to be selected.
Step 4	***Implement the statistical method:*** The specified statistical procedures for analyzing the data and reviewing the underlying assumptions will be implemented. The underlying assumptions and tolerance for uncertainty in statistical evaluations will be considered during data analysis.
Step 5	***Document data usability and draw conclusions:*** An evaluation of analytical control limits and of the PARCCS parameters will be performed. If significant issues with the data are found, data results will be discussed with the PM. The PM will then decide whether the total study error could cause an incorrect decision. Using this approach, the probability of making an incorrect decision (i.e., either a false negative or positive) based on the information collected is considered small. Conclusions about data usability will be drawn based on the evaluation of PARCCS parameters. The PARCCS parameters are:

	Precision. The precision of a measurement is an expression of mutual agreement among individual measurements of the same analysis taken under prescribed similar conditions. Precision is quantitative and most often expressed as RPD. FD samples in all media will be collected as specified in Worksheet #20 to provide a measure of the contribution to overall variability of field-related sources. Contribution of laboratory-related sources to overall variability is measured through various laboratory QC samples (e.g., laboratory duplicates). Chemical analytical data will be evaluated for precision using FDs, laboratory duplicates, MS/MSDs, and LCSDs as applicable. RPD is calculated as follows: RPD = (S-D)/((S+D)/2) × 100 Where: S = Sample result D = Duplicate result **Accuracy.** Accuracy is the degree of agreement of a measurement with an accepted reference or true value and is a measure of the bias in a system. Accuracy is quantitative and usually expressed as the percent recovery of a sample result. Ideally, it is desirable that the reported concentration equals the actual concentration present in the sample. Chemical analytical data will be validated for accuracy using MS/MSDs, LCS/LCSDs, calibration recoveries, surrogates, interference check sample recoveries, and inductively coupled plasma serial dilution results as applicable. Percent recovery is calculated as follows: %R = SSR - SR/SA × 100 Where: SSR = spiked sample result SR = sample result SA = actual spike concentration **Representativeness**. Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is most concerned with the proper design of the sampling plan and the absence of cross contamination. Representativeness is a consideration that will be employed during all sample location and collection efforts and will be assessed qualitatively by reviewing field procedures and actual sampling locations versus planned locations. It will be quantitatively assessed by evaluating blank samples, both field blanks and laboratory blanks. **Comparability.** Consistency in sample acquisition, handling, and analysis and data reporting is necessary for comparing results. Where appropriate, the results of analyses obtained will be compared with the results obtained in previous studies. Standard analytical methods and QC will be used to ensure comparability of results with other analyses performed in a similar manner. Comparability is a qualitative parameter and cannot be assessed using QC samples. **Completeness.** Completeness is a measure of the amount of usable data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Evaluating the PARCCS parameters will support the determination of data usability.

	Data that need no qualification or are qualified as estimated data are considered usable. Rejected data are not considered usable in most instances. Completeness will be calculated during the data assessment. For these investigations, a completeness goal of 90% or greater is projected for all analytical data to generate sufficient enforcement quality data for use in the SI. If this goal is not met, additional sampling may be necessary to adequately achieve project objectives. Completeness calculations are as follows: % Completeness = V/n × 100 Where: V = number of measurements judged valid n = total number of measurements made % Completeness = C/P × 100 Where: C = number of samples collected P = total number of samples planned **Sensitivity**. Data results will be compared to project action limits provided on Worksheet #15. A discussion summarizing any conclusions about sensitivity of the analyses will be presented, and any limitations on the use of the data will be described in the report. **Reconciliation with User Requirements** The CDM Smith project chemist will prepare the QC summary report. This report will include limitations of the data and recommendations on the usability of the laboratory data for decision-making. The report findings will be presented so that the completion of project objectives and overall data quality can be verified for the sample results. The data validation and usability report will include the following: ▪ **Introduction.** Summarizes the purpose of the QA review and validation process and the samples reviewed. ▪ **Analytical data.** Summarizes the number and types of samples collected, including field QC samples, analytical methods performed, and data evaluation purpose. ▪ **Findings.** Provides overall summaries of the data validation findings (e.g., only the criteria exceedances that resulted in data qualification are discussed) specific for each analytical method. ▪ **Overall Assessment.** Provides a summary of the overall completeness of the data set and discusses any limitations in the use of the analytical data. ▪ Copies of all data validation reports and data quality assessment evaluation. The QC summary report will assess only the laboratory data packages and EDDs.

Figures



Legend

- Drinking Water Supply Well
- Monitoring Well (MW)
- PFAS Sampling Location
- Veteran Affairs Medical Center Campus

PCE Isoconcentration Contours (data through November 2022)

Concentration

- 5 µg/L
- 50 µg/L

Notes
µg/L = micrograms per liter
PCE = tetrachloroethene
PFAS = per- and polyfluoroalkyl substances

N
W E
S

0 250 500 Feet

Figure 1
PFAS Sampling Locations

700 South 1600 East PCE Plume
Salt Lake City, Utah

Appendix A

Sample Custody	SOP 1-2 Revision: 9 Date: August 2020

Approved: Ernest Ashley **Technical Review:** Cherie Zakowski

1.0 Objective

Because of the evidentiary nature of the samples, possession of samples collected during environmental investigations should be traceable from the time the samples are collected until their derived data are incorporated into reports and/or introduced as evidence in legal proceedings. Sample custody procedures are followed to maintain and document sample possessions. All paperwork associated with the sample custody procedures will be retained in CDM Smith files unless the client requests that it be transferred to them for use in legal proceedings or at contract completion.

Note: Sample custody documentation requirements vary with the specific EPA region or client. This technical standard operating procedure (SOP) is intended to present basic sample custody requirements, along with common options. Specific sample custody requirements shall be presented in the project-specific quality assurance (QA) project plan or project-specific modification or clarification form.

2.0 Background

2.1 Definitions

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Sample - A sample is a material to be analyzed that is contained in single or multiple containers representing a unique sample identification number.

Sample Custody - A sample is under custody if:

1. It is in your possession
2. It is in your view, after being in your possession
3. It was in your possession and you locked it up
4. It is in a designated secure area

Chain-of-Custody Record - A chain-of-custody record is a form used to document the transfer of custody of samples from one individual to another.

Custody Seal - A custody seal is a tape-like seal that is part of the chain-of-custody process and is used to detect tampering with samples after they have been packed for shipping.

Sample Label - A sample label is an adhesive label placed on sample containers to designate a sample identification number and other sampling information.

Sample Tag - A sample tag is attached to a sample container with string to designate a sample identification number and other sampling information. Tags may be used when it is difficult to physically place adhesive labels on the container (e.g., in the case of small air sampling tubes). Check with your EPA regional Contract Laboratory Program (CLP) coordinator as not all regions require sample tags.

3.0 General Responsibilities

Project Manager - The project manager is responsible for ensuring that field personnel are trained in the use of this SOP and related SOPs.

Field Team Leader - The field team leader (FTL) is responsible for ensuring that strict chain-of-custody procedures are maintained during all sampling events. The FTL is also responsible for coordinating with the subcontractor laboratory to ensure that adequate

information is recorded on custody records. The FTL determines whether proper custody procedures were followed during the fieldwork.

Sampler - The sampler is personally responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

Field Sample Custodian - The field sample custodian, when designated by the FTL, is responsible for accepting custody of samples from the sampler(s) and properly packing and shipping the samples to the laboratory assigned to perform the analyses. A field sample custodian is typically designated only for large and complex field efforts.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site/quality assurance project plan (QAPP).

4.0 Required Supplies

- Chain-of-custody records (applicable client or CDM Smith forms)
- Sample labels and/or tags
- Scribe software (if required)
- Custody seals
- Clear tape
- Computer
- Printer and paper

5.0 Procedures

5.1 Chain-of-Custody Record

This procedure establishes a method to maintain custody of samples through a chain-of-custody record. This procedure will be followed for all samples collected or split samples until they are accepted at the laboratory.

Field Custody

1. Collect only the number of samples needed to represent the media being sampled. To the extent possible, determine the quantity and types of samples and sample locations before the actual fieldwork. As few people as possible shall handle samples.

2. Complete sample labels or tags for each sample using waterproof ink.

3. Maintain personal custody of the samples (in your possession) at all times until custody is transferred for sample shipment or directly to the analytical laboratory.

Transfer of Custody and Shipment

1. Complete a chain-of-custody record for all samples (see Figure 1 for an example of a chain-of-custody record. Similar forms may be used when requested by the client). When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents sample custody transfer from the sampler, often through another person, to the sample custodian in the appropriate laboratory.

    - The date/time will be the same for both signatures when custody is transferred directly to another person. When samples are shipped via common carrier (e.g., Federal Express), the date/time will not be the same for both signatures. Common carriers are not required to sign the chain-of-custody record.
    - In all cases, it should be readily apparent that the person who received custody is the same person who relinquished custody to the next custodian.
    - If samples are left unattended or a person refuses to sign, this should be documented and explained on the chain-of-custody record.

    Note: If a field sample custodian has been designated, he/she may initiate the chain-of-custody record, sign, and date as the relinquisher. The individual sampler(s) should sign in the appropriate block but does (do) not need to sign and date as a relinquisher (refer to Figure 1).

2. Package samples properly for shipment and dispatch to the appropriate laboratory for analysis. Each shipment should be accompanied by a separate chain-of-custody record. If a shipment consists of multiple coolers, a chain-of-custody record shall be filled out for each cooler documenting only samples contained in that particular cooler.

3. The original record will accompany the shipment, and the copies will be retained by the FTL and, if applicable, distributed to the appropriate sample coordinators. Freight bills will also be retained by the FTL as part of the permanent documentation. The shipping number from the freight bill shall be recorded on the applicable chain-of-custody record and field logbook in accordance with SOP 4-1, Field Logbook Content and Control.

Procedure for Completing CDM Smith Example Chain-of-Custody Record

The following procedure is to be used to fill out the CDM Smith chain-of-custody record. The record provided herein (Figure 1) is an example chain-of-custody record. If another type of custody record (i.e., provided by the EPA Contract Laboratory Program [CLP] or a subcontract laboratory or generated by Scribe) is used to track the custody of samples, the custody record shall be filled out in its entirety.

1. Record the project number.
2. Record FTL for the project (if a field sample custodian has been designated, also record this name in the "Remarks" box).
3. Record the name and address of the laboratory to which samples are being shipped.
4. Enter the project name/location or code number.
5. Record the overnight courier's airbill number.
6. Record the sample location number.
7. Record the sample number.
8. Note preservatives added to the sample.
9. Note media type (matrix) of the sample.
10. Note the sample type (grab or composite).
11. Enter the date of sample collection.
12. Enter the time of sample collection in military time (24 hour clock).
13. When required by the client, enter the names or initials of the samplers next to the sample location number of the sample they collected.
14. List parameters for analysis and the number of containers submitted for each analysis.
15. Enter appropriate designation for laboratory quality control (e.g., matrix spike/matrix spike duplicate [MS/MSD], matrix spike/duplicate [MS/D]), or other remarks (e.g., sample depth).
16. Sign the chain-of-custody record(s) in the space provided. All samplers must sign each record.
17. If sample tags are used, record the sample tag number in the "Remarks" column.
18. The originator checks information entered in Items 1 through 16 and then signs the top left "Relinquished by" box, prints his/her name, and enters the current date and time (military).
19. Send the top two copies (usually white and yellow) with the samples to the laboratory; retain the third copy (usually pink) for the project files. Retain additional copies for the project file or distribute as required to the appropriate sample coordinators.
20. The laboratory sample custodian receiving the sample shipment checks the sample label information against the chain-of-custody record. Sample condition is checked and anything unusual is noted under "Remarks" on the chain-of-custody record. The laboratory custodian receiving custody signs in the adjacent "Received by" box and keeps the copy. The white copy is returned to CDM Smith.

5.2 Sample Labels and Tags

Unless the client directs otherwise, sample labels or tags will be used for all samples collected or accepted for CDM Smith projects.

1. Complete one label or tag with the information required by the client for each sample container collected. A typical label or tag would be completed as follows (see Figure 2 for example of sample tag; labels are completed with the equivalent information):

   - Record the project code (i.e., project or task number).
   - Enter the station number (sample number or EPA CLP identification number) if applicable.

- Record the date to indicate the month, day, and year of sample collection.
- Enter the time (military) of sample collection.
- Place a check to indicate composite or grab sample.
- Record the station (sample) location.
- Sign in the space provided.
- Place a check next to "yes" or "no" to indicate if a preservative was added.
- Place a check under "Analyses" next to the parameters for which the sample is to be analyzed. If the desired analysis is not listed, write it in the empty slot. Note: Do not write in the box for "laboratory sample number."
- Place or write additional relevant information under "Remarks."
- If perfluoroalkyl substances (PFAS) samples are collected, ball point pens should be used on any labels or custody seals. Sharpies (or equivalent) may be used to label sample bottles in the staging area, but markers should not be used in the immediate sampling environment.

2. Place adhesive labels directly on the sample containers. Place clear tape over the label to protect from moisture.

3. Securely attach sample tags to the sample bottle if required. On 2.27 liter (80 oz.) amber bottles, the tag string may be looped through the ring-style handle and tied. On all other containers, it is recommended that the string be looped around the neck of the bottle, then twisted, and relooped around the neck until the slack in the string is removed. In some instances, when the tag cannot be physically attached to the sample container, it is acceptable to simply place the sample tag in the zip lock bag with a sample container.

4. Double-check that the information recorded on the sample label or tag is consistent with the information recorded on the chain-of-custody record.

5.3 Custody Seals

Two custody seals should be placed on opposite corners of all shipping containers (e.g., cooler) before shipment. The seals shall be signed and dated by the shipper.

Custody seals may also be required to be placed on individual sample bottles. Check with the client or refer to EPA regional guidelines for direction. In these instances, the custody seal is placed over, or in some cases around, the lid or cap of the sample container.

If custody seals are required on individual sample bottles and PFAS samples are collected, ball point pens should be used on any custody seals. Sharpies (or equivalent) may be used in the staging area, but markers should not be used in the immediate sampling environment.

5.4 Sample Shipping

SOP 2-1, *Packaging and Shipping Environmental Samples* defines the requirements for packaging and shipping environmental samples.

6.0 Restrictions/Limitations

Check with the EPA region or client for specific guidelines. If no specific guidelines are identified, this procedure shall be followed.

For EPA CLP sampling events, combined chain-of-custody/traffic report forms generated with Scribe or other EPA-specific records may be used. Refer to regional guidelines for completing these forms.

The EPA Scribe software may be used to customize sample labels and custody records when directed by the client or the CDM Smith project manager.

The evolving regulatory standards for PFAS should be considered in the implementation of SOP 1-2 as well as the development of project planning documents such as: work plans, sampling and analysis plans, quality assurance project plans, data management plans, accident prevention plans, health and safety plans, and laboratory statements of work used to guide the collection of samples for PFAS analysis.

A consideration of the PFAS-specific sampling requirements is needed during the planning phase because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. This means that the development of project data quality objectives (DQOs), and selection of action levels, and reporting limits are all impacted with the inclusion of sampling for PFAS analysis.

Before implementing this SOP for collection of samples for PFAS analysis, it is important to review current regulatory standards to determine whether site- or project-specific changes to this SOP should be included in project planning documents to align with the latest regulatory standards and sampling guidance. CDM Smith regulatory updates, and state and federal regulatory limit updates can be found on the PFAS InfoCenter: https://cdmsmith.libguides.com/PFAS_InfoCenter

7.0 References

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Figure 1
Example CDM Smith Chain-of-Custody Record

125 Maiden Lane, 5th Floor
New York, NY 10038
(212) 785-9123
Fax: (212) 785-6114

CHAIN OF CUSTODY RECORD

PROJECT ID.	FIELD TEAM LEADER	LABORATORY AND ADDRESS	DATE SHIPPED
PROJECT NAME/LOCATION		LAB CONTRACT:	AIRBILL NO.

MEDIA TYPE
1. Surface Water
2. Groundwater
3. Leachate
4. Field QC
5. Soil/Sediment
6. Oil
7. Waste
8. Other _____

PRESERVATIVES
1. HCl, pH <2
2. HNO3, pH <2
3. NaOH, pH >12
4. H2SO4, pH <2
5. Zinc Acetate, pH >9
6. Ice Only
7. Not Preserved
8. Other _____

SAMPLE TYPE
G = Grab
C = Composite

SAMPLE LOCATION NO.	LABORATORY SAMPLE NUMBER	PRESER-VATIVES ADDED	MEDIA TYPE	SAMPLE TYPE	20__ DATE	TIME SAMPLED	ANALYSES (List no. of containers submitted)								REMARKS (Note if MS/MSD)
1.															
2.															
3.															
4.															
5.															
6.															
7.															
8.															
9.															
10.															

SAMPLER SIGNATURES:

RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME	RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME
(SIGN)		(SIGN)		(SIGN)		(SIGN)	
RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME	RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME
(SIGN)		(SIGN)		(SIGN)		(SIGN)	

COMMENTS:

DISTRIBUTION: White and yellow copies accompany sample shipment to laboratory; yellow copy retained by laboratory. Pink copy retained by samplers.

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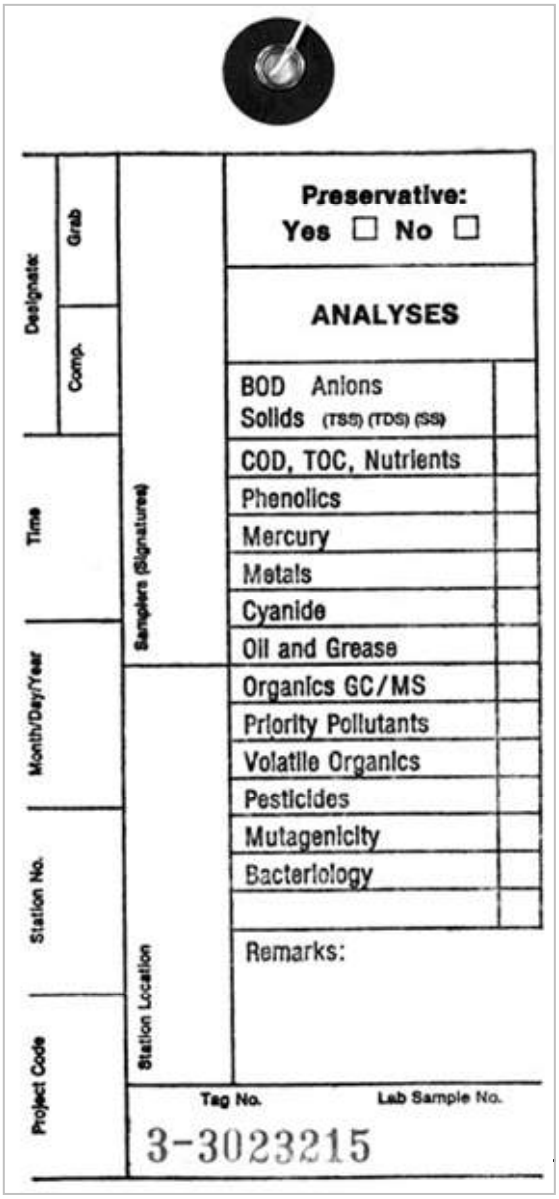
Note: If requested by the client, different chain-of-custody records may be used. Copies of the template for this record may be obtained from the Chantilly Graphics Department.

Figure 2
Example Sample Tag



Groundwater Sampling Using Bailers

SOP 1-5
Revision: 10
Date: August 2020

Approved: Ernest Ashley **Technical Review:** Jeffrey Weeber

1.0 Objective

The purpose of this technical standard operating procedure (SOP) is to define requirements for the collection of groundwater samples with bailers.

2.0 Background

Collection of groundwater samples from monitoring wells on or near a hazardous waste site may be required to characterize the nature and extent of contamination.

Methods used for the collection of groundwater samples include bailing and a variety of pumping techniques. Bailers are hollow cylinders with unidirectional (open up) check valves. Single check valve bailers have a check valve at the bottom of the body, while double check valve bailers have another check valve at the top to allow the collection of a sample at a specific depth. Bailers used in environmental applications are typically constructed of polyvinyl chloride (PVC), polyethylene, stainless steel, or Teflon®. Disposable polyethylene, PVC, and Teflon® bailers are commonly used to eliminate cross contamination that may occur as a result of poor decontamination practices. The bailer line typically consists of disposable nylon cord, disposable polypropylene cord, Teflon-coated stainless steel wire, or a combination (e.g., Teflon-coated stainless steel leader with nylon haul cord). The bailer is slowly lowered into the well using an acceptable type of line until submerged. The bailer is then retrieved to the surface for sample collection. For the best results, the sequence of sampling is from least to most contaminated wells. It is preferable to have bailers dedicated to each monitoring well. Do not use Teflon® and other fluoropolymer materials (e.g., Viton®) that may be found in bailer construction at sites where per- and polyfluoroalkyl Substances (PFAS) are to be sampled.

2.1 Associated Procedures

- SOP 1-2, *Sample Custody*
- SOP 1-6, *Water Level Measurement*
- SOP 2-1, *Packaging and Shipping Environmental Samples*
- SOP 4-1, *Field Logbook Content and Control*
- SOP 4-3, *Well Development and Purging*
- SOP 4-5, *Field Equipment Decontamination at Nonradioactive Sites*

3.0 General Responsibilities

Project Manager - The project manager ensures that field personnel are trained in the use of this procedure and for verifying that groundwater samples are collected in accordance with this procedure.

Field Team Leader - The field team leader ensures that sampling efforts are conducted in accordance with this procedure and any associated SOPs.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site/quality assurance project plan (QAPP).

4.0 Required Equipment

* See **Section 7.0** for PFAS-specific materials and equipment *

- Site-specific plans
- Field logbook
- Indelible black ink pens and markers
- Labels and appropriate forms/documentation for sample shipment
- Sample chain-of-custody forms

- Insulated cooler and waterproof sealing tape (strapping tape)
- Plastic zip-top bags
- Ice double-bagged in plastic zip-top bags
- Bailer of the appropriate design and construction for the sampling application
- Clean bailer line of sufficient length for well condition
- Water level meter and/or other water level measuring device
- Clean beaker(s) or other container for measurement of water quality parameters
- Plastic sheeting (4-mil thickness)
- Latex or appropriate gloves
- Filtering apparatus (e.g., peristaltic pump), if required
- Appropriate sample containers with labels and preservatives, as required
- Temperature, conductivity, pH, dissolved oxygen, turbidity, and other meters as required by the site-specific field sampling plan
- Photoionization detector (PID) or equivalent and other instruments as required by the site-specific health and safety plan
- Decontamination supplies, as required by SOP 4-5
- Personal protective clothing and equipment as required by the site-specific health and safety plan

5.0 Procedures

* See **Section 7.0** for PFAS-specific procedures *

- Review site-specific health and safety plan and project plans before initiating sampling activity.

- Don personal protective clothing and equipment as specified in the site-specific health and safety plan. All field equipment will be calibrated, tested, or checked for proper functioning before use per the manufacturer's instructions.

- Prepare the site for sample acquisition. If required, cover the ground surface around the wellhead with plastic sheeting. Arrange the required decontaminated sampling and monitoring equipment for convenient use. If onsite decontamination is required, arrange the necessary supplies in a nearby but separate location, away from the wellhead (i.e., in the contamination reduction zone).

- Open the well and note the condition of the casing and cap. Immediately check for organic vapors using a PID, flame ionization detector, detector tubes, etc. as appropriate. Refer to the site health and safety plan for the required monitoring and frequencies.

- Determine the static water level and depth to well bottom in accordance with SOP 1-6. Record this information in the field logbook and/or on the appropriate form.

- Purge the well according to SOP 4-3. Allow the water level in the well to recover to 75 percent of its static level so that a representative sample of the screened portion of the aquifer can be obtained. The bailer shall be completely submerged but not contact the bottom of the well, which may introduce sediment into the groundwater sample. Samples will be collected within 3 hours of purging if recharge is sufficient. Collect wells with a low recharge rate within 24 hours of purging.

- Securely attach the bailer to the line. The opposite end of the line shall be secured to prevent loss of the bailer into the well.

- Arrange the sample containers in the order of use. Using a bailer in a well may increase the turbidity of the groundwater sample and bias certain laboratory analyses. Therefore, sample containers for those analytes that may be impacted by turbidity should be filled first and in order of the degree of turbidity impact. For example:

a) Total metals
b) Radionuclides
c) Per- and Polyfluoroalkyl Substances (PFAS)
d) Extractable organics*
g) Inorganic ions (cations & anions)
h) Volatile Organic Compounds (VOCs)
i) Purgeable organic carbon or halogens (POC or POX)

e) Total organic carbon or halogens (TOC or TOX)
f) Cyanide

*Extractable organics include semivolatile organic compounds, pesticides, and PCBs.

- Wear clean sampling gloves; lower the decontaminated or disposable bailer into the well. Be sure the bailer enters the water slowly to prevent aeration, particularly when VOC samples are being collected. Do not allow the bailer to come in contact with the well bottom, which may increase sample turbidity and bias analytical results for some samples.

- Bring the filled bailer to the surface. To prevent contamination of the bailer line, do not allow the line to contact the ground; keep the line in a clean pail or other clean container. Hang the bailer from a bailer stand or other support, if available, or have an assistant hold it off the ground.

- Obtain any required volatile samples (VOC, POC, POX, TOX, or TOC) by gently transferring water from the bailer to the sample bottle through a VOC sampling device inserted into the bottom of the bailer. Care shall be taken to adjust the flow of the water into the vial so that it is not too fast, with as little agitation as possible. The vial should be tilted so that the stream of water is directed down the side of the vial to reduce nonlaminar flow into the vial and to prevent aeration. The vial should be filled so there is a meniscus above the vial lip, verify there are no bubbles floating on the meniscus, then securely tighten the cap. Check the filled VOC vials for bubbles by inverting and tapping on your hand, which will dislodge any bubbles. If bubbles are present in a vial, top the vial off using the minimal amount of sample necessary to recreate the meniscus.

- After the bottle(s) for a laboratory analyte have been properly filled, any water remaining in the bailer should be discarded as investigative-derived waste (IDW) and the bailer lowered back into the well to collect additional sample for other analytes. Fresh sample should be collected for each analyte. If sample filtration is required for metals, it should be performed immediately following sample retrieval, and before sample preservation. Organic samples generally do not require filtration; VOC and PFAS samples are never filtered. At a minimum, the first one half of a liter of sample passed through the filter will not be collected to allow the filter media to equilibrate to the sample. Preservation of samples should be performed according to the applicable field plan. Check the pH on samples (other than VOCs) that require preservation. Collect additional quality assurance/quality control samples (i.e., duplicate samples) as required by the applicable field plan.

- Clean the outer surfaces of the sample containers with a Kim-wipe or clean paper towel. Additional sample bottle decontamination may be appropriate in some cases.

- Properly label all containers according to SOP 2-1.

- Place sample containers in individual zip-top plastic bags and seal the bags (if required by site-specific plans).

- Immediately pack all sample containers that require a 4ºC preservation on ice in coolers (refer to SOP 2-1 and site-specific plans).

- Record the parameters to be analyzed and volumes collected, and time and date of collection in the field logbook. Prepare chain-of-custody forms according to site-specific plans and SOP 1-2.

- Decontaminate sampling equipment as needed, according to SOP 4-5.

- Close and lock the well cover. Clean up the area and place disposable materials (plastic sheeting, gloves, Tyvek®) in the designated waste receptacle.

- If required by the site-specific field sampling plan, obtain required field measurements such as temperature, conductivity, pH, oxidation reduction potential (ORP), turbidity, salinity, or dissolved oxygen measurements immediately after samples have been collected and record them in the field logbook.

6.0 Restrictions/Limitations

Careful sampling for VOC analysis or for analysis of any other compound(s) that may be degraded by aeration is necessary to minimize sample disturbance and analyte loss. The representativeness of this sample is difficult to determine because the collected sample represents a single point, is not homogenized, and has been disturbed.

If the well was purged with a submersible or peristaltic pump, several bailers of water should be removed from the well prior to the sample collection. The water above the pump inlet may be stagnant and not representative of groundwater conditions.

Samples with high turbidity may prevent the proper functioning of the check valve during sample collection.

Use of non-disposable bailers may contribute to cross contamination if proper and thorough decontamination procedures are not followed.

It is critical that no Teflon® or other fluoropolymer compounds (e.g., Viton®) are used when sampling for PFAS to prevent equipment related contamination. This includes the materials that make up the bailer body, bailer cord (e.g., Teflon®-coated stainless steel), check valve in the bailer, and O-rings (e.g., bottom emptying devices attached to stainless steel bailers use O-rings).

Consider the evolving regulatory standards for PFAS when implementing SOP 1-5, and when developing project planning documents. These include work plans, sampling and analysis plans, quality assurance project plans, data management plans, accident prevention plans, health and safety plans, and laboratory statements of work used to guide the collection of PFAS analysis.

Consideration of PFAS-specific sampling requirements is needed during the planning phase because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. This means that the development of project data quality objectives (DQOs), and selection of action levels and reporting limits are impacted with the inclusion of sampling for PFAS analysis.

Before implementing TSOP 1-5 for collection of samples for PFAS analysis, it is important to review current regulatory standards to determine whether site- or project-specific changes to TSOP 1-5 should be included in project planning documents to align with the latest regulatory standards and sampling guidance. CDM Smith Regulatory Updates can be located in the InfoCenter. Specific state and federal regulatory limits updates can be found at: https://cdmsmith.libguides.com/PFAS_InfoCenter.

7.0 PFAS-Specific Procedures and Equipment

With PFAS action levels in the low parts per trillion range, cross-contamination is a prominent concern for data quality. When sampling for PFAS compounds, good housekeeping, detailed documentation, and clearly defined exclusion zones are to be strictly followed. Below are procedural modifications to field activities when sampling for PFAS compounds:

Good Practices

- Utilize good safety planning and institute exclusion zones, contamination reduction zones, and support zones (no visitors within 30 feet of sampling).
- Do not eat in or near sampling areas (food packaging may contain PFAS).
- Be vigilant about PPE donning and doffing practices.
- Wash hands before and after eating.
- Wear powderless nitrile gloves and change them frequently.
- Only open the sample container during sample collection and never set the sample container lid down.
- Keep hands away from the container opening when sampling can keep lid protected.
- Develop a project-specific checklist for review with field personnel:
    - It needs to be project specific
    - Completed prior to 1) beginning the PFAS sampling event; 2) whenever there are staffing changes; or 3) whenever sample media changes or the associated sampling/field equipment changes.

- Consider appropriate sampling/field work sequences for each matrix.
- Sampling/field work sequences
- PFAS sampling/field work should occur first on sites where other contaminants will also be sampled.
- The CDM Smith PFAS sampling Guidance Team can assist with the development of the project-specific checklist.

Avoid

- **PTFE**, **low-density polyethylene (LDPE)**, sticky notes, waterproof field books, aluminum foil.
- Field filtering of water samples because of glass fiber filters
- Avoid the use of markers, if possible, during sampling. Use only regular ink pens. If needed, write over regular ink with marker after the sample containers are sealed.
- Consult the materials checklists for equipment concerns. The materials checklist can be found below and at: https://www.yammer.com/cdmsmith.com/#/files/214861635584.

Materials and Equipment

Because of the evolving nature of PFAS regulation and guidance, the information below is based on the best available information as of February, 2020. Some of the recommendations made below may reflect an overly cautious approach to avoid cross-contamination by removing items from the immediate sampling environment. As additional information about PFAS is confirmed, the below checklist may be revised to reflect that new information. The most up-to-date materials checklist can be found on the Emerging Contaminants group in Yammer, the PFAS section of the InfoCenter, or the PFAS team itself.

1. Critical: Items in direct contact of environmental media under investigation. These can include, but not limited to, sample containers, sampling parts and equipment, drilling equipment, well construction items and materials, parts and equipment for hydrogeological testing, in-situ treatment parts and equipment.
2. Very important: PPE, personal hygiene of sampling personnel
3. Important: Items used in coolers for shipping and transporting PFAS samples
4. Less important/awareness level concern: Activities in the staging area away for immediate PFAS investigation area

8.0 References

ASTM International. 2016. Standard Practice for Sampling Liquids Using Bailers. Standard Method D6699-16 (2016).

Office of Solid Waste and Emergency Response. 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA 542-S-02-001. May.

Office of Solid Waste and Emergency Response. 2005. Groundwater Sampling and Monitoring with Direct Push Technologies, OSWER 9200.1-51, EPA 540/R-04/005. August.

U.S. Environmental Protection Agency. Region 4. 2017. The Field Branches Quality System and Technical Procedures, Operating Procedure: Groundwater Sampling, SESDPROC-301-R4. April 26.

CDM Smith Resources

InfoCenter – PFAS Research Guide (https://cdmsmith.libguides.com/PFAS_InfoCenter)

InfoCenter – Remediation Community of Practice Research Guide (http://cdmsmith.libguides.com/cop_remediation)

Yammer – Emerging Contaminants Group

(https://www.yammer.com/cdmsmith.com/#/threads/inGroup?type=in_group&feedId=15318007)

Yammer – Remediation Community of Practice

(https://www.yammer.com/cdmsmith.com/#/threads/inGroup?type=in_group&feedId=5116633)

Remediation TKM (https://cdmsmithonline.sharepoint.com/sites/TKMLibrary/SitePages/Remediation.aspx)

Attachment

Item	Good to Use	Needs Verification (2)(3)	Should Avoid (1)(2)	Comments
Field Clothing or PPE				
Clothing or boots containing "water resistance" or "stain-treated" fabrics				
Cloths washed with fabric softeners				Fabric softeners may contain PFAS.
New and unwashed clothing				Fabric treatment may contain PFAS.
Uncoated Tyvek				USEPA PFAS sampling guidance from Region 2 prohibits use of Tyvek.
Coated Tyvek				
PVC or wax-coated fabrics				
Neoprene				
Synthetic and natural fibers (preferably cotton)				
Steel-toed boots made with polyurethane and PVC				If it is not possible to find PFAS free steel-toed footwear, PFAS-free over boots may be worn. The over boots must be put on and the hands washed after putting the over boots on prior to the beginning of the sampling activities. Over boots may only be removed in the staging area and after the sampling activities have been completed.
Well laundered clothes				Several times from time of purchase
Well washed cotton coveralls				Washed several times
Personnel Hygiene and Protective Skin Products				
Sunscreens				Good to use: Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, and baby sunscreens that are "free" or "natural."
Insect Repellents				Good to use: Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics.
International Brands of sunscreens and insect repellents				Must be evaluated on a case-by-case basis.
Field Sampling Items				
Waterproof field paper or books				Use loose plain paper.
Post-it notes				
Aluminum foil				
Brand-name markers				Sharpie may be used to label sample bottles in the staging area, but markers should not be used in the immediate sampling environment.
Off-brand markers				
Ball point pens				

Item	Good to Use	Needs Verification (2)(3)	Should Avoid (1)(2)	Comments
Plastic clipboards				NJ DEP sampling guidance, use metal clipboard.
Plastic table cover				
Sampling Equipment				
Item containing high-density polyethylene (HDPE)				
Item containing polypropylene				PP sample bottles must be used for drinking-water samples in accordance with USEPA method 537.1.1.
Item containing polyurethane				
Item containing Polyvinyl chloride (PVC)				
Item containing silicon				
Item made of stainless steel				
Alconox®				
Citronex®				
Liquinox®				
Powderless nitrile gloves				
HDPE Hydrasleeves or sonic core bags				
Neoprene				
Crisco® or other vegetable-based greases for lubricating parts				
Item containing PTFE				Items or equipment that contain PTFE parts that will be in direct contact with sampling media.
Item containing Teflon®				Field sampling items or equipment that contains Teflon® and that will be in direct contact with the sampling media.
Item containing fluoropolymer				
Low-density polyethylene (LDPE)				Items or equipment that contains LDPE parts and that will be in direct contact with the sampling media.
Viton® O-rings				Viton® O-rings used in pressure washers used for sampling equipment decontamination.
Glass sample containers				
Field filter				Field filtration should be avoided regardless of filter types.
Decon 90				
Items containing fluorosurfactants				
Teflon-bearing plumber's tape				
Blue (or chemical) ice				Later data (unpublished) suggest no cross contamination from blue ice. The category may be changed after data are published.

Item	Good to Use	Needs Verification (2)(3)	Should Avoid (1)(2)	Comments
Water ice				Double bag in polyethylene bags
Internal valves and equipment parts for sampling or decon				
Methanol or other solvents				
LDPE plastic bags (e.g., Ziploc® bags)				For larger biota sampling, Ziploc bags may be used, but collecting an equipment blank is recommended because these bags may be made of LDPE.
Drilling fluids				
LDPE sonic core sample bags				Manufactured by Boart Longyear and Hole Products.
Equipment with moving parts that may be lubricated with PFAS containing lubricants or greases				
Rental equipment				Must be verified to have no PFAS-bearing parts prior to use.
Others				
Food wrappers				Field personnel must wash hands after having food wrapped with grease-repelling paper.

(1) If an alternative is not available for an item that may contain PFAS, the item should be pre-tested for PFAS before use in the field.

(2) This mostly refers to the immediate sampling environment, particularly, the item is in contact with environmental media to be sampled.

(3) There are no standard operation procedures on how an item can be verified; please contact PFAS experts for advice on the best practice of testing a potential PFAS containing item. PFAS experts at CDM Smith may be contacted through the Emerging Contaminants Group.

Groundwater Level Measurement

SOP 1-6
Revision10S
August 2020

Approved: Ernest Ashley **Technical Review:** Nicholas Castonguay, P.G.

1.0 Objective

Groundwater level measurements are fundamental in the evaluation of groundwater resources, characterization of sites, and groundwater remediation. Groundwater level measurements are conducted during site investigation activities including groundwater gauging, groundwater sampling, and aquifer testing. This technical standard operating procedure (SOP) defines the techniques and requirements for obtaining depth to groundwater (or groundwater level) measurements.

2.0 Background

2.1 Definitions

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Water Level Indicator - A portable device for measuring the depth from a fixed point (which could be below, at, or above the ground surface) to groundwater inside a well, borehole, or other underground opening

Measurement Point - An easily located and clearly defined mark at the top of a well from which all water level measurements from that particular well are made. The measurement point shall be as permanent as possible to provide consistency in measurements.

Electrical Tape - A graduated plastic tape onto which a water-sensitive electrode is connected that will electronically signal the presence of water (as a result of circuit closure)

Immiscible Fluids - Two or more fluid substances that will not mix and, therefore, will exist together in a layered form. The fluid with the highest density will exist as the bottom layer, the fluid with the lowest density will exist as the top layer, and any other fluid layers will be distributed relative to their respective densities.

Discharge - The removal/release of water from the zone of saturation

Recharge - The addition of water to the zone of saturation

Static Water Level - The level of water in a well, borehole, or other underground opening that is not influenced by discharge or recharge

Well Casing - A steel, stainless steel, or polyvinyl chloride (PVC) pipe that extends into a borehole and is connected to the well screen or sealed at the bedrock surface in open-hole wells. The upper portion (approximately 3 to 4 feet) of the well casing is normally enclosed by an outer steel protective casing.

Protective Casing - A steel cylinder or square protective sleeve extending approximately 3 to 5 feet into the ground, surrounding the well casing. For flush-mounted wells, the protective casing will extend only high enough so that the well and protective casing can be enclosed by a road box or equivalent vault. In above-grade wells, the protective casing will extend above the ground surface approximately 2 to 3 feet. The protective casing protects the well casing.

Pressure Transducer - A type of measurement device that converts pressure-induced mechanical changes into an electrical signal

2.2 Associated Procedures

- SOP 4-1, *Field Logbook Content and Control*
- SOP 4-5, *Field Equipment Decontamination at Nonradioactive Sites*

2.3 Discussion

The most common uses of static groundwater water level data are to: determine the elevation of groundwater, the direction of groundwater flow (horizontally and vertically), identify areas of recharge and discharge, evaluate the effects of manmade and natural stresses on the groundwater system, define the hydraulic characteristics of aquifers, and evaluate surface water body-aquifer relationships. Specific uses for water level data may include to:

- Determine ambient daily, precipitation influenced and seasonal fluctuations in groundwater levels
- Determine the change in water level due to tidal influences
- Determine the change in water level due to distribution and rate of regional groundwater withdrawal or recharge
- Show the relationship of groundwater to surface water
- Estimate the amount, source, and area of recharge and discharge
- Determine rate and direction of groundwater movement

Static water level measurements shall be obtained from each well before purging, sampling, or other disturbance of the water table.

3.0 General Responsibilities

Project Manager - The project manager is responsible for ensuring that measurements are conducted in accordance with this procedure and any other SOP pertaining to site activities related to obtaining groundwater level measurements.

Field Team Leader - The field team leader is responsible for ensuring that field personnel obtain water level measurements in accordance with this and other relevant procedures.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field sampling plan or site/quality assurance project plan (QAPP).

4.0 Required Equipment

4.1 General

- Site plans, including well construction information, and health & safety plan
- Field logbook
- Waterproof ink pens
- Decontamination equipment and supplies, including rinse bottles, deionized water, scrub brush and absorbent pads.
- Five-gallon buckets
- Water level meter
- Engineering ruler
- Photoionization detector
- Pressure transducer and transducer cable
- Portable computer with transducer software
- Pressure transducer communication cable

4.2 Measuring Devices

The equipment required to obtain water level measurements is dependent on the type of procedure chosen. Measurements may be made with a number of different devices and procedures. Measurements are taken relevant to a permanent measurement point on the well riser or well casing.

Electrical tapes are preferred over other devices such as steel tape because of the electrical tape's simplicity and ability to make measurements quickly. Many types of electrical instruments have been devised for measuring water levels; most operate on the principle that a circuit is completed when two electrodes are immersed in water. Examples of electrical tapes that are frequently used include the Solinst® and Heron® electronic water level indicators. These instruments are powered by batteries that should be checked before mobilization to the field.

Electrical tapes are coiled on a hand-cranked reel unit that contains the batteries and a signaling device that indicates when the circuit is closed (i.e., when the probe reaches the water). Electrodes are generally contained in a weighted probe that keeps the tape taut in addition to providing some shielding of the electrodes against false indications as the probe is lowered into the hole. The electrical tapes are marked with 0.01-foot increments. Exercise caution while using electrical tapes when the water contains elevated amounts of dissolved solids. Under these conditions, the signaling device will remain activated after the probe is removed from the water. When the water being measured contains very low amounts of dissolved solids, it is possible for the probe to extend several inches below the water level before activating the signaling device or may not signal at all. Both of these conditions are related to the conductivity of the water and in some cases may be compensated for by the sensitivity control, if the device has this option. In groundwater with high conductivity, the sensitivity control may need to be turned down. In groundwater with low conductivity, the sensitivity control may need to be turned up to obtain a proper depth to groundwater measurement.

Pressure transducers and associated equipment are used to measure water levels in groundwater monitoring wells at user-specified intervals and record the measurements in the computer memory for later retrieval. A pressure transducer installed at a fixed depth in a groundwater well senses the change in pressure against a membrane. The pressure changes occur in response to changes in the height, and thus in the weight of the water column in the well above the transducer. Pressure transducers typically record temperature, pressure, and the converted depth to water or groundwater elevation. Two types of pressure transducers are typically used, vented and non-vented. The vented transducers have an air tube that is open to the atmosphere above the water level which automatically compensates for barometric pressure changes. The non-vented transducers are completely submerged with no open tube to the atmosphere. When using non-vented transducers, a barometric pressure transducer is also needed above ground to record barometric pressure readings to allow for water level corrections. An example of a pressure transducer that is frequently used includes the In-Situ Level Troll 700® Piezoresistive Titanium vented transducer. Depending on the range of groundwater levels, the appropriate pressure in pounds per square inch gauge (psig) for the instrument will need to be selected as shown below.

Level Troll 700 vented psig vs maximum water level

- 5 psig: 11.5 feet
- 15 psig: 35 feet
- 30 psig: 69 feet
- 100psig: 231 feet
- 300 psig: 692 feet
- 500 psig: 1153 feet

5.0 Procedures

5.1 Preparation

The following steps should be taken when preparing to obtain water level measurements:

1. Assign a designated field logbook to record all field events and measurements according to SOP 4-1. Document any and all deviations from SOPs and site-specific plans in the field logbook and include rationale for the changes.

2. Always exercise caution to prevent inappropriate or contaminated materials from entering any groundwater well.

3. Standing upwind from the well, open the groundwater well. Monitor the well with a photoionization detector, flame ionization detector, or equivalent vapor analyzer as soon as the cap is opened, as dictated by the site-specific health and safety plan.

For comparability, water level measurements shall always be referenced to the same vertical (elevation) datum marker, such as a United States Geological Survey (USGS) vertical and horizontal control point monument. The elevations calculated from the measurement of static water levels shall be referenced to mean sea level unless otherwise specified in the site-specific plans.

The measurement point should be as permanent as possible, clearly defined, marked, and easily located. Frequently, the top of the PVC riser is designated as the measurement point. However, since the top of the riser is seldom smooth and horizontal, one particular

point on the riser pipe shall be designated and clearly marked. This can be accomplished by marking a point on the top of the riser pipe with a notch or indelible pen. To avoid spilling liquids into the well, paints or other liquid marking materials shall not be used.

5.2 Water Level Measurement Using Electrical Water Level Indicators

The following steps should be followed when taking water level measurements using electrical tapes:

1. Before lowering the probe into the well, the circuitry shall be checked by dipping the probe in tap water and checking to ensure that the signaling device responds to probe submergence. The probe shall then be lowered slowly into the well until contact with the water surface is indicated. The electrical tape reading is made at the measuring point. Take a second and third check reading to verify the measurement before completely withdrawing the tape from the well. All three measurements shall be recorded in the field logbook.

2. Independent electrical tape measurements of static water levels using the tape shall agree within 0.01 foot for depths of less than about 200 feet. At greater depths, independent measurements may not be this close. For a depth of about 500 feet, the maximum difference of independent measurement using the same tape shall be within 0.1 foot.

3. Decontaminate the electrical tape according to SOP 4-5 before proceeding to the next well to minimize cross contamination.

It may be necessary to check the electrical tape length with a graduated steel tape after the line has been used for a long period of time (at least annually) or after it has been pulled hard in attempting to free the line. Some electrical tapes, especially the single line wire, are subject to becoming permanently stretched.

5.3 Water-Level Measurement Using Pressure Transducers

The following steps should be followed when using pressure transducers:

1. Before departing to the site, confirm transducers and cables are functioning properly and can connect to the transducer software (e.g., Win-Situ®) on the portable computer via the communication cable (e.g., Troll communication cable).

2. Obtain a water level measurement prior to installing the pressure transducer. Once the static water level is confirmed, slowly lower the pressure transducer and associated cable to the desired depth in the well below the expected range of water level fluctuation. Do not allow the cable to rub on the outside edge of metal casing. As noted above, do not submerge the transducer to a water depth pressure greater than the pressure rating of the transducer. Secure the transducer cable to the top of the well casing using a well dock and PVC sleeve or an eye bolt with a small carabiner.

3. Monitor the water level in the well to ensure stabilization due to displacing water from the transducer installation. The water level is considered stable when the level is longer trending in one direction. After stabilization, connect the communication cable from the pressure transducer to the portable computer to program the pressure transducer to the measured depth to water (reference level). During programming, select the testing type (e.g. long-term monitoring) and the frequency of measurements (e.g., every 10 minutes) including other required input parameters. Confirm the depth of the probe is equal to the desired probe installation depth in the well (depth to water + probe depth below water). Once the pressure transducer log has started, confirm the pressure transducer readings are recording and are equal to the water level readings in the well via manual measurement.

4. Disconnect the transducer cable from the communications device, install the cable desiccant and confirm the cable is secure inside the well casing or well road-box. When conducting both short and long-term monitoring, it is important to conduct periodic visits to obtain water level measurements, complete data downloads and confirm the transducer is functioning properly. It is good practice to manually read the water level when downloading the data as transducers can drift slightly over time. If drift does occur, this can be corrected via re-programming the depth to water reference during the site visit.

5.4 Other Water Level Measurement Methods

Although the methods cited above (electrical water level indicator and pressure transducers) for measuring water levels predominates in the environmental sector, there are a number of other methods available that may be well suited for a particular purpose.

5.4.1 Ultrasonic Method

The ultrasonic method electronically measures the time it takes a sound wave to reach and reflect off the water surface and return to the ground surface. These instruments contain electronic microprocessors, capable of performing this measurement many times each second. The actual depth to water, as calculated by the microprocessor, is an average of many individual readings.

5.4.2 Pressure Gauge Method

This method, also called the air-line submergence method, uses a pressure gauge and is the preferred method for obtaining water level measurements in pumping wells. An air line constructed of semi-rigid tubing is inserted into the well below the water table. The tube end at the surface is connected to an air tank or compressor and pressure gauge. Filtered air is then forced through the tube and the resultant pressure is read in pounds per square inch (psi). This reading is converted to feet of water in the column and subtracted from the total tube length to give depth to water. Readings are then converted to groundwater elevation. Results are plotted on a field logging form. Calibration records and the exact procedures used should be maintained.

5.4.3 Acoustic Probe Method

The acoustic probe is an electronic device containing two electrodes and a battery-powered transducer. The probe is attached to a tape. The probe is lowered into the well until a sound is detected, indicating the electrodes in the probe have contacted the water surface. This method is similar to the electrical probe method discussed in Section 5.2.

5.5 Procedural Considerations For PFAS

Development of PFAS awareness in guidance and incorporation into specific SOPs is necessary because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. For example, Federal drinking water MCL for Arsenic is 10,000 ppt where the EPA health advisory level is a combined 70 ppt for PFOA and PFOS.
Procedural modifications to field activities when sampling for PFAS analysis involve the concerns listed below. Practice good housekeeping, document these extra steps in detail, and maintain vigilance to adhere to clearly defined exclusion zones:

Good practices

- Use good safety planning and institute exclusion zones, contamination reduction zones, and support zones (no visitors within 30 feet of sampling).
- Do not eat in or near sampling areas (food packaging may contain PFAS).
- Be vigilant about PPE donning and doffing practices.
- Wash hands before and after eating .
- Wear powderless nitrile gloves and change them frequently.
- Develop a project-specific checklist for review with field personnel.
    - It should be project-specific.
    - Completed prior to beginning PFAS sampling event, or when there are staffing changes, or when sample media change and associated sampling/field equipment changes
    - Consider appropriate sampling/field work sequences for each matrix
    - Sampling/field work sequences
    - PFAS sampling/field work should occur first on sites where other contaminants will also be sampled.
    - CDM Smith PFAS Sampling Guidance Team can assist with development of your project-specific checklist.

Avoid

- **Polytetrafluoroethylene (PTFE),low density polyethylene (LDPE)**, sticky notes, waterproof field book, aluminum foil
- Field filtering of water samples because of glass fiber filters

- Avoid use of markers, if possible. Use only regular ink pens during sampling. If needed, write over regular ink with marker after the sample containers are sealed.
- Consult materials checklists for equipment concerns

6.0 Restrictions/Limitations

6.1 Groundwater and Miscible Fluids

It may not be possible to obtain an accurate reading where water is rapidly dripping or flowing into a well, either from the top of the well or from fractures.

The effect of the water flowing into the well may interfere with an electronic water level measuring device, resulting in a false water level measurement. If water levels should be recorded in wells completed in aquifers that are recharging or discharging, the electronic water level indicator is the preferred measuring device but shall be used with awareness of possible false measurements. To minimize the effects of "splashing," a 1-inch drop pipe (decontaminated for environmental wells) may be lowered into the pumping well into which the water level indicator is then inserted. This will minimize the effect of "splashing" until the probe contacts the groundwater. It will also protect the probe from becoming tangled in pump wiring or well spacers associated with downhole equipment such as submersible pumps. It is recommended that pressure transducers be used when water levels need to be recorded at frequent intervals during aquifer testing (recharging or discharging) in combination with water level indicators.

6.2 Immiscible Fluids

For wells containing immiscible contaminants including light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL), field personnel will need to use special procedures for the measurement of fluid levels. The procedure to follow will depend on whether layers are light immiscibles that form lenses floating on the top of the water table (LNAPL), or dense immiscibles that sink through the aquifer and form lenses over less permeable layers (DNAPL).

In the case of LNAPL and DNAPL, measurements of immiscible fluid and water levels can be accomplished by using an oil/water interface probe manufactured by companies such as Solinst®, Geotech® and Heron®.

Techniques have been specially developed to measure fluid levels in wells containing immiscible fluids, particularly petroleum products. An oil/water interface probe can be used to detect the presence of conducting and nonconducting fluids. Thus, if a well is contaminated with low density, nonconducting immiscible fluids such as gasoline, the probe will first detect the surface of the gasoline, but it will not register electrical conduction (continuous signal). However, when the probe is lowered deeper to contact water, it will detect electrical conduction (beeping signal). Normally, a variation in an audible signal indicates the difference between phases. The variation in the audible signal associated with the detection of differing phase liquids will allow the user to obtain a groundwater depth and dense immiscible thickness measurement.

The oil/water interface probe is less effective with heavier and less refined petroleum products because the product tends to stick to the tape or probe, giving a greater product thickness measurement than is present. In instances where an accurate product thickness measurement cannot be completed, a bottom filling bailer can be used to provide an estimate of the thickness of LNAPL or DNAPL in a groundwater well. Note the diameter of the bailer opening is typical narrower than the diameter of the bailer sidewalls resulting in an underestimate of the thickness of the NAPL layer. Another method of measuring thickness of a separate phase layer is by using tubing which can be sealed at the top to form a vacuum after insertion through the layer, similar to a Coliwasa sampler or "thief". Note that water levels obtained in this situation are not suitable for determining hydraulic gradients without further interpretation. To use such data to determine hydraulic gradients, the difference in density between the light immiscible phase and water has to be considered.

6.3 Conducting Groundwater Level Measurement at Per- and Polyfluoroalkyl Substances (PFAS) Sites

The evolving regulatory standards for PFAS should be considered when implementing groundwater level gauging as well as when developing project planning documents such as: work plans, sampling and analysis plans, quality assurance project plans, data

management plans, accident prevention plans, health and safety plans, and laboratory statements of work used to guide the collection of samples for PFAS analysis.

Consider PFAS-specific sampling requirements during the planning phase because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. This means that the development of project data quality objectives (DQOs), the selection of action levels, and reporting limits are all impacted with the inclusion of sampling for PFAS analysis.

Before implementing groundwater level monitoring during the collection of samples for PFAS analysis, it is important to review current regulatory standards to determine whether site- or project-specific changes to groundwater level measurement should be included in project planning documents to align with the latest regulatory standards and sampling guidance. CDM Smith regulatory updates, and state and federal regulatory limit updates, can be found on the PFAS InfoCenter:

https://cdmsmith.libguides.com/PFAS_InfoCenter

Procedural modifications for groundwater gauging and other related field activities at PFAS sites is attached. A check list containing common materials and sampling equipment that contain PFAS compounds can be found here:

https://www.yammer.com/cdmsmith.com/#/files/214861635584

7.0 References

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Field Measurement of Total Organic Vapors

SOP 1-10
Revision: 8
Date: February 2020

Approved: Ernest Ashley **Technical Review:** Nicholas Castonguay, P.G.

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the techniques and the requirements for the measurement of total organic vapors in the field.

2.0 Background

2.1 Definitions

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Photoionization Detector (PID) - A field portable, hand-held instrument that measures the concentration of gaseous organic compounds through the photoionization of organic vapors

Flame Ionization Detector (FID) - A field portable, hand-held instrument that measures the concentration of gaseous organic compounds through the flame ionization of organic vapors

Colorimetric Indicator Tubes - A field portable, hand-held pump that measures the concentration of specific organic gaseous compounds in air through a glass tube containing a granular carrier solid that has been saturated with a specific chemical reagent (i.e. benzene). The indicator tubes and pumps are typically referred to by their brand names such as Dräger Tubes®.

Gas Chromatograph - A field portable, hand-held instrument that measures the concentration of specific volatile organic compounds (VOCs) and is capable of analyzing groundwater, soil, and air samples. The gas chromatographs are typically referred by their brand names such as the FROG-5000™, which is identified as a gas chromatograph and photoionization detector (GC/PID).

2.2 Associated Procedures

- SOP 1-4, *Subsurface Soil Sampling*
- SOP 1-5, *Groundwater Sampling Using Bailers*
- SOP 1-6, *Water Level Measurement*
- SOP 1-8, *Volatile Organic Compound Air Sampling Using USEPA Method TO-15 with SUMMA Canister*
- SOP 1-12, *Low-Stress (Low-Flow) Groundwater Sampling*
- SOP 3-1, *Geoprobe® Sampling*
- SOP 3-5, *Lithologic Logging*
- SOP 4-3, *Well Development and Purging*

2.3 Discussion

The measurement of organic vapors is a required step during numerous field and site characterization activities. The primary purpose of such measurements is health and safety monitoring to determine if the breathing zone in a work area is acceptable or if personal protective equipment such as a respirator or a supplied air device is necessary for field personnel. At the perimeter of a work area, measurements can be taken as part of a perimeter air monitoring plan to document protection of a surrounding community. In addition to health and safety monitoring, total organic vapor measurement is also used in conjunction with sampling activities, including screening subsurface soil samples, soil vapor and indoor air sampling, and groundwater sampling, where measurements are useful for establishing approximate contaminant levels or ranges.

The two types of instruments most commonly used to measure total organic vapors are PIDs and FIDs. Both instruments first ionize the gaseous compound and then measure the response, which is proportional to the concentration. For site specific contaminants of concern (COCs) such as benzene, colorimetric tubes can be used to determine air concentrations in the breathing zone primarily for

health and safety purposes. For multi-media organic vapor measurement, the GC/PID can be used to determine specific VOC concentrations primarily for site characterization purposes.

2.3.1 PID Operation

The PID is preferred when the compound of interest is an aromatic or halogenated volatile organic compound (VOC). The PID ionizes the sampled vapors using an ultraviolet lamp that emits light energy at a specific electron voltage (eV - labeled on the lamp). The ultraviolet lamp produces photons that are absorbed by the sampled vapor molecule. The molecule becomes excited, producing a positively charged ion and emitting an electron. The number of electrons emitted is proportional to the concentration of the sampled gases. Every organic compound has a specific ionization potential in electron volts. The energy emitted by the lamp should be higher than the ionization potential of the compound for the compound to become ionized and emit an electron. If the ionization potential of the compound is higher than the eV of the lamp, there will be no response on the instrument. Therefore, the ionization potential of the known or suspected compounds shall be checked against the energy of the ultraviolet lamp to verify that the energy provided by the lamp is greater. The manufacturer's manual should be consulted to determine the appropriate ultraviolent lamp to be used for the known or suspected compounds. Additionally, manufacturer's manuals shall be consulted to obtain the appropriate correction factors for known or suspected contaminants.

Water vapor in the vapor sample can interfere with the PID detector and cause the instrument to stop responding or cause the zero baseline to drift. This can occur using the PID on a rainy day or when sampling headspace samples that have been in the sun. If moisture interference is suspected, the calibration gas shall be used to check the instrument response by inserting the gas as a check sample, not by recalibrating. If the response is lower than the gas level, then the probe and the ionization chamber should be dried out before reusing the instrument.

The sampling probe shall not be inserted directly into soil samples or dusty areas, as the instrument vacuum will pull dirt into the ionization chamber. Under particularly dirty or dusty conditions, the lamp may become covered with a layer of dust. If dirty conditions are encountered, or if the instrument response seems to have decreased, then the lamp should be cleaned. The instrument manual provides instructions on how to remove the instrument cover to access the lamp, and how to clean the screen in the ionization chamber and the surface of the lamp.

The instrument manual may provide instruction on use of disposable dust and/or moisture filters for minimizing effects from dust and/or moisture. The ultraviolet lamp in the PID is sensitive to shock, especially when using the higher eV lamps. Therefore, they should be handled and transported carefully.

2.3.2 FID Operation

The FID is preferred when sampling for petroleum hydrocarbons and other organic compounds such as methane (landfill gases). It responds well to aromatic hydrocarbons but is not as convenient to use as the PID. The FID allows measurement of a wide variety of compounds, but in general its sensitivity is not as high as the PID for compounds where the PID is applicable. The FID is virtually unaffected by ambient levels of water vapor.

The FID ionizes the vapor sample by burning it in a hydrogen/air flame and measuring the response beyond what is caused by the hydrogen alone. This instrument requires a hydrogen supply, contained in a small tank in the instrument. This hydrogen, including the gas in the instrument tank, is considered a flammable gas and appropriate requirements should be adhered to when shipping. The instrument shall be emptied of hydrogen before shipping. Federal Express Hazardous Material shipping manifests must be completed when shipping the gas.

The hydrogen gas in the FID combustion chamber is ignited by pressing a red button on the side of the instrument, which sends electrical current to a small resistance coil igniter in the combustion chamber. This igniter is very sensitive, and if the red button is pressed for longer than 5 seconds, the coil will burn out and the instrument will be unusable unless another igniter is available. If the instrument will not light, check the electrical connections and switches for proper settings. Check that the pump is pumping and allow fresh air to flow through the combustion chamber for several minutes before lighting. Check to see if the exhaust port of the combustion chamber is dirty.

2.3.3 Colorimetric Indicator Tube Operation (DrägerTubes®and Pump)

Colorimetric indicator tubes such as DrägerTubes® and pumps can provide real time VOC and other organic gaseous compound concentrations in ambient air. The colorimetric tube is preferred when monitoring for site specific COCs in the breathing zone. The pump is compatible with over 500 different short-term gas detection tubes and is suitable for site characterization and industrial hygiene purposes. The Dräger Tubes® are capable of analyzing VOCs in the air with results reporting in parts per million (ppm) concentrations. The glass colorimetric indicator tubes typically consist of a glass tube containing a granular solid that has been saturated with a specific chemical compound (i.e., benzene). As contaminated air is pumped through the glass tube, the contaminant reacts with the reagent on the granular solid to produce a color stain or change in color, which is proportional to the amount of contamination in the air. The air is drawn through the DrägerTubes® by a hand pump or a battery-powered pump that controls the volume of air sampled. The number of pump strokes (i.e. the volume of air) required to reach this full stain is compared to a chart to determine the concentration of the contaminant in the air. A set number of pump strokes (volumes) of air will be drawn through the tube and the length of stain is compared to a calibration scale, often printed on the tube, to determine the concentration. For these tubes, a high concentration would cause a deeper or darker color change after a set number of pump strokes. It is critical that the operator of the tube be familiar with the manufacturer's directions and knows which mode of operation is used.

2.3.4 Gas Chromatograph Operation (FROG-5000™)

A portable field gas chromatograph such as the FROG-5000™ can provide real time soil, groundwater, and air VOC concentrations that can aid in the characterization of contaminated sites. The FROG-5000™ chemical analysis system is a field portable gas chromatograph/photoionization detector (GC/PID) capable of analyzing samples in minutes. The FROG-5000™ is vendor calibrated for VOCs of interest and is ready to analyze samples upon arrival in the field. The FROG-5000™ quantitatively determines VOC concentrations down to single part per billion (ppb) or at high part per million (ppm) concentrations depending on its configuration. During sample analysis (thermal desorption), the VOCs are passed into a miniature GC column where the mixed VOC analytes are each separated. The PID then determines the resolved VOCs eluting from the GC and outputs the concentration. A real-time readout and associated laptop connected to the FROG-5000™ allows the field analyst to monitor analysis of each sample by observing the development of the gas chromatogram in real-time.

3.0 Responsibilities

Project Manager - The project manager is responsible for ensuring that field activities are conducted in accordance with this procedure and any other SOPs pertaining to the specific activity.

Field Team Leader - The field team leader is responsible for ensuring that field personnel conduct field activities in accordance with this and other relevant procedures. The field team leader is responsible for ensuring the appropriate field equipment is used for site specific or contaminants of concern.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site/project-specific quality assurance plan.

4.0 Required Equipment

- Site-specific plans (i.e., scope of work)
- Health and safety plan
- Field logbook
- Waterproof black ink pen
- Personal protective clothing and equipment
- Photoionization detector
- Flame ionization detector
- Dräger Tubes® for required COCs and pump
- Calibration gases in a range appropriate for the expected use

- 0.5 liter (16-ounce) or "Mason" type glass jar or Ziploc-type plastic bags
- Hydrogen canister and fill valve and hose (if using FID for a period of more than 1 day)

5.0 Procedures

5.1 Direct Reading Measurement (PID and FID)

1. Connect the measurement probe to the instrument and make necessary operational checks (e.g., battery check, etc.) as outlined in the manufacturer's manual.

2. Calibrate the instrument following the applicable manufacturer's manual.

3. Make sure the instrument is reading zero and all function and range switches are set appropriately.

4. Insert the end of the probe directly into the atmosphere to be measured (e.g., breathing zone, monitoring well casing, split spoon, etc.) and read the total organic vapor concentration in parts per million (ppm) from the instrument display. Apply the appropriate correction factor if necessary. Record the highest instrument response.

5. Immediately document the reading in the field logbook or on the appropriate field form.

5.2 Headspace Measurement (PID and FID)

1. Connect the measurement probe to the instrument and make necessary operational checks (e.g., battery check, fan check, etc.) as outlined in the manufacturer's manual.

2. Calibrate the instrument following the appropriate manufacturer's manual.

3. Make sure the instrument is reading zero and all function and range switches are set appropriately.

4. Fill a clean glass jar or Ziploc-type plastic bag approximately half-full of the sample to be measured. For a jar, quickly cover the top of the jar with one or two sheets of clean aluminum foil and apply cap to seal the jar. For a bag, quickly seal the bag minimizing volume of air in the bag.

5. Allow headspace to develop for approximately 10 minutes. It is generally preferable to shake the sealed jar for 10 to 15 seconds at the beginning and end of headspace development. For a bag, kneed the bag to break apart the sample and maximize sample surface area.

Note: When the ambient temperature is below 0°C (32°F), the headspace development and subsequent measurement shall occur within a heated vehicle or building.

6. For a jar, remove the jar cap and quickly puncture the foil and insert the instrument probe to a point approximately one-half of the headspace depth. Do not let the probe contact the soil. For a bag, quickly puncture the bag wall and insert the probe, wrapping the bag wall around the probe stem to minimize loss of vapors. If using a PID and there is condensation on the inside of the jar or bag, only leave the probe in the jar or bag long enough to obtain a reading. Remove the probe and allow fresh air to flow through the instrument to avoid excess water vapor to build up.

7. Read the total organic vapor concentration in ppm from the instrument display. Apply the appropriate correction factor if necessary. Record the highest instrument response.

8. Immediately record the reading in the field logbook or on the appropriate field form.

5.3 Colorimetric Indicator Tube Measurement (Dräger Tubes® and Pump)

1. Sample pumps should be checked for leaks to ensure that the appropriate volume of air is drawn through the tube. The pump should be allowed to fully complete every pump stroke. Incomplete strokes or leaks in the system will cause less than the appropriate volume of sample air to pass through the tube, potentially resulting in a lower reading than is actually present. Perform a pump leak test by inserting an unopened tube into the hand pump socket. Squeeze the pump completely and release. If the stroke indicator has not appeared after 15 minutes, then your pump is leak-proof. If the stroke indicator does appear, then try another pump or contact the field team leader for direction. Otherwise, remove the tube and reset the counter to zero and prepare for use.
2. Open both ends of the tube using the integrated ceramic blade on the bottom of the pump or use the tube opener. When using the opener on the pump, make sure to keep the tube pressed against the ceramic edge and turn the tube to score the glass. When using the tube opener, use the instructions on the side of the pump box. Insert the tube into the pump with the black arrow facing inwards. Squeeze the pump to create one stroke. The number of strokes required will be indicated on your chosen tube pack and instructions.

3. The tube with the hand pump may be operated as follows:

   A. The pump may be operated until the length of the stain reaches a certain preset point. The number of pump strokes (i.e. the volume of air) required to reach this full stain is compared to a chart to determine the concentration of the contaminant in the air. In this case, a high concentration of contaminant in the air would require fewer strokes to reach full stain.

   B. A set number of pump strokes (volumes) of air will be drawn through the tube and the length of stain is compared to a calibration scale, often printed on the tube, to determine the concentration. For a set number of pump strokes, a high concentration would cause a longer stain.

   C. A predetermined number of pump strokes of air are drawn through the tube and the degree or tint of the color change is compared to a chart to determine the concentration. For these tubes, a high concentration would cause a deeper or darker color change after a set number of pump strokes. It is critical that the operator of the tube be familiar with the manufacturer's directions and knows which mode of operation is used.

4. Read the total organic vapor concentration and record in the field logbook. If breathing zone air concentrations exceed contaminant thresholds, keep a safe distance from the work zone, contact the field team leader, and upgrade PPE (i.e. level D to C), if required and available. If upgraded PPE is not available, contact the field team leader to discuss plans for executing work when the appropriate PPE is available.

5.4 Gas Chromatograph Operation (FROG-5000™)

1. Before conducting field work, confirm the FROG-5000™ is functioning properly and can connect to the appropriate software on the portable computer.

2. Before sampling, make sure the instrument settings are correct for the application. Typically, the equipment rental company can provide training, calibrate, and set up project specific analytical parameters to analyze for so that the unit is ready to go. Run a blank before attempting sample analysis, a blank run should produce a clean baseline.

3. For soil, water and air sampling, refer to the FROG-5000™ user manual since there are numerous steps to prepare and analyze the samples. Before conducting field work, review the user manual to ensure proper and efficient use of the software and instruments in a field setting. The user manual is located here: http://www.defiant-tech.com/pdfs/FROG-5000-Manual-2017-Rev3.pdf.

5.5 Procedural Considerations For PFAS

Development of PFAS awareness in guidance and incorporation into specific SOPs is necessary because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. (For example, Federal drinking water MCL for Arsenic is 10,000 ppt where the EPA health advisory level is a combined 70 ppt for PFOA and PFOS.)
Procedural modifications to field activities when sampling for PFAS analysis involve the concerns listed below. Good housekeeping, detailed documentation of these extra steps, and vigilance about clearly defined exclusion zones that are strictly adhered to shall be followed:

PFAS Sampling Materials Checklist

- Use good safety planning and institute exclusion zones, contamination reduction zones, and support zones (no visitors within 30 feet of sampling).
- Do not eat in or near sampling areas (food packaging may contain PFAS).
- Be vigilant about PPE donning and doffing practices.
- Wash hands before and after eating.
- Wear powderless nitrile gloves and change them frequently.
- Only open sample container during sample collection and never set the sample container lid down.
- Keep hands away from the container opening when sampling and keep lid protected.
- Develop a project specific-checklist for review with field personnel.
    - It should be project-specific.
    - Completed prior to beginning PFAS sampling event or whenever there are staffing changes or whenever sample media change and associated sampling/field equipment changes
    - Consider appropriate sampling/field work sequences for each matrix
    - Sampling/field work sequences
    - PFAS sampling/field work should occur first on sites where other contaminants will also be sampled.
    - CDM Smith PFAS Sampling Guidance Team can assist with development of your project-specific checklist.

Avoid

- **PTFE, LDPE**, sticky notes, waterproof field book, aluminum foil
- Field filtering of water samples because of **glass** fiber filters
    - Avoid use of markers, if possible, during sampling; use only regular ink pens. If needed, write over regular ink with marker after the sample containers are sealed.
- Consult materials checklists for equipment concerns.

6.0 Restrictions/Limitations

The two PID and FID methods outlined above are the most commonly used for field measurement of total organic vapors but do not apply to all circumstances. Consult project- or program-specific procedures and guidelines for deviations. Both the PID and FID provide quantitative measurement of total organic vapors, but generally neither instrument is compound-specific. The typical reading range of the PID is 0 to 10,000 ppm, and the typical reading range of the FID is 0 to 50,000 ppm. The FID will measure methane while the PID will not. ***Note***: The presence of methane will cause erratic PID measurements. In methane rich environments, toxic organic vapors shall be monitored with an FID. If desired, a charcoal filter can be placed temporarily on the FID inlet probe, which will trap all organic vapors except methane. The filtered (methane only) reading can be subtracted from unfiltered (total organic vapors) to provide an estimate of non-methane organic vapors. The reading accuracy of both instruments can be affected by ambient temperature, barometric pressure, humidity, lithology, etc.

The colorimetric Dräger Tubes® method is commonly used to determine the concentration of site specific COCs primarily for industrial hygiene purposes. The tubes' accuracy may be affected by temperature, humidity and atmospheric pressure. Colder temperatures will typically slow down the reaction and high temperatures may affect the rate of chemical reaction. If tubes are to be used in cold weather, they should be stored in a warm place and carried next to the body. Where temperature will significantly affect the performance of the tube, the manufacturer will include compensation factors in the instructions. Regarding limitations, tubes can have poor accuracy with errors ranging from 25% to 50%. The manufacturers generally provide accuracy information with the

instructions. The tubes have a specific shelf-life which may cause the degradation of the reagent. Chemical reagents will deteriorate over time, even if the tube is not opened and exposed to air. High temperatures may cause degradation of the reagent. The manufacturer will stamp an expiration date on each pack of tubes. Storing the tubes in a refrigerator may maintain or extend the shelf life, but expired tubes should not be used.

The GC/PID such as the FROG-5000™ is typically used for site characterization and can also be used for industrial hygiene purposes. The FROG-5000™ quantitatively determines soil, groundwater and air VOC concentrations down to single part per billion (ppb) concentrations or at high part per million (ppm) concentrations depending on its configuration. The chemicals commonly detected by the FROG-5000™ include benzene, toluene, ethylbenzene, xylenes, vinyl chloride, trans-1,2-dichloroethene, cis-1,2-dichloroethene, trichloroethene, tetrachloroethene, chlorinated alkenes, and naphthalene. Please refer to the user manual for restrictions/limitations: http://www.defiant-tech.com/pdfs/FROG-5000-Manual-2017-Rev3.pdf.

6.1 Conducting Total Organic Vapor Monitoring at Per- and Polyfluoroalkyl Substances (PFAS) Sites

At sites where sample collection for PFAS analysis will occur, the evolving regulatory standards for PFAS should be considered in the implementation of total organic vapor monitoring as well as the development of project planning documents such as: work plans, sampling and analysis plans, quality assurance project plans, data management plans, accident prevention plans, health and safety plans, and laboratory statements of work used to guide the collection of samples for PFAS analysis.

A consideration of the PFAS-specific sampling requirements is needed during the planning phase because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. This means that the development of project data quality objectives (DQOs), and selection of action levels reporting limits are all impacted with the inclusion of sampling for PFAS analysist.

Before implementing total organic vapor monitoring during the collection of samples for PFAS analysis, it is important to review current regulatory standards to determine whether site- or project-specific changes to field measurements for total organic vapors should be included in project planning documents to align with the latest regulatory standards and sampling guidance. CDM Smith regulatory updates, as well as state and federal regulatory limit updates can be found on the PFAS InfoCenter: https://cdmsmith.libguides.com/PFAS_InfoCenter

Procedural modifications for groundwater gauging and other related field activities at PFAS sites is attached. A checklist containing common materials and sampling equipment that contain PFAS compounds can be found here: https://www.yammer.com/cdmsmith.com/#/files/214861635584

7.0 References

American Society for Testing & Materials (ASTM). D4490-96 (Re-Approved 2016), Standard Practice For Measuring the Concentration of Toxic Gasses or Vapors Using Detector Tubes.

Defiant Technologies Inc, FROG-5000™. Chemical Analysis User's Manual, 2018 (Rev.3). http://www.defiant-tech.com/pdfs/FROG-5000-Manual-2017-Rev3.pdf.

Department of Defense. Environmental Field Sampling Handbook, Revision 1. April 2013 or current revision.

Low- Stress (Low-Flow) Groundwater Sampling

SOP 1-12
Revision: 3
Date: August 2020

Approved: Ernest Ashley **Technical Review:** Nicholas Castonguay, P.G.

1.0 Objective

The purpose of this technical standard operating procedure (SOP) is to define the procedural requirements for low-flow (minimal drawdown) groundwater sampling.

2.0 Background

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Low-flow groundwater sampling is a method of collecting samples from a well that, unlike traditional purging methods, does not require the removal of large volumes of water from the well. The objective of low-flow groundwater sampling is to collect samples with minimal alterations to water chemistry through pumping the well at a rate low enough to minimize drawdown and to avoid disturbance in the well. Low-flow groundwater sampling refers to the velocity that water enters the pump intake, and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface of the well, which can be affected by flow regulators or restrictions.

Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrogeological situation. The objective of low-flow groundwater sampling is to pump the well in a manner that minimizes stress (drawdown) to the system. Minimal drawdown should be stabilized so that the water to be sampled is representative of the formation surrounding the screened interval and is not from the stagnant water column above the screened interval. Minimal drawdown is achieved to the extent practical taking site sampling objectives into account. Typically flow rates on the order of 0.1 to 0.5 liter per minute (L/min) are used. However, achieving flow rates of 0.1 to 0.5 L/min can be dependent on site-specific hydrogeology. Some very coarse-grained sand formations have successfully been sampled via low-flow techniques at flow rates up to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper well screen location, well screen length, and well construction and development techniques.

Low-flow groundwater sampling can be used to collect samples for all categories of aqueous-phase contaminants and naturally occurring analytes, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and other organic compounds including metals and other inorganics, pesticides, polychlorinated biphenyls (PCBs), radionuclides, microbiological constituents, and per- and polyfluoroalkyl substances (PFAS). Low-flow groundwater sampling techniques are particularly well-suited in applications where it is desirable to sample aqueous-phase constituents that may sorb or partition to particulate matter. It is not applicable to sampling wells that contain either light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs).

A variety of sampling devices are available for low-flow groundwater sampling, including peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Pump type should be selected based on known site conditions, including well depth, well diameter, water level, and anticipated well volume, as well as sampling objectives. Note that peristaltic pumps (suction pumps) cannot be used under conditions where the water table is greater than 25 feet below ground surface. Additionally, in most instances, peristaltic pumps may not be used for collecting VOC samples because they create a vacuum that potentially contributes bias to sampling for VOC's via low flow techniques. Bailers, too, are generally inappropriate devices for low-flow sampling. Gas-driven pumps are generally not advisable for VOC or SVOC sample collection due to the potential for sample contamination.

Dedicated pumps (those that are permanently installed in the well, e.g., bladder pumps) are preferred over portable pumps because they eliminate disturbance to the water column in the well during pump insertion, thus providing lower turbidity values, shorter purge times, and lower purge volumes to achieve stabilized indicator parameter measurements. However, portable pumps can be used if care is taken to minimize disturbance to the water column during pump insertion, and if adequate time is allowed following pump insertion and prior to pump operation for any particulates agitated in the water column to settle. Both dedicated and portable pumps should be easily adjustable and should operate reliably at lower flow rates. All pumps typically have some limitations that should be evaluated with respect to site-specific considerations and data quality objectives on a case-by-case basis.

Water quality indicator field parameters should be continuously monitored during low-flow purging using a flow-through cell, or in-line parameter monitoring techniques. Continuous indicator parameter monitoring is a critical component to low-flow groundwater sampling. Water quality indicator parameters include temperature, pH, oxidation-reduction potential (ORP), specific conductivity, dissolved oxygen (DO), and turbidity. The flow-through cell enables continuous collection of real-time parameters during low-flow purging. Stabilization is achieved after all parameters fall within established limits for three successive readings as discussed in Section 5. Stabilization of low-flow parameters is further discussed in Section 5.0 (Procedure) of this SOP.

Advantages of low-flow groundwater sampling are:
- Improved sample quality (e.g., less turbid and more representative of the aquifer)
- Potentially reduced purging and sampling times
- Reduced purge water volume

2.1 Associated Procedures
- SOP 1-6, *Water Level Measurement*
- SOP 2-2, *Guide to Handing of Investigation Derived Waste*
- SOP 4-5, *Field Equipment Decontamination at Nonradioactive Sites*

3.0 General Responsibilities
Project Manager - The project manager is responsible for ensuring that field personnel are trained in the use of this procedure and for verifying that well development and purging are carried out in accordance with this procedure.

Field Team Leader - The field team leader is responsible for complying with this procedure as well as reading/reviewing field plans and coordinating assigned tasks before conducting the field work.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance plan.

4.0 Required Equipment
- Site plans and well construction information
- Field logbook and health & safety plan
- Waterproof ink pens
- Pump (including peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps as discussed in Section 2.0 of this SOP).
- Appropriate controller for selected pump type.
- For bladder pumps: Compressor and controller for the system (compressed non-reactive gas may also be used in lieu of a compressor).
- Power source (e.g., battery or generator), as required.
- Pump tubing (typically polyethylene with Teflon® lining). Note that portable bladder pumps require combination tubing (for air and water); therefore, the correct tubing sizes for the portable bladder pump should be verified. Additionally, peristaltic pumps require flexible tubing (silicone or Tygon) tubing for the pump head. Polyethylene tubing with Teflon® should not be used when sampling for per- and polyfluoroalkyl substances (PFAS). It is recommended that high-density polyethylene tubing be used instead.
- Electronic water level meter or oil-water interface probe (according to SOP 1-6)
- Water quality meter (e.g., YSI 600 or YSI Professional Series) with a closed flow-through cell for continuous in-line measurement of temperature, pH, conductivity, ORP, and DO prior to sample collection.
- Turbidity meter (reporting in nephelometric turbidity units [NTUs])
- Standards for calibration and field check, as needed, of water quality and turbidity meters (as determined by anticipated field conditions).
- Volume measuring device to determine flow (e.g., graduated cylinder).

- Stop watch
- Tape measure
- Engineering ruler
- Personal protective equipment as specified in the site-specific health and safety plan.
- Polyethylene sheeting
- Sample containers, including packaging supplies and all associated paperwork (e.g., chain of custody forms) as required in the sampling plan and per SOP 2-1, packaging and shipping environmental samples.
- Decontamination supplies, as required, according to SOP 4-5.
- Disposal drums (e.g., 55-gallon Department of Transportation-approved) or other purge water storage container, if required by the site-specific sampling plan.
- Photoionization detector (PID)/organic vapor monitor (OVM) or equivalent as specified in site-specific health and safety plan.

Note: All sampling devices (bladders, pumps, and tubing) should be constructed of stainless steel, polyethylene, Teflon®, glass, or similar non-reactive materials. Procedural modifications for low-flow groundwater sampling at PFAS sites are included in Section 6 and attached.

5.0 Procedure

The following steps should be followed for low-flow groundwater sampling activities:

1. Review site-specific health and safety plan, and site-specific project and sampling plans before initiating sampling activities.

2. Review available existing data for site to evaluate approach to sampling site wells. Prepare to sample site wells in the order of least contaminated to most contaminated. Additionally, existing site data should be reviewed to determine anticipated hydrogeologic conditions and well completion details.

3. Prior to sampling, all sampling devices and monitoring equipment shall be calibrated according to manufacturer's recommendations and the site-specific sampling plan. Calibration of pH should be performed with at least two buffers that bracket the expected pH range. DO calibrations should be corrected for local barometric pressure readings and altitude.

4. Put on personal protective clothing and equipment as specified in the site-specific health and safety plan.

5. Open the well cover and check condition of the wellhead, including the condition of the surveyed reference mark, if any. If no reference mark exists, create a reference mark on the well riser using a permanent marker or equivalent. Record the location of the reference mark in the field notes.

6. Monitor the air space at the wellhead for VOCs using a PID/OVM or equivalent immediately upon removal of the well plug and as according to health and safety requirements.

7. Determine the depth to static water level in accordance with SOP 1-6, taking precautions to minimize disturbance of the stagnant water column above the screened interval during water level measurement. Well depth should be obtained from review of the well completion logs, from previous work or after sampling is complete. Insertion of a water level measuring device to the bottom of the well casing will result in resuspension of settled solids from the formation surrounding the screened interval, thus requiring longer purging times for turbidity and other field parameter equilibration.

8. Dedicated sampling devices (those permanently installed in the well) capable of pumping and sampling are preferred over any other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids collected at the bottom of the well or in the surrounding formation within the screened interval.

9. New polyethylene tubing shall be used for each sample when using non-dedicated sampling equipment. Prepare the pump and tubing for insertion into the well. Lower the pump intake down into the well casing. Connect the flow-through cell in-line with the pump effluent tubing.

10. Generally, the pump intake should be placed in the mid-point of the screened interval. This provides consistency between sampling rounds. However, if the geology of the screened interval consists of heterogeneous materials with layers of contrasting hydraulic conductivity, the pump intake should be positioned adjacent to the zone of highest hydraulic conductivity (as determined via review of the existing site hydrogeologic conditions/well completion logs). Also, the sampling plan should be consulted to determine if particular zones (e.g., known zones of contamination) are targeted for sampling per DQOs). When conducting low flow sampling to evaluate vapor intrusion, the pump intake should be collected at or near the water table (i.e., 0-2 feet below the water table) to ensure groundwater samples are representative of the shallowest portion of the aquifer.

11. To achieve low-flow purging conditions, the purge rate should generally not exceed 0.5 L/min. Adjust the pump control to stabilize the flow rate, and therefore minimize drawdown (less than 0.3 foot during purging activities). The water level in the well should be measured throughout the purging process to monitor drawdown. Flow rate can be measured from the discharge tube using a volumetric measuring device (e.g., a graduated cylinder) and a stopwatch. (Note: determine flow rate by measuring volume in 0.5-minute or 1-minute increments.)

12. Record water level measurements, and field parameters including pH, temperature, specific conductivity, oxidation reduction potential (ORP), DO, turbidity, and flow rate every three to five minutes during the purging process. Record all measurements and observations in the logbook or on a groundwater purging and sampling form (**Attachment 1**). Purging shall continue until the field parameters have stabilized. Parameters are considered stable when three consecutive readings are within the limits of the criteria defined in Table 5.1 and/or in accordance with the site-specific sampling plan. Turbidity ideally should stabilize below 10 NTU prior to sample collection, particularly if groundwater samples are to be collected for metals or PCB analyses.

TABLE 5.1 Stabilization of Water Quality Indicator Parameters

Parameter	Units	Stabilization Criteria
Water Level	Feet/meters	< 0.3 foot (< 0.1 meter)
Temperature	°F/°C	± 3 percent, or ±1.8 degrees Fahrenheit (°F) /±1 degree Celsius (°C)
pH	(n/a)	± 10 percent, or ±0.1 standards units (SU)
Specific Conductivity	µm/cm	±3 percent (microsiemens per centimeter, or µm/cm)
ORP	mV	±10 millivolts (mV)
Dissolved Oxygen	mg/L	±10 percent for values greater than 0.5 mg/L, or 0.2 milligram per liter (mg/L) - whichever is greater. If three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized.
Turbidity	NTU	± 1 Nephelometric Turbidity Unit (NTU) (±10 percent for turbidity if greater than 5 NTU) If three Turbidity values are less than 5 NTU, consider the values as stabilized
Flow Rate	L/min	0.1 to 0.5 Liters per minute (L/min) (< 1 L/min), specific flow rates and sampling rates to be identified in the sampling plan if project/contract required.

13. In low recharge aquifers, the following steps shall be followed:
    (1) If the initial water level is less than 10 feet above the top of the well screen, then purge the well until dry and allow sufficient recharge to collect samples.
    (2) If the initial water level in the well is greater than 10 feet above the top of the screen, then care shall be taken to prevent the dewatering of the screened interval during purging of the well.
        (2a) Continue purging until the water level is between 1 foot (0.3 meter) and 5 feet (1.5 meters) above the top of the screened interval.
        (2b) Allow the well to recharge, then continue purging until at least one full initial well volume has been purged.
    (3) Record all data, measurements, and observations in the logbook.

14. After field parameters have stabilized, disconnect the flow through cell, and collect groundwater samples directly from the discharge tubing into an appropriate sample container. If using a peristaltic pump to collect VOC samples, refer to item 16 of this SOP for the correct procedure for sampling VOCs with a peristaltic pump. If an in-line, flow-through cell is used to continuously monitor indicator parameters, it should be disconnected or bypassed during sample collection. During sample collection, maintain the pump rate at the same rate used during purging (unless specified in the sampling plan). The pump rate used during sample collection may need to be lowered to minimize aeration, bubble formation, or turbulent flow of water into sample bottles, or to prevent sample preservatives from being washed out of the sample container. Note: Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOC and dissolved gases in the groundwater samples.

15. Groundwater sampling (including the collection of all required quality assurance/quality control samples specified in the sampling plan) shall be performed immediately upon completion of purging (unless time for recharge is required for low-recharge wells) using the same equipment used for purging. Sampling should occur in a progression from the least to the most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g., Fe^{2+}, CH_4, H_2S/HS^-, and alkalinity) analytes should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are required. Filtered samples should be collected last and in-line filters should be used. After all unfiltered samples have been collected, a 0.45 micron (µm) in-line filter shall be inserted in the discharge line for collection of filtered samples, as required.

16. VOC samples should not be collected directly from the discharge end of a peristaltic pump. After field parameters have stabilized, and all other samples have been collected as required, stop the pump and simultaneously pinch the discharge end of the tubing shut. Disconnect the flow-through cell. Remove the tubing from the well and fill the VOC sample containers from the influent end of the sample tubing, (the end of the tubing that was located down-well during purging activities). The flow rate when filling sample vials may be controlled by setting the peristaltic pump in reverse.

17. Place all samples in a cooler with ice or ice packs to comply with project, laboratory, and/or regulatory requirements. Do not use "blue ice" packs with samples to be analyzed for PFAS.

18. After sampling activities have been completed, remove the portable pump assembly from the well, if used, and decontaminate all non-disposable components. Re-install and secure the well gripper plug and cover. Clean up the work area; containerize and/or dispose of purge water as required by the site-specific sampling plan, and dispose of tubing and all other disposable sampling equipment as investigation derived waste (IDW) after each use as described in the site-specific sampling plan.

5.1 Conducting Low Flow Groundwater Sampling at Per- and Polyfluoroalkyl Substances (PFAS) Sites

The evolving regulatory standards for PFAS should be considered in the implementation of low-flow groundwater sampling as well as the development of project planning documents such as: work plans, sampling and analysis plans, quality assurance project plans, data management plans, accident prevention plans, health and safety plans, and laboratory statements of work used to guide the collection of samples for PFAS analysis.

A consideration of the PFAS-specific sampling requirements is needed during the planning phase because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. This means that the development of project data quality objectives (DQOs), and selection of action levels, reporting limits are all impacted with the inclusion of sampling for PFAS analysist.

Before implementing low-flow groundwater sampling for collection of samples for PFAS analysis, it is important to review current regulatory standards to determine whether site- or project-specific changes to low-flow groundwater sampling should be included in project planning documents to align with the latest regulatory standards and sampling guidance. CDM Smith regulatory updates can be located at the INFOCENTER. Specific state and federal regulatory limit updates can be found here:

https://cdmsmith.libguides.com/PFAS_InfoCenter

Procedural modifications for low-flow groundwater sampling and other related field activities at PFAS sites are provide below. A check list containing common materials and sampling equipment that may contain PFAS compounds is attached and also can be found here:

https://www.yammer.com/cdmsmith.com/#/files/214861635584

Procedural Considerations For PFAS Sampling

Development of PFAS awareness in guidance and incorporation into specific TSOPs is necessary because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. (For example, Federal drinking water MCL for Arsenic is 10,000 ppt where the EPA health advisory level is a combined 70 ppt for PFOA and PFOS.) Procedural modifications to field activities when sampling for PFAS analysis involve the concerns listed below. Good housekeeping, detailed documentation of these extra steps and vigilance about clearly defined exclusion zones should be strictly adhered to.

Good practices

- Utilize good safety planning and institute exclusion zones, contamination reduction zones, and support zones (no visitors within 30 feet of sampling).
- Do not eat in or near sampling areas (food packaging may contain PFAS).
- Be vigilant about PPE donning and doffing practices.
- Wash hands before and after eating.
- Wear powderless nitrile gloves and change them frequently.
- Only open sample container during sample collection and never set the sample container lid down.
- Keep hands away from the container opening when sampling and keep lid protected.
- Develop a project-specific checklist for review with field personnel.
    - It should be project-specific
    - Completed prior to beginning PFAS sampling event, whenever there are staffing changes, and whenever sample media change and associated sampling/field equipment changes
    - Consider appropriate sampling/field work sequences for each matrix
    - Sampling/field work sequences
    - PFAS sampling/field work should occur first on sites where other contaminants will also be sampled.
    - CDM Smith PFAS Sampling Guidance Team can assist with development of your project-specific checklist.

Avoid

- **PTFE, LDPE**, sticky notes, waterproof field book, aluminum foil
- Field filtering of water samples because of glass fiber filters
    - Avoid use of markers, if possible, during sampling use only regular ink pens. If needed, write over regular ink with marker after the sample containers are sealed.
- Consult materials checklists for equipment concerns.

6.0 Restrictions/Limitations

Only grounded electrical devices should be used for low-flow sampling activities. If a gasoline-powered electrical source is used, place portable power sources (e.g., generators) 50 feet (15 meters) or farther from the wellhead to prevent potential contamination of samples. Additionally, it should be clearly noted in the field notes or on the Groundwater Sampling Log (Attachment 1) if a well has been pumped dry and allowed to recharge prior to sample collection, as low-flow sampling data is no longer applicable.

7.0 References

ASTM D6452-99(2012)e1, Standard Guide for Purging Methods for Wells Used for Groundwater Quality Investigations, ASTM International, West Conshohocken, PA, 2012.

ASTM D4448-01(2013), Standard Guide for Sampling Ground-Water Monitoring Wells, ASTM International, West Conshohocken, PA, 2013.

Puls, R.W. and M.J. Barcelona. April 1996. Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. U.S. EPA, Ground Water Issue, Publication Number EPA/540/S-95/504.

Reinhart, R. and Smaldone, John. September 2017. Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. U.S. EPA, Region 1 Quality Assurance Unit, EQASOP-GW4.

U. S. Environmental Protection Agency. May 2002. *Groundwater Sampling Guidelines for Superfund and RCRA Project Managers.* Ground Water Forum Issue Paper, EPA 542-S-02-001, OSWER, Technology Innovative Office, Washington, D.C.

_____. Region 4. April 2017. The Field Branches Quality System and Technical Procedures, Operating Procedure Groundwater Sampling. SESDPROC-301-R4.

Attachment 1
EXAMPLE LOW-FLOW GROUNDWATER SAMPLING PURGING DATA SHEET

Site Name: _____ **Date:** _____ **OVM:** **FID** ☐ **PID** ☐ **In Casing (ppm): (Initial)** _____ **(Vented to)** _____

Well ID: _____ **Purging/Sampling Device:** _____

Initial Static Water Level (feet btoc): _____ **Analytical Parameters:** _____

Final Water Level (feet btoc): _____ **QC Samples Collected:** _____

Purge Start Time: _____ **Sample Number:** _____

Sample Time: _____ **Samplers' Signatures:** _____

Time	Water Level (ft btoc)	Temperature (ºC)	pH (SU)	Conductivity (µs/cm)	Dissolved Oxygen (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (mL/min)	Comments (e.g., depth of pump intake, screened interval)

Parameter	Units	Stabilization Criterion
Water Level	Feet/meters	< 0.3 foot (< 0.1 meter)
Temperature	°F/°C	± 3 percent, or ±1.8 degrees Fahrenheit (°F) /±1 degree Celsius (°C)
pH	(n/a)	± 10 percent, or ±0.1 standards units (SU)
Specific Conductivity	µm/cm	±3 percent (microsiemens per centimeter, or µm/cm)
ORP	mV	±10 millivolts (mV)
Dissolved Oxygen	mg/L	±10 percent, or 0.2 milligram per liter (mg/L) - whichever is greater If three DO values values are less than 0.5 mg/L, consider the values as stabilized.
Turbidity	NTU	± 1 Nephelometric Turbidity Unit (NTU) (±10 percent for turbidity if greater than 5 NTU), If three turbidity values are less than 5 NTU, consider the values as stabilized.
Flow Rate	L/min	0.1 to 0.5 Liters per minute (L/min) (< 1 L/min)

Attachment

PFAS Sampling Materials Checklist

Development of PFAS sampling guidance TSOPs is necessary because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the parts per trillion (ppt) range. The levels of awareness for PFAS cross contamination vary by the opportunities of introducing PFAS into the environment media under investigation.

1. Critical: Items in direct contact of environmental media under investigation. These can include, but not limited to, sample containers, sampling parts and equipment, drilling equipment, well construction items and materials, parts and equipment for hydrogeological testing, in-situ treatment parts and equipment.
2. Very Important: PPE, personal hygiene that are used by sampling personnel.
3. Important: Items used in coolers for shipping and transporting PFAS samples.
4. Less important/awareness level concern: Activities in the staging area away from immediate PFAS investigation area.

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
Field Clothing or PPE				
Clothing or boots containing "water resistance" or "stain-treated" fabrics			X	
Cloths washed with fabric softeners			X	Fabric softeners may contain PFAS.
New and unwashed clothing			X	fabric treatment may contain PFAS
Uncoated Tyvek		X		USEPA PFAS sampling guidance from Region 2 prohibits use of Tyvek.
Coated Tyvek			X	
PVC or wax-coated fabrics	X			
Neoprene	X			
Synthetic and natural fibers (preferably cotton)	X			
Steel-toed boots made with polyurethane and PVC	X			If it is not possible to find PFAS free steel-toed footwear, PFAS-free over boots may be worn. The over boots must be put on and the hands washed after putting the over boots on prior to the beginning of the sampling activities. Over boots may only be removed in the staging area and after the sampling activities have been completed.
Well-laundered clothes	X			several times from time of purchase.
Well-washed cotton coveralls	X			washed several times.

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
Personnel Hygiene and Protective Skin Products				
Sunscreens		X		Good to use: Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, and baby sunscreens that are “free” or “natural.
Insect Repellents		X		Good to use: Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics.
International brands of sunscreens and insect repellents		X		Must be evaluated on a case-by-case basis.
Field Sampling Items				
Waterproof field paper or books			X	Use loose plain paper.
Post-it notes			X	
Aluminum foil			X	
Brand-name markers			X	Sharpie may be used to label sample bottles in the staging area, but markers should not be used in the immediate sampling environment.
Off-brand markers		X		
Ball point pens	X			
plastic clipboards			X	NJ DEP sampling guidance, use metal clipboard.
Plastic table cover			X	
Sampling Equipment				
Item containing high-density polyethylene (HDPE)	X			
Item containing polypropylene	X			PP sample bottles must be used for drinking-water samples in accordance with USEPA method 537.1.1.
Item containing polyurethane	X			
Item containing Polyvinyl chloride (PVC)	X			
Item containing silicon	X			
Item made of stainless steel	X			
Alconox®	X			
Citronex®	X			
Liquinox®	X			
Powderless nitrile gloves	X			

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
HDPE Hydrasleeves or sonic core bags	X			
Neoprene	X			
Crisco® or other vegetable-based greases for lubricating parts	X			
Item containing PTFE			X	Items or equipment that contains PTFE parts that will be in direct contact with sampling media.
Item containing Teflon®			X	Field sampling items or equipment that contains Teflon® and that will be in direct contact with the sampling media.
Item containing fluoropolymer			X	
Low-density polyethylene (LDPE)			X	Items or equipment that contains LDPE parts and that will be in direct contact with the sampling media.
Viton® O-rings			X	Viton® O-rings used in pressure washers used for sampling equipment decontamination.
Glass sample containers			X	
Field filter			X	Field filtration should be avoided regardless of filter types.
Decon 90			X	
Items containing fluorosurfactants			X	
Teflon-bearing plumber's tape			X	
Blue (or chemical) ice			X	Later data (unpublished) suggest no cross contamination from blue ice. The category may be changed after data are published.
Water ice	X			Double bag in polyethylene bags.
Internal valves and equipment parts for sampling or decon		X		
Methanol or other solvents		X		
LDPE plastic bags (e.g., Ziploc® bags)		X		For larger biota sampling, Ziploc bags may be used, but collecting an equipment blank is recommended because these bags may be made of LDPE.
Drilling fluids		X		
LDPE sonic core sample bags		X		Manufactured by Boart Longyear and Hole Products.

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
Equipment with moving parts that may be lubricated with PFAS containing lubricants or greases		X		
Rental equipment		X		Must be verified to have no PFAS-bearing parts prior to use.
Others				
Food wrappers			X	Field personnel must wash hands after having food wrapped with grease repelling paper.

(1) If an item that may contain PFAS but alternative is not available, the item should be tested for PFAS before use.
(2) This mostly refers to the immediate sampling environment, particularly, the item is in contact with environmental media to be sampled.
(3) There are no standard operation procedures on how an item can be verified. Please contact PFAS experts for advice on the best practice for testing an item for potential PFAS contamination.

Packaging and Shipping Environmental Samples

SOP 2-1
Revision: 7
Date: August 2020

Approved: Ernest Ashley **Technical Review:** Mary Lou Fox

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to outline requirements for packaging and shipping environmental samples. Additionally, Sections 2.0 through 7.0 outline requirements for packaging and shipping regulated environmental samples under the U.S. Department of Transportation (USDOT) Hazardous Materials Regulations, the International Air Transportation Association (IATA), and International Civil Aviation Organization (ICAO) Dangerous Goods Regulations for shipment by air and applies only to domestic shipments. This SOP does not cover requirements for packaging and shipping equipment (including data loggers and self-contained breathing apparatus [SCBAs] or bulk chemicals that are regulated under the DOT, IATA, and ICAO.

1.1 Packaging and Shipping of All Samples

This SOP applies to packaging and shipping all environmental samples. If the sample is preserved or radioactive, the following sections may also be applicable and therefore, should be reviewed for additional requirements.

Section 2.0 - Packaging and Shipping Samples Preserved with Methanol
Section 3.0 - Packaging and Shipping Samples Preserved with Sodium Hydroxide
Section 4.0 - Packaging and Shipping Samples Preserved with Hydrochloric Acid
Section 5.0 - Packaging and Shipping Samples Preserved with Nitric Acid
Section 6.0 - Packaging and Shipping Samples Preserved with Sulfuric Acid
Section 7.0 - Packaging and Shipping Limited-Quantity Radioactive Samples

Note: This SOP does not address shipment of hazardous materials. Shipping of hazardous materials are strictly prohibited unless you have received training that meets CDM Smith, DOT, and IATA requirements. Check with CDM Smith University for training courses.

1.2 Background

1.2.1 Definitions

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Environmental Sample - An aliquot of air, water, plant material, sediment, or soil that represents the contaminant levels on a site. Samples of potential contaminant sources, like tanks, lagoons, or non-aqueous phase liquids are normally not considered "environmental" for this purpose. This procedure applies only to environmental samples that contain less than reportable quantities for any foreseeable hazardous constituents, according to DOT regulations promulgated in 49 CFR - Part 172.101 Appendix A.

Custody Seal - A custody seal is a narrow adhesive-backed seal that is applied to individual sample containers and/or the container (i.e., cooler) before shipping offsite. Custody seals indicate that sample integrity has not been compromised during transport from the field to the analytical laboratory.

Inside Container - The container (normally made of glass or plastic) that actually contacts the shipped material. Its purpose is to keep the sample from mixing with the ambient environment.

Outside Container - The container (normally made of metal or plastic) that the transporter contacts. Its purpose is to protect the inside container.

Secondary Containment - The outside container provides secondary containment if the inside container breaks (i.e., plastic overpackaging if liquid sample is collected in glass).

Allowed Quantity - Allowed quantities, below which USDOT, IATA, ICAO regulations do not apply, limit the mass or volume of a hazardous material in the inside and outside containers. Allowed quantity limits are very low and most regulated shipments are made under excepted or limited quantities (see descriptions below).

Excepted Quantity – Excepted quantity is the maximum amount of a hazardous material below which there are specific labeling or packaging exceptions.

Limited Quantity - Limited quantity is the maximum amount of a hazardous material below which there are specific labeling or packaging exceptions. The limited quantity will be a higher amount than the excepted quantity for a given substance.

Performance Testing - Performance testing refers to required testing of outer packaging, such as drop and stacking tests.

Qualified Shipper - A qualified shipper is a person who has been adequately trained to perform the functions of shipping hazardous materials. Required trainings include Hazardous Materials Shipping (HAZ 003) for ground shipping of hazardous materials and Hazardous Transportation/Shipping Air (IATA THZ 203) and hold resulting training certificates not more than three years old.

1.2.2 Associated Procedures

- SOP 1-2, *Sample Custody*

1.2.3 Discussion

Proper packaging and shipping is necessary to ensure the protection of the integrity of environmental samples shipped for analysis. These shipments are potentially subject to regulations published by DOT, IATA, or ICAO. Failure to abide by these rules places both CDM Smith and the individual employee at risk of serious fines. The analytical holding times for the samples must not be exceeded. The samples shall be packed in time to be shipped for overnight delivery. Prior arrangements with the laboratory should be made before sending samples for weekend delivery.

1.3 Required Equipment

- Coolers with return address of the appropriate CDM Smith office
- Heavy-duty plastic garbage bags (contractor bags, 3.0 millimeter thickness)
- Plastic zip-type bags, small and large
- Clear tape
- Nylon reinforced strapping tape
- Duct tape
- Kitty litter/pine bedding (or an equivalent nonflammable material that is inert and absorbent)*
- Bubble wrap (optional)
- Ice
- Custody seals
- Completed chain-of-custody record or contract laboratory program (CLP) custody records, if applicable
- Completed bill of lading
- "This End Up" and other directional arrow labels

*Check for any client-specific or laboratory requirements related to the use of absorbent packaging materials.

1.4 Packaging Environmental Samples

The following steps are required when packing sample bottles and jars for shipment:

1. Verify the samples undergoing shipment meet the definition of "environmental sample" and are not a hazardous material as defined by USDOT. Professional judgment and/or consultation with qualified persons such as the appropriate health and safety coordinator or the health and safety manager shall be observed.

2. Select a sturdy cooler in good condition. Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Ensure the handles used for carrying the cooler are in good condition. Also, tape the drain plug from the inside and outside of the cooler. Line the cooler with a large heavy-duty plastic garbage bag.

3. Be sure the caps on all bottles are tightly sealed and will not leak; check to see that labels and chain-of-custody records are completed properly (SOP 1-2, Sample Custody).

4. Place all bottles in separate and appropriately sized plastic zip-top bags and close the bags. Up to three volatile organic analyte (VOA) vials may be packed in one bag. Binding the vials together with a rubber band on the outside of the bag or separating them so that they do not contact each other will reduce the risk of breakage. VOA vials may be packaged in foam containers designed for packaging them as well. Bottles may be wrapped in bubble wrap. Optionally, place three to six VOA vials in a quart metal can and then fill the can with kitty litter/pine bedding or equivalent. Note: Include trip blanks in coolers containing VOA samples.

5. Place 2 to 4 inches of an absorbent material into a cooler that has been lined with a garbage bag, and then place the bottles and cans in the bag with sufficient space to allow for the addition of packing material between the bottles and cans. It is preferable to place sample bottles and jars (especially glass) into the cooler vertically. Glass containers are less likely to break when packed vertically rather than horizontally, and sample bottles are less likely to leak when upright in the cooler.

6. While placing sample containers into the cooler, conduct an inventory of the contents of the shipping cooler against the chain-of-custody record. The chain-of-custody with the cooler shall reflect only those samples within the cooler.

7. Put ice in large plastic zip-top bags (double bagging the zip-tops is preferred) and properly seal. Place the ice bags on top of and/or between the samples. Several bags of ice are required (dependent on outdoor temperature, staging time, etc.) to maintain the cooler temperature at approximately 4° $\pm$ 2° Celsius (C) if the analytical method requires cooling. Large volumes of soil samples may require an interim cooling step to ensure that the shipping ice will be sufficient for the samples to reach the laboratory in satisfactory condition. Fill all remaining space between the bottles or cans with packing material. Securely fasten the top of the large garbage bag with fiber or duct tape.

8. When approved by the client/ laboratory, an alternate method of packing ice to keep sample cold during shipment is to line the cooler with a contractor bag and then put a layer of ice in the bottom of the bag. Place an inner contractor bag inside the outer contractor bag and the ice layer and place samples inside the inner bag. If a temperature blank is being used, place the temperature blank inside the inner bag with the samples. Then pour ice between the inner and outer contractor bags around the inner bag containing the samples. When all samples and a temperature blank, if applicable, are in the inner bag, twist the inner bag closed, tape the twisted closure, and place a custody seal around the taped closure. Cover the custody seal with clear tape. The custody seal around the inner bag closure maintains the custody seal for the samples, should the cooler open for any reason during shipment. Twist the outer bag closed and seal it with tape, as well.

9. Place the completed chain-of-custody record or the CLP traffic report form (if applicable) for the laboratory into a plastic zip-top bag, seal the bag, tape the bag to the inner side of the cooler lid, and close the cooler.

10. Secure the cooler lid with nylon reinforced strapping tape by wrapping each end of the cooler a minimum of two times. Attach completed chain-of-custody seals across the opening of the cooler on opposite sides. The custody seals should be affixed to the cooler with half of the seal on the strapping tape, so that the cooler cannot be opened without breaking the seal. Complete two more wraps around with fiber tape and place clear tape over the custody seals.

11. Mark the shipping container lid with a **"THIS END UP"** and appropriate upward position arrow labels. These upward position arrows should also be affixed to the cooler. Place a label containing the name and address of the shipper (CDM Smith) to the outside of the container. Labels used in the shipment of hazardous materials (such as Cargo Only Aircraft, Flammable Solids, etc.) are not permitted on the outside of containers used to transport environmental samples and should not be used. The name and address of the laboratory shall be placed on the container. When shipping by common courier, the bill of lading shall be completed and attached to the lid of the shipping container.

12. Per- and polyfluoroalkyl substances (PFAS) samples (collected in high density polyethylene containers), once they are securely closed and labeled, are to be shipped as "other environmental samples" with water ice to chill the samples below 6° Celsius. A PFAS sample container should not be opened after being sealed following collection. If, for any reason, the container is opened at this

point, great care should be taken to avoid cross-contamination as materials allowed for the shipment of the sealed containers may be sources of PFAS.

2.0 Packaging and Shipping Samples Preserved with Methanol

2.1 Containers

1. The maximum volume of methanol in a sample container is 30 milliliters (ml) per sample vial and 500 mls total for the cooler for shipment as an excepted quantity.

2. The sample container should not be full of methanol.

2.2 Responsibility

To legally ship a dangerous good such as methanol, applicable training is required. It is the responsibility of the qualified shipper to:

1. Ensure that the samples undergoing shipment contain no other contaminant that meets the definition of "hazardous material" as defined by the USDOT.

2. Determine the amount of preservative in each sample so that accurate determination of quantities can be made.

   Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance project plan (QAPP).

2.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

1. Inner packing (may consist of glass or plastic jars)

2. Outer packaging (for excepted or limited quantities) should be an insulated cooler that has passed the ICAO drop test and is in good condition.

3. Survey documentation (if shipping from Department of Energy [DOE] or radiological sites)

4. "Dangerous Goods" labels completed appropriately for methanol for excepted quantities, or appropriate hazard class labels (i.e. flammable liquid") for limited quantities

5. Orientation labels

6. Consignor/consignee labels

2.4 Packaging Samples Preserved with Methanol

The following steps are required when packaging excepted or limited-quantity sample shipments:

1. Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.

   All sample containers will be properly labeled and the label protected with waterproof tape before sampling. No taping of labels should be done for VOC samples that are collected with EPA method 5035 in pre-weighed vials, as the mass of the soil sample is obtained by the difference between the received sample weight (soil + methanol + vial) and the weight of the vial and methanol that was pre-weighed. At a minimum the label should contain:

- Project name
- Project number
- Date and time of sample collection
- Sample location
- Sample identification number
- Collector's initials
- Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form)

2. Wrap each container (40-ml VOA vials) in bubble wrap (secure with waterproof tape) to prevent breakage.

3. Place the bubble-wrapped container into a 3.0-mil zip-type bag, removing trapped air.

4. Place wrapped containers inside a polyethylene bottle filled with an absorbent; seal the bottle. (Maximum of four VOA vials will fit inside a 500-ml wide-mouth polyethylene bottle.)

5. Total volume of methanol per shipping container should not exceed 500 ml.

6. Line the bottom of the cooler with absorbent material to absorb any leakage that may occur.

7. Line the cooler with a contractor grade garbage bag.

8. Pack the samples, with bottles placed upright, appropriately inside the garbage bag to prevent movement during shipment.

9. Place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.

10. Seal the garbage bag by tying or taping.

11. The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any excepted or limited-quantity shipment of dangerous goods.

12. Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.

13. If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.

14. Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.

15. Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.

16. For a limited quantity, mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

    Methanol Mixture
    UN1230
    LTD. QTY.

17. For an excepted quantity, there must be a "dangerous goods in excepted quantities" label on the cooler. The label must have the hazard class for methanol on it below the "E". Methanol is flammable (class 3).

18. Place a label on the top or front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.

19. Affix a "flammable liquid" label to the outside of the cooler for limited quantities.

20. Affix package orientation labels on two opposite sides of the cooler.

21. Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment. An example of cooler labeling/marking locations is shown below in Figure 1.

    Note: No marking or labeling can be obscured by strapping or duct tape.

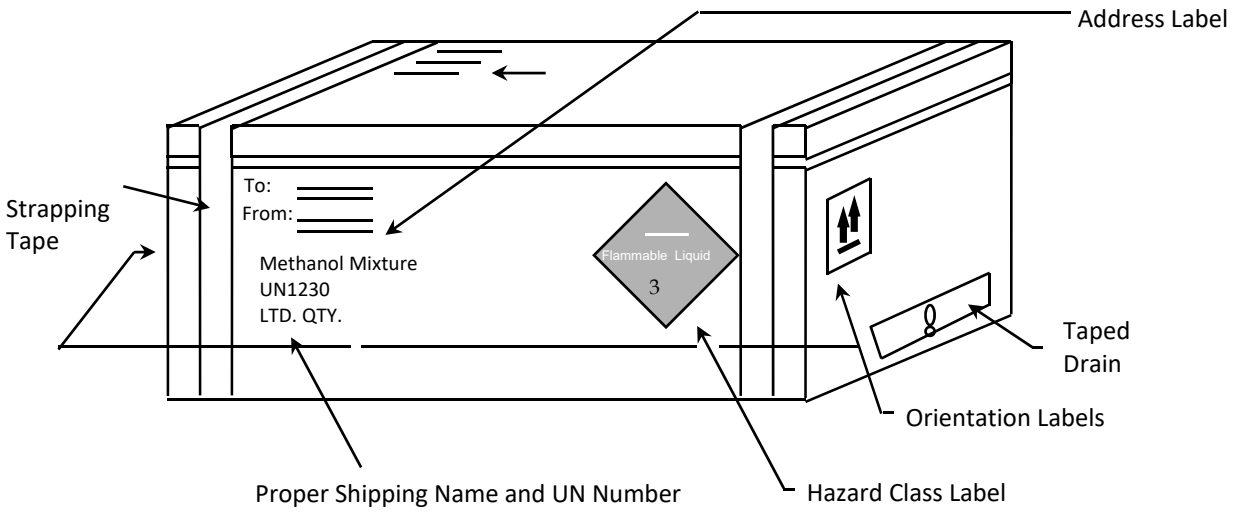
    Note: Place inner packaging of dangerous goods into the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

22. When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 millirem/hour (mrem/h) on all sides. This survey will be documented and the results reviewed by the qualified shipper.

23. Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Excepted/Limited-Quantity (Appendix A).

24. Complete a Dangerous Goods airbill.

Figure 1
Example of Cooler Label/Marking Locations for Limited Quantities



3.0 Packaging and Shipping Samples Preserved with Sodium Hydroxide

3.1 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Excepted Quantities of Sodium Hydroxide Preservatives

Preservative		*Desired in Final Sample*		*Quantity of Preservative (ml) for Specified Container*				
		pH	**Conc.**	**40 ml**	**125 ml**	**250 ml**	**500 ml**	**1 L**
NaOH	30%	>12	0.08%	'--	.25	0.5	1	2

20 drops = 1 ml

3.2 Responsibility

It is the responsibility of the qualified shipper to determine the amount of preservative in each sample so that accurate determination of quantities can be made.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific QAPP.

3.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

- Outer packaging (for limited quantities) should be an insulated cooler that has passed the ICAO drop test and is in good condition.
- Inner packings may consist of glass or plastic jars no larger than 1 pint.
- Survey documentation (if shipping from DOE or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

3.4 Packaging Samples Preserved with Sodium Hydroxide

Samples containing sodium hydroxide (NaOH) as a preservative that exceed the excepted concentration of 0.08 percent (2 ml of a 30 percent NaOH solution per liter) may be shipped as a limited quantity per packing instruction Y819 of the IATA/ICAO Dangerous Goods Regulations.

The following steps are required when packaging limited-quantity samples shipments:

1. Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.

2. All sample containers will be properly labeled and the label protected with waterproof tape before sampling.

   At a minimum the label should contain:

   - Project name
   - Project number
   - Date and time of sample collection
   - Sample location
   - Sample identification number
   - Collector's initials
   - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form)

3. If the containers are breakable; wrap each container in bubble wrap (secure with waterproof tape) to prevent breakage.

4. Place the bubble-wrapped container into a 3.0-mil zip-type bag, removing trapped air.

5. Place glass containers inside a polyethylene bottle filled with an absorbent; seal the bottle.

6. The total volume of sample in each cooler should not exceed 1 liter.

7. Place sufficient amount of an absorbent in the bottom of the cooler to absorb any leakage that may occur.

8. Line the cooler with a contractor grade garbage bag .

9. Pack the samples, with bottles placed upright, appropriately inside the garbage bag to prevent movement during shipment.

10. Place sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.

11. Seal the garbage bag by tying or taping.

12. The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.

13. Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.

14. If the shipment is from a DOE or other radiological facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.

15. Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.

16. Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.

17. Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

    Sodium Hydroxide Solution
    UN1824
    LTD. QTY.

18. Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.

19. Affix a "corrosive" label to the outside of the cooler.

20. Affix package orientation labels on two opposite sides of the cooler.

21. Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment. An example of cooler labeling/marking locations is shown above in Figure 1.

    Note: **Samples meeting the allowed concentration of 0.08 percent NaOH by weight may be shipped as nonregulated or nonhazardous following the procedure in Section 1.4.**

    Note: No marking or labeling can be obscured by strapping or duct tape.

    Note: Place the inner packaging of dangerous goods into the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

22. When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.

23. Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited-Quantity (Appendix A).

24. Complete a Dangerous Goods Air Bill.

4.0 Packaging and Shipping Samples Preserved with Hydrochloric Acid

4.1 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Excepted Quantities of Hydrochloric Acid Preservatives

Preservative		*Desired in Final Sample*		*Quantity of Preservative (ml) for Specified Container*		
		pH	**Conc.**	**40 ml**	**125 ml**	**250 ml**
HCl	2N	<2	0.04%	.2	.5	1

20 drops = 1 ml

4.2 Responsibility

It is the responsibility of the qualified shipper to:

1. Determine the samples undergoing shipment contain no other contaminant that meets the definition of hazardous material as defined by DOT.

2. Determine the amount of preservative in each sample so that accurate determination of quantities can be made.

Note: Responsibilities may vary from site to site; therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific QAPP.

4.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3.

- Inner packing may consist of glass or plastic jars no larger than 1 pint.
- Outer packaging (for limited quantities) should be an insulated cooler that has passed the ICAO drop test.
- Survey documentation (if shipping from DOE or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

4.4 Packaging Samples Preserved with Hydrochloric Acid

The following steps are to be followed when packaging limited-quantity sample shipments:

1. Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.

2. All sample containers will be properly labeled and the label protected with waterproof tape before sampling.

   At a minimum the label should contain:

   - Project name
   - Project number
   - Date and time of sample collection
   - Sample location
   - Sample identification number
   - Collector's initials
   - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form)

3. Wrap each container (40-ml VOA vials) in bubble wrap (secure with waterproof tape) to prevent breakage.

4. Place the bubble-wrapped container into a 3.0-mil zip-type bag, removing trapped air.
5. Place wrapped containers inside a polyethylene bottle filled with an absorbent; seal the bottle. (No more than four VOA vials will fit inside a 500-ml, wide-mouth polyethylene bottle.)
6. Total volume of sample inside each cooler should not exceed 1 liter.
7. Line the bottom of the cooler with sufficient absorbent material to absorb any leakage that may occur.
8. Line the cooler with a contractor-grade garbage bag.
9. Pack the samples, with bottle placed upright, appropriately inside the garbage bag to prevent movement during shipment.
10. Place sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
11. Seal the garbage bag by tying or taping.
12. The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.
13. Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.
14. If the shipment is from a DOE or other radiological facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
15. Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
16. Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
17. Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below) .

    Hydrochloric Acid Solution
    UN1789
    LTD. QTY.

18. Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
19. Affix a “corrosive” label to the outside of the cooler.
20. Affix package orientation labels on two opposite sides of the cooler.
21. Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment. An example of cooler labeling/marking locations is shown in Figure 1.

    Note: **Samples containing less than the allowed concentration of 0.04 percent HCl by weight will be shipped as nonregulated or nonhazardous following the procedure in Section 1.4.**

    Note: No marking or labeling can be obscured by strapping or duct tape.

Note: Place the inner packaging of dangerous goods inside the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

22. When shipping from a DOE facility, the cooler is to be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey should be documented, and the results reviewed by the qualified shipper.
23. Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Excepted/Limited-Quantity (Appendix A).
24. Complete a Dangerous Goods airbill.

5.0 Packaging and Shipping Samples Preserved with Nitric Acid

5.1 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Excepted Quantities of Nitric Acid Preservatives

Preservative		*Desired in Final Sample*		*Quantity of Preservative (ml) for Specified Container*				
		pH	**Conc.**	**40 ml**	**125 ml**	**250 ml**	**500 ml**	**1 L**
HNO_3	6N	<2	0.15%		2	4	5	8

5 drops = 1 mg/L

5.2 Responsibility

It is the responsibility of the qualified shipper to:

1. Determine the samples undergoing shipment contain no other contaminant that meets the definition of hazardous material as defined by DOT.
2. Determine the amount of preservative in each sample so that accurate determination of quantities can be made.

Note: Responsibilities may vary from site to site; therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific QAPP.

5.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

- Inner packings may consist of glass or plastic jars no larger than 100 ml.
- Outer packaging (for limited quantities) should be an insulated cooler that has passed the ICAO drop test.
- Survey documentation (if shipping from DOE or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

5.4 Packaging Samples Preserved with Nitric Acid

Samples containing nitric acid (HNO_3)as a preservative that exceed the excepted concentration of 0.15 percent HNO_3 will be shipped as a limited quantity per packing instruction Y807 of the IATA/ICAO Dangerous Goods Regulations.

The following steps are to be followed when packaging limited-quantity sample shipments:

1. Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.

2. All sample containers will be properly labeled and the label protected with waterproof tape before sampling.

   At a minimum the label should contain:
   - Project name
   - Project number
   - Date and time of sample collection
   - Sample location
   - Sample identification number
   - Collector's initials
   - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form

3. If the containers are breakable; wrap each container in bubble wrap (secure with waterproof tape) to prevent breakage.

4. Place the bubble-wrapped container into a 3.0-mil zip-type bag, removing trapped air.

5. Place glass containers inside a polyethylene bottle filled with an absorbent; seal the bottle.

6. Line the bottom of the cooler with sufficient absorbent material to absorb any leakage that may occur.

7. Line the cooler with a contractor grade garbage.

8. Pack the samples, with bottles placed upright, appropriately inside the garbage bag to prevent movement during shipment.

9. Place sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.

10. Seal the garbage bag by tying or taping.

11. The maximum volume of preserved solution in the cooler should not exceed 500 ml.

12. The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.

13. Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.

14. If the shipment is from a DOE or other radiological facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.

15. Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.

16. Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.

17. Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below) for limited quantities.

    Nitric Acid Solution (with less than 20 percent)
    UN2031
    Ltd. Qty.

18. Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.

19. Affix a "corrosive" label to the outside of the cooler.

20. Affix package orientation labels on two opposite sides of the cooler.

21. Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment. An example of cooler labeling/marking locations is shown above in Figure 1.

    Note: **Samples meeting the allowed concentration of 0.15 percent HNO3 by weight will be shipped as nonregulated or nonhazardous following the procedure in Section 1.4.**

    Note: No marking or labeling can be obscured by strapping or duct tape.

    Note: **Place** the inner packaging of dangerous goods inside the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

22. When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.

23. Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited-Quantity (Appendix A).

24. Complete a Dangerous Goods airbill.

6.0 Packaging and Shipping Samples Preserved with Sulfuric Acid

6.1 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Excepted Quantities of Sulfuric Acid Preservatives

Preservative		*Desired in Final Sample*		*Quantity of Preservative (ml) for Specified Container*				
		pH	**Conc.**	**40 ml**	**125 ml**	**250 ml**	**500 ml**	**1 L**
H_2SO_4	37N	<2	0.35%	.1	.25	0.5	1	2

5 drops = 1 ml

6.2 Responsibility

It is the responsibility of the qualified shipper to:

1. Ensure the samples undergoing shipment contain no other contaminant that meets the definition of hazardous material as defined by the DOT.

2. Determine the amount of preservative in each sample so that accurate determination of quantities can be made.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific QAPP.

6.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

- Inner packings may consist of glass or plastic jars no larger than 100 ml.
- Outer packaging (for limited quantities) should be an insulated cooler that has passed the ICAO drop test.
- Survey documentation (if shipping from DOE or other radiological sites)

- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

6.4 Packaging of Samples Preserved with Sulfuric Acid

Samples containing sulfuric acid (H_2SO_4) as a preservative that exceed the excepted concentration of 0.35 percent will be shipped as a limited quantity per packing instruction Y809 of the IATA/ICAO Dangerous Goods Regulations.

The following steps are required when packaging limited-quantity samples shipments:

1. Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.

2. All sample containers will be properly labeled and the label protected with waterproof tape before sampling.

   At a minimum the label should contain:

   - Project name
   - Project number
   - Date and time of sample collection
   - Sample location
   - Sample identification number
   - Collector's initials
   - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form)

3. Wrap each glass container in bubble wrap (secure with waterproof tape) to prevent breakage.

4. Place the bubble-wrapped container into a 3.0-mil zip-type bag, removing trapped air.

5. Place glass containers inside a polyethylene bottle filled with an absorbent; seal the bottle.

6. Line the bottom of the cooler with sufficient absorbent material, or other approved material, to absorb any leakage that may occur.

7. Line the cooler with a contractor grade garbage bag cooler.

8. Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.

9. Place sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.

10. Seal the garbage bag by tying or taping.

11. The maximum volume of preserved solution in the cooler should not exceed 500 ml.

12. The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.

13. Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.

14. If the shipment is from a DOE or other radiological facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.

15. Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.

16. Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.

17. Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

    Sulfuric Acid Solution
    UN2796
    LTD. QTY.

18. Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.

19. Affix a "corrosive" label to the outside of the cooler.

20. Affix package orientation labels on two opposite sides of the cooler.

21. Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment. An example of cooler labeling/marking locations is shown in Figure 1.

    Note: **Samples containing less than the allowed concentration of 0.35 percent H_2SO_4 by weight will be shipped as nonregulated or nonhazardous in accordance with the procedure described in Section 1.4.**

    Note: No marking or labeling can be obscured by strapping or duct tape.

    Note: **Place** the inner packaging of dangerous goods into the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

22. When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.

23. Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited-Quantity (Appendix A).

24. Complete a Dangerous Goods airbill.

7.0 Packaging and Shipping Limited-Quantity Radioactive Samples

7.1 Containers

The inner packaging containers that may be used for these shipments include:

1. Any size sample container

7.2 Description/Responsibilities

The qualified shipper should ensure that the samples undergoing shipment contain no other contaminant that meets the definition of hazardous material as defined by the DOT.

The qualified shipper will ship all samples that meet the Class 7 definition of radioactive materials and meet the activity requirements specified in Table 4 and 7 of 49 CFR 173.425, as Radioactive Materials in Limited Quantity. The qualified shipper should verify that all packages and contents meet the requirements of 49 CFR 173.421, *Limited Quantities of Radioactive Materials*.

Packaging used for shipping is required to meet the general requirements for packaging and packages specified in 49 CFR 173.24 and the general design requirements provided in 173.410. These standards state that a package must be capable of withstanding the effects of any acceleration, vibration, or vibration resonance that may arise under normal transport conditions, without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices, even after repeated use.

If the shipment is from a DOE facility, radiological screenings will be completed on all samples taken. The qualified shipper should review the results of each screening (alpha, beta, and gamma speciation). Samples will not be shipped offsite until the radiological screening has been performed.

The total activity for each package will not exceed the relevant limits listed in Table 4 and 7 of 49 CFR 173.425. The A_2 value of the material will be calculated based on all radionuclides found during previous investigations (if any) in the area from which the samples are derived. The A_2 values to be used will be the most restrictive of all potential radionuclides as listed in 49 CFR 173.435.

The radiation level at any point on the external surface of the package bearing the sample(s) will not exceed 0.005 millisievert per hour (mSv/h) (0.5 mrem/hour). These will be verified by dose and activity monitoring before shipment of the package.

The removable radioactive surface contamination on the external surface of the package will not exceed the limits specified in 49 CFR 173.443(a). CDM Smith will apply the DOE-established free release criteria for removable surface contamination of less than 20 disintegrations per minute (dpm)/100 cm^2 (alpha) and 1,000 dpm/100 cm^2 (beta/gamma). It shall be noted that these values are more conservative than the DOT requirements for removable surface contamination.

The qualified shipper should verify that the outside of the inner packaging is marked "Radioactive."

The qualified shipper should verify that the excepted packages prepared for shipment under the provisions of 49 CFR 173.421 have a notice enclosed, or shown on the outside of the package, that reads, **"This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910."**

Note: Responsibilities may vary from site to site; therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific QAPP.

7.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

- Survey documentation/radiation screening results (if shipping from DOE or radiological sites)
- Orientation labels
- Excepted quantities label
- Consignor/consignee labels

7.4 Packaging of Limited-Quantity Radioactive Samples

The following steps are required when packaging limited-quantity sample shipments:

1. The cooler is to be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.

2. Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.

3. All sample containers will be properly labeled and the label protected with waterproof tape before sampling. At a minimum the label should contain:

- Project name
- Project number
- Date and time of sample collection
- Sample location
- Sample identification number
- Collector's initials

4. If the containers are breakable; wrap each container in bubble wrap (secure with waterproof tape) to prevent breakage.

5. Line the bottom of the cooler with sufficient absorbent material, or other approved packaging material, to absorb any leakage that may occur.

6. Line the cooler with a contractor grade garbage bag .

7. Pack the samples, with bottles placed upright, appropriately inside the garbage bag to prevent movement during shipment.

8. If required, place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.

9. Seal the garbage bag by tying or taping.

10. Place a label marked "radioactive" on the outside of the sealed bag.

11. Enclose a notice that includes the name of the consignor or consignee and the following statement: ***"This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910."***

12. Note that both the DOT and IATA apply different limits to the quantity in the inside packing and in the outside packing.

13. The maximum weight of the package shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.

14. Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.

15. If the shipment is from a DOE or other radiological facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.

16. If a cooler is used, wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.

17. Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.

18. Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code, for both shipper and recipient.

19. Affix package orientation labels on two opposite sides of the cooler/package.

20. Affix a completed "excepted quantities" label to the side of the cooler/package.

21. Secure any marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment. An example of the cooler labeling/marking is shown below in Figure 2.

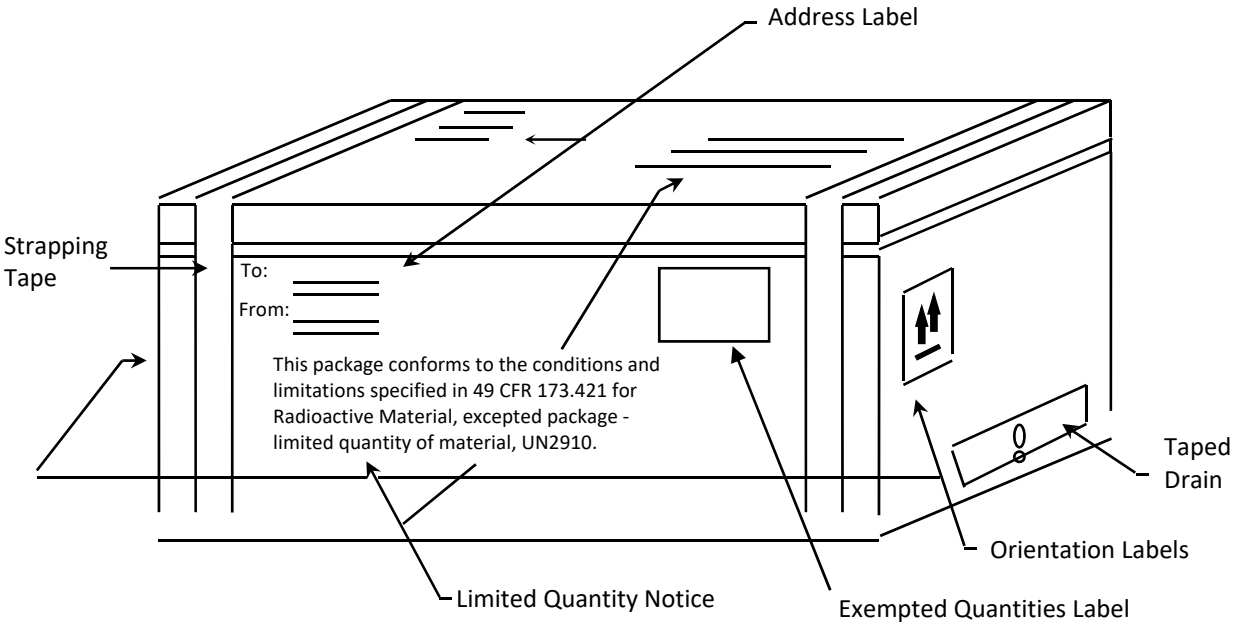
    Note: No marking or labeling can be obscured by strapping or duct tape.

22. Complete the Shipment Quality Assurance Checklist (Appendix B).

Note: Except as provided in 49 CFR 173.426, the package will not contain more than 15 grams of ^{235}U.

Note: A declaration of dangerous goods is not required.

Figure 2
Radioactive Material – Limited-Quantity Cooler Marking Example



8.0 References

U.S. Environmental Protection Agency. May 2015, or current revision. Region 4. The Field Branches Quality System and Technical Procedures, Packing, Marking, Labeling, and Shipping of Environmental and Waste Samples SESDPROC-209-R3. February.

_____. 2013. Region 4. The Field Branches Quality System and Technical Procedures, Sample and Evidence Management SESDPROC-005-R2. January.

_____. 2007 or current revision. *Sampler's Guide, Contract Laboratory Program, Guidance for Field Samplers*, EPA-540-R-07-06.

Title 49 Code of Federal Regulations, Department of Transportation. 2015 or current revision. *Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements*, 49 CFR 172.

Title 49 Code of Federal Regulations, Department of Transportation. 2015 or current revision. *Shippers - General Requirements for Shipments and Packaging*, 49 CFR 173.

Appendix A

Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Excepted or Limited-Quantity

Sample Packaging

Yes	No	N/A	
ϒ	ϒ	ϒ	The VOA vials are wrapped in bubble wrap and placed inside a zip-type bag.
ϒ	ϒ	ϒ	The VOA vials are placed inside a polyethylene bottle, filled with an absorbent, and tightly sealed.
ϒ	ϒ	ϒ	The drain plug is taped inside and outside to ensure control of interior contents.
ϒ	ϒ	ϒ	The samples have been placed inside garbage bags with sufficient bags of ice to preserve samples at 4°C.
ϒ	ϒ	ϒ	The cooler weighs less than the 66-pound limit for limited-quantity shipment.
ϒ	ϒ	ϒ	The garbage bag has been sealed with tape (or tied) to prevent movement during shipment.
ϒ	ϒ	ϒ	The chain-of-custody has been secured to the interior of the cooler lid.
ϒ	ϒ	ϒ	The cooler lid and sides have been taped to ensure a seal.
ϒ	ϒ	ϒ	The custody seals have been placed on both the front and back hinges of the cooler, using waterproof tape.

Air Waybill Completion

Yes	No	N/A	
ϒ	ϒ	ϒ	Section 1 has the shipper's name, company, and address; the account number, date, internal billing reference number; and the telephone number where the shipper can be reached.
ϒ	ϒ	ϒ	Section 2 has the recipient's name and company along with a telephone number where they can be reached.
ϒ	ϒ	ϒ	Section 3 has the **Bill Sender** box checked.
ϒ	ϒ	ϒ	Section 4 has the **Standard Overnight** box checked.
ϒ	ϒ	ϒ	Section 5 has the **Deliver Weekday** box checked.
ϒ	ϒ	ϒ	Section 6 has the number of packages and their weights filled out. Was the total of all packages and their weights figured up and added at the bottom of Section 6?
ϒ	ϒ	ϒ	Under the **Transport Details** box, the **Cargo Aircraft Only** box is obliterated, leaving only the **Passenger and Cargo Aircraft** box.
ϒ	ϒ	ϒ	Under the **Shipment Type**, the **Radioactive** box is obliterated, leaving only the **Non-Radioactive** box.
ϒ	ϒ	ϒ	Under the **Nature and Quantity of Dangerous Goods** box, the **Proper Shipping Name, Class or Division, UN or ID No., Packing Group, Subsidiary Risk, Quantity and Type of Packing, Packing Instructions, and Authorization** have been filled out for the type of chemical being sent.
ϒ	ϒ	ϒ	The **Name, Place and Date, Signature, and Emergency Telephone Number** appears at the bottom of the FedEx airbill.
ϒ	ϒ	ϒ	The statement "In accordance with IATA/ICAO" appears in the **Additional Handling Information** box.
ϒ	ϒ	ϒ	The **Emergency Contact Information** at the bottom of the FedEx airbill lists someone who can truly respond any time of the day or night.

Proper Shipping Name	*Class or Division*	*UN or ID No.*	*Packing Group*	*Sub Risk*	*Quantity*	*Packing Instruction*	*Authorization*
Hydrochloric Acid Solution	8	UN1789	II		1 plastic box × 0.5 L	Y809	Ltd. Qty.
Nitric Acid Solution (with less than 20%)	8	UN2031	II		1 plastic box × 0.5 L	Y807	Ltd. Qty.
Sodium Hydroxide Solution	8	UN1824	II		1 plastic box × 0.5 L	Y809	Ltd. Qty.
Sulfuric Acid Solution	8	UN2796	II		1 plastic box × 0.5 L	Y809	Ltd. Qty.
Methanol	3	UN1230	II		1 plastic box × 1 L	Y305	Ltd. Qty.

Sample Cooler Labeling

Yes	No	N/A	
ϒ	ϒ	ϒ	The proper **shipping name, UN number**, and **Ltd. Qty.** appears on the shipping container (limited quantity shipments).
ϒ	ϒ	ϒ	The corresponding **hazard labels** or **dangerous goods in excepted quantity label** are affixed on the shipping container; the labels are not obscured by tape.
ϒ	ϒ	ϒ	The **name and address of the shipper and receiver** appear on the top and side of the shipping container.
ϒ	ϒ	ϒ	The **air waybill** is attached to the top of the shipping container.
ϒ	ϒ	ϒ	**Up arrows** have been attached to opposite sides of the shipping container.
ϒ	ϒ	ϒ	Packaging tape does not obscure markings or labeling.

Appendix B

Shipment Quality Assurance Checklist

Date: _____ Shipper: _____ Destination: _____

Item(s) Description: _____

Radionuclide(s): _____

Radiological Survey Results: surface _____mrem/hr 1 meter _____

Instrument Used: Mfgr: _____ Model: _____

S/N: _____ Cal Date: _____

Limited-Quantity or Instrument and Article

Yes	No		
___	___	1.	Strong tight package (package that will not leak material during conditions normally incidental to transportation).
___	___	2.	Radiation levels at any point on the external surface of package less than or equal to 0.5 mrem/hr.
___	___	3.	Removable surface contamination less than 20 dpm/100 cm^2 (alpha) and 1,000 dpm/100 cm^2 (beta/gamma).
___	___	4.	Outside inner package bears the marking "Radioactive."
___	___	5.	Package contains less than 15 grams of ^{235}U (check yes if ^{235}U not present).
___	___	6.	Notice enclosed within or on the package that includes the consignor or consignee and the statement, **"This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910."**
___	___	7.	Activity less than that specified in 49 CFR 173.425. Permissible package limit: Package Quantity:
___	___	8.	On all air shipments, the statement **Radioactive Material, excepted package-limited quantity of material** shall be noted on the air waybill.

Qualified Shipper: _____ Signature: _____

Guide to Handling Investigation-Derived Waste

SOP 2-2
Revision: 9
Date: August 2020

Approved: Ernest Ashley **Technical Review:** David Sembrot

1.0 Objective

This technical standard operating procedure (SOP) presents guidance for the management of investigation-derived waste (IDW). The primary objectives for managing IDW during field activities include:

- Leaving the site in no worse condition than existed before field activities
- Removing wastes that pose an immediate threat to human health or the environment
- Proper handling of onsite wastes that do not require offsite disposal or extended aboveground containerization
- Complying with federal, state, local, and facility applicable or relevant and appropriate requirements (ARARs)
- Careful planning and coordination of IDW management options
- Minimizing the quantity of IDW

2.0 Background

2.1 Definitions

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Hazardous Waste - Discarded material that is regulated listed waste, or waste that exhibits ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.3 or state regulations.

Investigation-Derived Wastes - Discarded materials resulting from field activities such as sampling, surveying, drilling, excavation, and decontamination processes that, in present form, possess no inherent value or additional usefulness without treatment. Wastes may be solid, sludge, liquid, gaseous, or multiphase materials that may be classified as hazardous or nonhazardous.

Mixed Waste - Any material that has been classified as both hazardous and radioactive.

PFAS – Per- and polyfluoroalkyl substances are a group of man-made chemicals that includes PFOA, PFOS, GenX, and many other chemicals.

Radioactive Wastes - Discarded materials that are contaminated with radioactive constituents with specific activities in concentrations greater than the latest regulatory criteria (i.e., 10 CFR 20).

Treatment, Storage, and Disposal Facility (TSDF) - Permitted facilities that accept hazardous waste shipments for further treatment, storage, and/or disposal. These facilities must be permitted by the U. S. Environmental Protection Agency (EPA) and appropriate state and local agencies.

Aqueous liquid – a water based polar solution with a specific gravity at or near 1. Light non-aqueous phase liquids, also known as LNAPL), such as oils (non-polar, typically float on aqueous (polar) solutions (or pure water). Dense non-aqueous phase liquids (DNAPL), such as chlorinated organic solvents or PCB containing oils, sink in aqueous based liquids.

2.2 Discussion

Field investigation activities result in the generation of waste materials that may be characterized as hazardous or radioactive. IDWs may include drilling muds, cuttings, and purge water from test pit and well installation; purge water, soil, and other materials from collection of samples; residues from testing of treatment technologies and pump and treat systems; personal protective equipment (PPE); solutions (aqueous or otherwise) used to decontaminate nondisposable protective clothing and equipment; and other wastes or supplies used in sampling and testing potentially hazardous or radiologically contaminated material.

2.2.1 PFAS Considerations

Currently, PFAS characterization and disposal requirements are being initiated by many disposal facilities in anticipation of regulatory initiatives on the state and federal level. These evolving regulatory standards for PFAS must be considered in the implementation of many SOPs including SOP 2-2. These same concerns must be considered in the development of general project planning documents such as: work plans, sampling and analysis plans, quality assurance project plans, data management plans, accident prevention plans, health and safety plans and laboratory statements of work used to guide the collection of samples for PFAS analysis.

- A consideration of the PFAS-specific sampling requirements is needed during the project planning phase because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. This means that the development of project data quality objectives (DQOs), and selection of action levels, reporting limits are all impacted with the inclusion of sampling for PFAS analysis.
- Before implementing the IDW (SOP 2.2) for collection of samples for PFAS waste characterization analysis for disposal purposes, it is important to review current disposal facility requirements and state and federal regulatory standards to determine whether site- or project-specific changes to this SOP should be included in project planning documents to align with the latest regulatory standards and sampling guidance. CDM Smith Regulatory Updates can be located at the INFOCENTER. Specific State and Federal Regulatory Limit updates can be found here: https://cdmsmith.libguides.com/PFAS_InfoCenter

Note: The client's representatives may not be aware of all potential contaminants. The management of IDW must comply with applicable regulatory requirements.

3.0 General Responsibilities

Site Manager - The site manager is responsible for ensuring that all IDW procedures are conducted in accordance with this SOP. The site manager is also responsible for ensuring that handling of IDW is in accordance with site-specific requirements.

Project Manager - The project manager is responsible for identifying site-specific requirements for the disposal of IDW in accordance with federal, state, and/or facility requirements.

Field Crew Members - Field crew members are responsible for implementing this SOP and communicating any unusual or unplanned condition to the project manager's attention.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site/project specific quality assurance plan.

4.0 Required Equipment

Equipment required for IDW containment will vary according to site-specific/client requirements. Management decisions concerning the necessary equipment required shall consider: containment method, sampling, labeling, maneuvering, and storage (if applicable). Equipment must be onsite and inspected before commencing work.

The selection of the container type and size for containerizing IDW must consider:

- waste/contaminant segregation (i.e. do not mix hazardous and non-hazardous wastes or incompatible materials),
- efficiency/ability to move the containerized waste (i.e. size of equipment needed vs. accessibility and bulk vs. individual containers),
- cost of storage, (i.e. rental vs. purchase)
- transportation and disposal of the material in the containers selected.
- PFAS is present many commonly used materials. Please see the PFAS material list in Section 4.5.

4.1 IDW Containment Devices

The appropriate containment device (drums, tanks, etc.) will depend on site- or client-specific requirements and the ultimate disposition of the IDW. Typical IDW containment devices can include:

- Plastic sheeting (polyethylene) with a minimum thickness of 20 micrometers
- Department of Transportation (DOT)-approved steel containers
- Polyethylene or steel bulk storage tanks

Containment of IDW shall be segregated by waste type (i.e., solid or liquid, corrosive or flammable, etc.) and source location. Volume of the appropriate containment device will depend on site-specific requirements.

4.2 IDW Container Labeling

A "Waste Container" or "IDW Container" label or indelible marking shall be applied to each container. Labeling or marking requirements for onsite IDW not expected to be transported offsite are as detailed below.

- Labels and markings must contain the following information: project name, generation date, location of waste origin, container identification number, sample number (if applicable), and contents (drill cuttings, purge water, PPE, etc.).
- Each label or marking will be applied to the upper one-third of the container at least twice, on opposite sides.
- Containers that are 5 gallons or less may only require one label or set of markings.
- Labels or markings will be positioned on a smooth part of the container. The label must not be affixed across container bungs, seams, ridges, or dents.
- Labels must be constructed of a weather-resistive material with markings made with a permanent marker or paint pen and capable of enduring the expected weather conditions. If markings are used, the color must be easily distinguishable from the container color.
- Labels will be secured in a manner to ensure that they remain affixed to the container.

Labeling or marking requirements for IDW expected to be transported offsite must be in accordance with the requirements of 49 CFR 172.

4.3 IDW Container Movement

Staging areas for IDW containers shall be predetermined and in accordance with site-specific and/or client requirements. Arrangements shall be made before field mobilization as to the methods and personnel required to safely transport IDW containers to the staging area. Transportation of IDW containers offsite via a public roadway is prohibited unless 49 CFR 172 requirements are met.

4.4 IDW Container Storage

Containerized IDW awaiting results of pending chemical analysis or further onsite treatment shall be staged on site. Staging areas and bulk storage procedures are to be determined according to site-specific requirements. Containers are to be stored in such a fashion that the labels can be easily read. A secondary/spill container must be provided for liquid IDW storage and as appropriate for solid IDW storage (e.g., steel drums shall not be stored in direct contact with the ground).

5.0 Procedures

The three general options for managing IDW are: (1) collection and onsite disposal, (2) collection for offsite disposal, and (3) collection and interim management. Attachment 1 summarizes media-specific information on generation processes and management options. The option selected shall take into account the following factors:

- Type (soil, sludge, liquid, debris), quantity, and source of IDW
- Risk posed by managing the IDW onsite
- Compliance with regulatory requirements
- IDW minimization and consistency with the IDW remedy and the site remedy

In all cases the client shall approve the plans for IDW. Formal plans for the management of IDW must be prepared as part of a work plan or separate document.

5.1 Collection and Onsite Disposal

5.1.1 Soil/Sludge/Sediment

The options for handling soil/sludge/sediment IDW are:

1. Return IDW to boring, pit, or source immediately after generation as long as returning the media to these areas will not increase site risks (e.g., so that "clean" areas are not contaminated, the IDW material will not be replaced at a greater depth, or in a different area than from where it was originally obtained.

2. Spread IDW around boring, pit, or source within the area of contamination (AOC) as long as returning the media to these areas will not increase site risks (e.g., direct contact with surficial contamination).

3. Consolidate IDW in a pit within the AOC as long as returning the media to these areas will not increase site risks (e.g., the contaminated soil will not be replaced at a greater depth than where it was originally so that it will not contaminate "clean" areas).

4. Send to onsite TSDF. This option may require results of laboratory analysis before treatment/disposal.

Note: These options may require client and/or regulatory approval.

5.1.2 Aqueous Liquids

The options for handling aqueous liquid IDW are:

1. Discharge to surface water, only when IDW is not contaminated, and with written client approval.

2. Discharge to ground surface close to the well from which it was extracted, only if soil contaminants will not be mobilized in the process and the action will not contaminate clean areas. If IDW from the sampling of background upgradient wells is not a community concern or associated with soil contamination, this presumably uncontaminated IDW may be released on the ground around the well with written client approval.

3. Discharge to sanitary sewer, only when IDW is not contaminated and with written client approval.

4. Send to onsite treatment/disposal facility, with facility acceptance and written client approval.

Note: These options may require results of laboratory analysis to obtain client and/or regulatory approval.

5. When small amounts (i.e., less than 5 gallons) of used decontamination fluids are generated during site characterization activities (e.g., during soil sampling using direct push technology methods), the fluids may be allowed to evaporate by spreading them on an asphalted surface, or allowing for evaporation from an open bucket.

5.1.3 Disposable PPE

The options for handling disposable PPE are:

1. Double-bag contents in nontransparent trash bags and place in onsite industrial dumpster, only if PPE is not contaminated.

2. Containerize, label, and send to onsite TSDF. This may require results of laboratory analysis before treatment/disposal.

5.2 Collection for Offsite Disposal

Before sending IDW to an offsite TSDF or to a publicly owned treatment works (POTW), laboratory analysis may be required. Manifests are required to accompany any IDW determined to be hazardous. In some instances, a bill of lading can be used for nonhazardous solid IDW (i.e., wooden pallets, large quantities of plastic sheeting). Arrangements must be made with the client

responsible for the site to sign as generator on any waste profile and all manifests or bill of ladings; it is CDM Smith's policy not to sign any waste profile or manifest. The TSDF and transporter must be permitted for the respective wastes. Nonbulk containers (e.g., drums) must have a DOT-approved label adhered to the container and all required associated placard stickers before leaving for an offsite TSDF. These labels must include information as required in 49 CFR 172. Bulk containers (i.e., rolloffs, tanks) do not require container specific labels for transporting offsite, but must include appropriate placards as required in 49 CFR 172.

5.2.1 Soil/Sludge/Sediment

When the final site remedy requires offsite treatment and disposal, the IDW may be stored (e.g., drummed, covered in a waste pile) or returned to its source until final disposal. The management option selected shall take into account the potential for increased risks, applicable regulations, and other relevant site-specific factors (e.g., weather, storage space, and public concern/perceptions).

5.2.2 Aqueous Liquids

When the final site remedy requires offsite treatment and disposal, the IDW may be stored (e.g., mobile tanks or drums with appropriate secondary containment) until final disposal. The management option selected shall take into account the potential for increased risks, applicable regulations, and other relevant site-specific factors (e.g., weather, storage space, and public concern/perceptions).

5.2.3 Disposable PPE

When the final site remedy requires offsite treatment and disposal, the IDW may be containerized and stored. The management option selected shall take into account potential for increased risks, applicable regulations, and other relevant site-specific factors (e.g., weather, storage space, and public concern/perceptions).

5.3 Collection and Interim Management

All interim measures must be approved by the client and regulatory agencies.

1. Storing IDW onsite until the final action may be practical in the following situations:
   - Returning wastes (especially sludges and soils) to their onsite source area would require reexcavation for disposal as determined for the final site remedy.
   - Interim storage in containers may be necessary to provide adequate protection to human health and the environment.
   - Offsite disposal options may trigger land disposal regulations under the Resource Conservation and Recovery Act (RCRA). Storing IDW until the final disposal of all wastes from the site will eliminate the need to address this issue more than once.
   - Interim storage may be necessary to provide time for sampling and analysis.

2. Segregate and containerize all waste for future treatment and/or disposal.
   - Containment options for soil/sludge/sediment may include drums or covered waste piles in AOC.
   - Containment options for aqueous liquids may include mobile tanks or drums.
   - Containment options for PPE may include drums or roll-off boxes.

6.0 Restrictions/Limitations

Site managers shall determine the most appropriate disposal option for aqueous liquids on a site-specific basis. Parameters to consider, especially when determining the level of protection, include the volume of IDW, the contaminants present in the aqueous liquid, the nature of contaminants present in the site soil , and whether groundwater or surface water is a drinking water supply, and if obtained from contaminated groundwater, whether the plume is contained or migrating. Special disposal/handling may be needed for drilling fluids because they may contain significant solid components and therefore may need to be handled, treated, disposed as non-liquid wastes.

Disposable sampling materials, disposable PPE, decontamination fluids, etc. will always be managed on a site-specific basis. Under no circumstances shall these types of materials be stored in a site office or warehouse.

7.0 References

Environmental Resource Center. 1997. *Hazardous Waste Management Compliance Handbook 2nd Edition*. Karnofsky (Editor).

Academy of Certified Hazardous Materials Manager. May 1999. *Hazardous Materials Management Desk Reference, 3rd Edition*. Cox.

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U. S. Environmental Protection Agency. 1987. *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001.1.

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CDM Smith Regulatory Updates can be located at the INFOCENTER. Specific State and Federal Regulatory Limit updates regarding PFAS can be found here: https://cdmsmith.libguides.com/PFAS_InfoCenter

Attachment 1
IDW Management Options

Type of IDW	*Generation Processes*	*Management Options*
Soil	▪ Well/Test pit installations ▪ Borehole drilling ▪ Soil sampling	**Onsite Disposal** ▪ Return to boring, pit, or source immediately after generation ▪ Spread around boring, pit, or source within the AOC ▪ Consolidate in a pit (within the AOC) ▪ Send to onsite TSDF **Offsite Disposal** ▪ Client to send to offsite TSDF **Interim Management** ▪ Store for future treatment and/or disposal
Sludge/Sediment	▪ Sludge pit/sediment sampling	**Onsite Disposal** ▪ Return to pit or source immediately after generation ▪ Send to onsite TSDF **Offsite Disposal** ▪ Send to offsite TSDF* **Interim Management** ▪ Store for future treatment and/or disposal
Aqueous Liquids (groundwater, surface water, drilling fluids, wastewater)	▪ Well installation/development ▪ Well purging during sampling ▪ Groundwater discharge during pump tests ▪ Surface water sampling ▪ Wastewater sampling	**Onsite Disposal** ▪ Pour onto ground close to well (nonhazardous waste) ▪ Discharge to sewer ▪ Send to onsite TSDF **Offsite Disposal** ▪ Send to offsite TSDF* ▪ Client to send to publicly owned treatment works (POTW) **Interim Management** ▪ Store for future treatment and/or disposal
Decontamination Fluids	▪ Decontamination of PPE and equipment	**Onsite Disposal** ▪ Send to onsite TSDF ▪ Evaporate (for small amounts of low contamination organic fluids) ▪ Discharge to ground surface **Offsite Disposal** ▪ Send to offsite TSDF* ▪ Discharge to sewer **Interim Management** ▪ Store for future treatment and/or disposal
Disposable PPE and Sampling Equipment	▪ Sampling procedures or other onsite activities	**Onsite Disposal** ▪ Place in onsite industrial dumpster ▪ Send to onsite TSDF **Offsite Disposal** ▪ Send to offsite TSDF* **Interim Management** ▪ Store for future treatment and/or disposal

* Client must sign waste profile, manifest, etc. for any waste sent offsite.
Adapted from U. S. Environmental Protection Agency, *Guide to Management of Investigation-Derived Wastes*, 9345-03FS, January 1992.

Field Logbook Content and Control

SOP 4-1
Revision: 9
Date: August 2020

Approved: Ernest Ashley **Technical Review:** Catherine Love

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to set criteria for field logbook content entry and form. Field logbooks are an essential tool to document field activities for historical and legal purposes.

2.0 Background

2.1 Definitions

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Biota - The flora and fauna of a region

Magnetic Declination Corrections - Compass adjustments to correct for the angle between magnetic north and geographical meridians

2.2 Discussion

Information recorded in field logbooks includes field team names; observations; data; calculations; date and time; weather; and a description of the data collection activity, methods, instruments, and results. Additionally, the logbook may contain record of deviations from plans. It may also hold descriptions of wastes, biota, geologic material, and site features, including sketches, maps, drawings, or photographic or videographic logs, as appropriate.

3.0 General Responsibilities

Project Manager (PM) - The PM is responsible for overall project management. They may be brought into decisions regarding data management.

Field Team Leader (FTL) - The FTL is responsible for ensuring that data entry format and content are in accordance with this procedure.

Site Personnel - All CDM Smith employees who make entries in field logbooks during onsite activities are required to read this procedure before engaging in this activity. The FTL will assign field logbooks to site personnel who will be responsible for their care and maintenance. Site personnel will return field logbooks to the records file at the end of the assignment.

Data Manager (DM) - For projects using cloud base field data collection tools, the DM is responsible ensuring that a copy of the initial data collected is stored as an official record in un-editable file. The DM is responsible for regularly backing up all data generated during electronic field collection, including tabular and spatial data and photographs.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities should be defined in the field plan or site-/project-specific quality assurance project plan (QAPP).

4.0 Required Equipment

- Site-specific plans
- Field logbook
- Indelible black or blue ink pen
- Ruler or similar scale

5.0 Procedures

5.1 Preparation

In addition to this SOP, site personnel responsible for maintaining logbooks should be familiar with all procedures applicable to the field activity being performed. These procedures should be consulted as necessary to obtain specific information about equipment and supplies, health and safety, sample collection, packaging, decontamination, and documentation requirements. These procedures should be available electronically or located at the field office or vehicle for easy reference.

Field logbooks shall be bound with lined, consecutively numbered pages. All pages should be numbered before initial use of the logbook. Before use in the field, each logbook will be marked with a specific document control number issued by the document control administrator, if required by the contract quality implementation plan (QIP). Not all contracts require document control numbers. The following information shall be recorded on the cover of the logbook:

- Field logbook document control number (if applicable)
- Activity (if the logbook is to be activity-specific), site name, and location
- Name of CDM Smith contact and phone number(s) (typically the project manager)
- Start date of entries
- End date of entries
- In specific cases, special logbooks may be required (e.g., waterproof paper for stormwater monitoring).

The first few (approximately three) pages of the logbook will be reserved for a table of contents (TOC). Mark the first page with the heading and enter the following:

Table of Contents

Date/Description	Pages
(Start Date)/Reserved for TOC	1-3

The table of contents remaining pages will be designated as such with "TOC" written on the top center of each page. The table of contents should be completed as activities are completed and before placing the logbook in the records file.

5.2 Operation

Follow these requirements when using a logbook:

- Record work, observations, quantities of materials, calculations, drawings, and related information directly in the logbook. If data collection forms are specified by an activity-specific plan, this information does not need to be duplicated in the logbook. However, the logbook should reference any forms used to record site information.
- Do not start a new page until the previous one is full or has been marked with a single diagonal line so that additional entries cannot be made. Use both sides of each page.
- Do not erase or blot out any entry at any time. Indicate any deletion by a single line through the material to be deleted. Initial and date each deletion. Take care to not obliterate what was written previously.
- Do not remove any pages from the book.
- All entries should be clearly written and legible.

Specific requirements for field logbook entries include:

- Initial and date each page
- Sign and date the final page of entries for each day
- Initial and date all changes
- Multiple authors should sign out the logbook by inserting the following:
  Above notes authored by:
  - (Sign name)
  - (Print name)

- (Date)

- A new author should sign and print his/her name before additional entries are made.
- Draw a diagonal line through the remainder of the final page at the end of the day.
- Record the following information on a daily basis:
  - Date and time
  - Name of individual making entry
  - Names of field team and other persons onsite
  - Description of activity being conducted, including station or location (i.e., well, boring, sampling location number) if appropriate
  - Weather conditions (i.e., temperature, cloud cover, precipitation, wind direction, and speed) and other pertinent data
  - Level of personal protection used
  - Serial numbers of instruments
  - Equipment calibration information
  - Serial/tracking numbers on documentation (e.g., carrier air bills)

An observation's time (written in military/24-hour units) should go before the entry. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged. Record all measurements made and samples collected unless they are documented by automatic methods (e.g., data logger), a field data collection tool, or on a separate form required by an operating procedure. In these cases, the logbook should reference the automatic data record or form. Site personnel collecting data with cloud-base field data collection tools are responsible for sending data to the cloud database as data is collected or when cellular or wi-fi service becomes available. If the tool is working in off-line editing, then data should be uploaded or synced at the end of the work day.

At each station where a sample is collected or an observation or measurement made, a detailed description of the location of the station is required. Use a compass (include a reference to magnetic declination corrections), scale, or nearby survey markers, as appropriate. A sketch of station location may be warranted. All maps or sketches made in the logbook should have descriptions of the features shown and a direction indicator. It is preferred that maps and sketches be oriented so that north is toward the top of the page. Maps, sketches, figures, or data that will not fit on a logbook page should be referenced and attached to the logbook to prevent separation.

Other events and observations that should be recorded include:

- Changes in weather that impact field activities
- Deviations from procedures outlined in any governing documents. Record the reason for any noted deviation.
- Problems, downtime, or delays
- Upgrade or downgrade of personal protection equipment
- Visitors to the site

5.3 Post-Operation

To guard against loss of data as a result of damage or disappearance of logbooks, completed pages shall be periodically photocopied or scanned (weekly, at a minimum) and forwarded to the field or project office. Other field records shall be photocopied or scanned and submitted regularly and as promptly as possible to the office. Information from a data logger shall be exported daily onto external storage device (e.g. a flash drive or external drive) and saved to ProjectWise on a daily basis if possible (weekly, at a minimum).

At the conclusion of each activity or phase of site work, the individual responsible for the logbook will ensure that all entries have been appropriately signed and dated and that corrections were made properly (single lines drawn through incorrect information, then initialed and dated). The completed logbook shall be submitted to the records file.

For cloud-based field data collection tools, all data (backups, raw inspection data) will be saved daily to the ProjectWise directory. Alternative timed uploads can be set to weekly data uploads at a minimum, if agreed upon by the DM and PM.
Field data collection tools should be designed so that a copy of the originally captured data is exported daily and saved on ProjectWise. This data serves as the official record and should not be altered or edited. Developers of the field tools should understand retention policies of their cloud platform and ensure that final data is stored on ProjectWise to meet project data retention requirements.

All data collection methods should follow the records control procedures specified in the site-specific plan.

6.0 Restrictions/Limitations

Field logbooks constitute the official record of onsite technical work, investigations, and data collection activities. Their use, control, and ownership are restricted to activities pertaining to specific field operations carried out by CDM Smith personnel and their subcontractors. They are documents that may be used in court to indicate dates, personnel, procedures, and techniques employed during site activities. Entries made in these logbooks should be factual, clear, precise, and objective. Field logbooks, and entries within, are not to be used for personal use.

Consider the evolving regulatory standards for per- and polyfluoroalkyl substances (PFAS) when implementing SOP 4-1 for specific sites. Also consider them when developing project planning documents such as: work plans, sampling and analysis plans, quality assurance project plans, data management plans, accident prevention plans, health and safety plans, and laboratory statements of work used to guide the collection of samples for PFAS analysis.

A consideration of the PFAS-specific sampling requirements is needed during the planning phase because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. This means that the development of project data quality objectives (DQOs), and selection of action levels, reporting limits are all impacted with the inclusion of sampling for PFAS analysist.

Before implementing SOP 4-1 associated with collection of samples for PFAS analysis, it is important to review current regulatory standards to determine whether site- or project-specific changes to SOP 4-1 should be included in project planning documents to align with the latest regulatory standards and sampling guidance. CDM Smith Regulatory Updates, including specific state and federal regulatory limits, can be located on the PFAS InfoCenter: https://cdmsmith.libguides.com/PFAS_InfoCenter

When conducting PFAS sampling, field staff should avoid cross contamination which can occur with use of items in the field, such as sticky notes, waterproof field books, and aluminum foil. Staff will need to avoid use of markers, if possible, during sampling use only regular ink pens. If needed, write over regular ink with marker after the sample containers are sealed. For a current list of materials to avoid, staff should refer to appropriate sampling technical operating procedures and project requirements.

7.0 References

EPA. 2013. Region 4. The Field Branches Quality System and Technical Procedures, Sample and Evidence Management SESDPROC-005-R2. January.

_____. 2013. Region 4. The Field Branches Quality System and Technical Procedures, Logbooks. SESDPROC-010-R5. May.

_____. 2007. Contract Laboratory Program Guidance for Field Samplers. Office of Superfund Remediation and Technology Innovation. OSWER 9240.0-44. EPA 540-R-07-06. July.

Photographic Documentation of Field Activities

SOP 4-2
Revision: 10
Date: August 2020

Approved: Ernest Ashley **Technical Review:** Catherine Love

1.0 Objective

The purpose of this technical standard operating procedure (SOP) is to provide standard guidelines and methods for photographic documentation, which include digital photography and recordings of field activities and site features (geologic formations, core sections, lithologic samples, water samples, general site layout, etc.). This SOP is intended for circumstances when formal photographic documentation is required. Based on project requirements, it may not be applicable for all photographic activities.

2.0 Background

2.1 Definitions

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Photographer - The camera operator of digital photography or recordings, whose primary function in this SOP is to produce documentary or data-oriented visual media

Identifier Component - Visual components used within a photograph, such as visual slates, reference markers, and pointers

Standard Reference Marker - A reference marker used to indicate a feature size in the photograph. It should be a standard length of measure, such as a ruler, meter stick, etc. In limited instances, if a ruled marker is not available or its use is not feasible, it can be a common object of known size placed within the visual field and used for scale.

Slates - Blank white index cards, marker boards, or paper used to present information pertaining to the subject/procedure being photographed. Letters and numbers on the slate will be bold and written with black indelible marking pens.

Arrows and Pointers - Markers/pointers used to indicate and/or draw attention to a special feature within the photograph

Camera - A standalone digital camera or a camera that is embedded in a smart phone or tablet

Contrasting Backgrounds - Backdrops used to lay soil samples, cores, or other objects on for clearer viewing and to delineate features.

Date Stamp - A built-in feature that will record the date and time directly on a digital image or recording

Field Tool Application - An application that runs on a smart phone or tablet. The application's purpose is to collect a specific set of information, which may include the ability to take and document photographs. Data collection with the field tool is stored in the field tool application database. The field tool application can be designed to capture information typically stored in the project logbook, however the tool cannot completely replace the log book.

Photographic Documentation - Any information collected in a logbook or in a field tool application that is required to describe the photograph. Documentation might include the file name of the photo, photo sequence, photographer, date and time, a description of the photo, or the direction the picture was taken.

Site Photo Map - A sketch of the site that marks where photographs were taken

2.2 Associated Procedures

- SOP 4-1, *Field Logbook Content and Control*

2.3 Discussion

Digital photographs and recordings made during field investigations are used as an aid in documenting and describing site features, sample collection activities, equipment used, and possible lithologic interpretation. This SOP is designed to illustrate the format and desired placement of identifier components, such as visual slates, standard reference markers, and pointers. How to use a photographic logbook and standardized entry procedures are also outlined. These procedures and guidelines will minimize potential ambiguities that may arise when viewing the images or recordings and ensure the representative nature of the photographic documentation.

3.0 General Responsibilities

Project Manager - The project manager (PM) will ensure the logbook and photographs fulfill contract requirements and is distributed appropriately. They will also provide guidance on site-specific photography requirements.

Field Team Leader - The field team leader (FTL) is responsible for ensuring that the format and content of photographic documentation are in accordance with this procedure. The FTL is responsible for directing the photographer to specific situations, site features, or operations that the photographer will be responsible for documenting. The FTL is responsible for making sure the photographer understands and follows data management process for logging, documenting, and backing up the photographic files. If a field tool application is being used to take photographs, the FTL is responsible for working with the data manager to ensure the application collects the proper metadata data about the photographs and that the photographs are being stored and backed up properly.

Data Manager - The data manager (DM) is responsible for ensuring that the field application tool collects and stores the proper photographic documentation about the photographs. The DM is also in charge of verifying that photographic files and documentation have been downloaded from the field tool application and stored in the project file.

Photographer - The photographer shall seek direction from the FTL and regularly discuss the visual documentation requirements and schedule. The photographer is responsible for maintaining a logbook per Sections 5.1, 5.2.4, and 5.3.1 of this SOP. The photographer's responsibilities will be defined in the project sampling plan.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site/quality assurance project plan (QAPP). Some clients and/or client facilities have specific restrictions on photography (e.g., some do not allow photographs to show secure or sensitive buildings). Obtain permission to use a camera on these facilities in advance. The photographer may need to review the photo record with responsible site personnel.

4.0 Required Equipment

A general list of equipment that may be used:

- Smart phone or tablet with camera or digital camera and appropriate storage media
- Extra battery pack and charging cord for smart phone or tablet
- Extra batteries for camera
- Digital video camera and appropriate storage media (e.g., SD card)
- Logbook
- field tool application
- Indelible black or blue ink pen
- Standard reference markers (e.g. ruler)
- Slates or marker boards
- Arrows or pointers
- Contrasting backgrounds

5.0 Procedures

5.1 Documentation

Documentation requirements for digital photographs and recordings should be specified in the site-specific plan. Otherwise, a commercially available, bound logbook will be used to log and document photographic activities. Alternatively, the project may develop a field tool application designed to run on a smart phone or tablet to take pictures and document the photographic activities. Review SOP 4-1, *Field Logbook Content and Control* and prepare all supplies needed for logbook entries.

Note: A separate photographic logbook is not required. A portion of the field logbook may be designated as the photographic log and documentation section.

Field Health and Safety Considerations

There are no hazards that an individual will be exposed to specific to photographic documentation. However, site-specific hazards may arise depending on the location or operation. The photographer should be aware of site-specific terrain to avoid tripping hazards. Personal protective equipment used in this operation will be site-specific and dictated through requirements set by the site safety officer, site health and safety plan, and/or prescribed by the CDM Smith Corporate Health and Safety Program. The photographer should contact the site safety officer for health and safety orientation before commencing field activities. Read, and sign the acknowledgement of, the site health and safety plan before entering the site.

The photographer should be aware of any potential physical hazards while photographing the subject (e.g., traffic, low overhead hazard, edge of excavation).

5.2 Operation

5.2.1 General Photographic Activities in the Field

The following sections provide general guidelines that should be followed to visually document field activities and site features using digital still and video cameras. General suggestions the photographer should consider when performing activities under this SOP are as follows:

- The photographer should be prepared to make a variety of shots, from close-up to wide-angle. Many shots will be repetitive in nature or format, especially close-up site feature photographs. Consider designing a system, camera settings, or technique that will provide a reliable repetition of performance. Not any special enhancement techniques in the log book or field tool application.
- Digital cameras have multiple photographic quality settings. A camera that produces higher resolution (quality) photographs has a higher number of pixels and will store a fewer number of photographs per digital storage medium. Determine project photo resolution requirements before implementing field work.
- If using a smart phone or tablet camera with a field tool application, consider that the device will need cellular service or WiFi to upload photos and documentation to the field tool application database. If using a smart phone or tablet camera that is not associated with a field tool application, the photographer shall develop a procedure for how the photographs will be extracted from the device and correlated with the photographic documentation in the log book.
- No preference of digital storage medium for a digital camera is specified. The photographer has discretion.
- Regardless of the type of camera, the photograph needs to be stored in a location that receives regular backups such as ProjectWise, OneDrive or Teams. For staff in the field without access to a regularly backed-up storage location, email can provide a temporary backup location until a more permanent location can be accessed.
- For projects dealing with confidential information or criminal investigation, the photographer should look at client-specific requirements for chain of custody procedures.

5.2.2 General Guidelines for Still Photography

Caption Information

Unless otherwise specified in a site-specific plan, all still photographs will have a full caption added after the images are downloaded on a photo log sheet. The caption should contain the following information:

- Photograph sequence number
- Date and time
- Photographer (required for enforcement cases)
- Description of activity/item shown (e.g., name of facility/site, specific project name, project number)
- Direction (if applicable)
- Site photo map (if applicable)

When directed by the sampling plan, a standard reference marker should be used in all documentary visual media. While the standard reference marker will be predominantly used in close-up feature documentation, consider including it in all scenes.

Images taken with a digital camera, smart phone, or tablet, should be downloaded at least once each day to a personal computer; the files should be in either "JPEG" or "TIFF" format. Files should be renamed at the time of download to correspond to the logbook or as directed in the site-specific plan.

Images taken with a camera as part of a field tool application that resides on a smart phone or tablet should fill out the photographic documentation in the application. The photographer will need to upload the data each night (at a minimum) to the field tool application database. The photographer should verify with the DM that photographs are properly stored and backup via the field tool application.

Regardless of the type of camera used, the photographs should be compared to the photo documentation to ensure that the log and the photographs match.

Close-Up and Feature Photography
When directed by the sampling plan, close-up photographs should include a standard reference marker of appropriate size, to indicate feature size. The photos should contain a slate or marker board marked with the site name and any identifying label, such as a well number or core depth, that clearly tells the viewer the specific feature being photographed.

Feature samples, core pieces, and other lithologic media should be photographed as soon as possible after they have been removed from their in situ locations. This enables a more accurate record of their initial condition and color. When directed by the sampling plan, include a standard reference color strip, like a color chart such as Munsell Soil Color Chart, within the scene. This serves as a reference aid to the viewer for formal lithologic observations and interpretations.

Site Photography
Site photography, in general, will consist predominantly of medium- and wide-angle shots. If required by the sampling plan, a standard reference marker should be placed adjacent to the feature or, when this is not possible, within the same focal plane.

While it is encouraged that a standard reference marker and slate/marker board be included in the scene, it is understood that situations will arise where they can't be included. This will be especially true of wide-angle shots. In such a case, the image number shall be entered in the photographic logbook along with other information pertinent to the scene.

5.2.3 General Photographic Documentation Using Digital Video Cameras

Documentary digital recordings of field activities may include an audio slate for all scenes. At the beginning of each video session, an announcer will recite the following information: date, time (in military units), photographer, site ID number, and site location. This oral account may include any additional information clarifying the subject matter being recorded.

A standard reference marker may be used when taking close-up shots of site features with a video camera. The scene may also include a caption/slate. It should be placed adjacent and parallel to the feature being photographed.

A standard reference marker and slate/marker board should be included in all scenes. The caption information is vital to the value of the documentary visual media and should be included. If it is not included within the scene, it should be placed before the scene.

Original video recordings will not be edited. This will maintain the integrity of the information contained on the videotape or DVD. If editing is desired, a working copy of the original video recording can be made.

A digital recording filename should be created with the appropriate identifying information (project name, project number, date, location, etc.).

5.2.4 Photographic Documentation

If required by the site-specific plan, photographic activities should be documented in a photographic logbook or in a section of the field logbook or as part of the field tool application. The photographer will be responsible for making proper entries.

In addition to following the technical standards for logbook entry as referenced in SOP 4-1, the following information should be maintained in the appropriate logbook:

- Photographer name
- Sequential tracking number for each photograph taken (the camera-generated number may be used)
- Date and time (military time)
- Location
- A description of the activity/item photographed
- If needed, a description of the general setup, including approximate distance between the camera and the subject
- Record as much other information as possible to help identify the photographic document.

5.3 Post Operation

The photographer shall be responsible for downloading image files or recordings to the project files.

As required, the photographer(s) will ensure that the appropriate logbook is completely filled out and maintained as outlined in SOP 4-1. Images and recordings will be handled according to contract records requirements. The PM will ensure their proper distribution. Completed pages of the appropriate logbook will be copied weekly and submitted to the project files.

6.0 Restrictions/Limitations

This document is designed to provide a set of guidelines to maintain an effective and standardized program of visual documentation.

It is not within the scope of this document to provide instruction in photographic procedures, nor is it within the scope of this document to set guidelines for presentation or “show” photography.

The procedures outlined herein are general by nature. The photographer is responsible for specific operational activity or procedure described in site-specific plans. Questions concerning specific procedures or requirements should be directed to the PM or FTL.

Note: Some sites do not permit photographic documentation. Check with the site contact for any restrictions.

7.0 References

U. S. Environmental Protection Agency. 2013. Region 4. The Field Branches Quality System and Technical Procedures, Logbooks. SESDPROC-005-R5. January.

_____. 2013. Region 4. The Field Branches Quality System and Technical Procedures, Sample and Evidence Management SESDPROC-005-R2. January.

_____. 1992. National Enforcement Investigations Center. *Multi-Media Investigation Manual*, EPA-330/9-89-003-R. p. 85. Revised March.

U. S. Army Corps of Engineers. 2001. *Requirements for the Preparation of Sampling and Analysis Plans*, EM 200-1-3. Appendix F. February.

Field Equipment Decontamination at Nonradioactive Sites

SOP 4-5
Revision: 11
Date: March 2020

Approved: Ernest Ashley **Technical Review:** David Sembrot

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to describe the general procedures required for decontamination of field equipment at nonradioactive sites. This SOP serves as a general guide and is applicable at most sites; however, it shall be noted that site-specific conditions (i.e., type of contamination, type of media sampled), the governing agency (e.g., EPA, DOE, USACE), and site-specific work plans, sampling and analysis plans and/or quality assurance (QA) project plans may require modifications to the decontamination procedures provided in this SOP. Decontamination of field equipment is necessary to ensure acceptable quality of samples by preventing cross contamination. Further, decontamination reduces health hazards and prevents the spread of contaminants offsite.

2.0 Background

2.1 Definitions

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Acid Rinse - A solution of 10 percent nitric or hydrochloric acid made from reagent grade acid and analyte-free water

Analyte-Free Water - Tap water that has been treated so that the water contains no detectable heavy metals or other inorganic compounds. Analyte-free water shall be stored only in clean glass, stainless steel, or plastic containers that can be closed when not in use.

Clean - Free of contamination and when decontamination has been completed in accordance with this SOP

Cross Contamination - The transfer of contaminants through equipment or personnel from the contamination source to less contaminated or noncontaminated samples or areas.

Decontamination - The process of rinsing or otherwise cleaning the surfaces of sampling or other equipment to rid them of contaminants and to minimize the potential for cross contamination of samples or exposure to personnel

Safety Data Sheets (SDS) - These documents discuss the proper storage and physical and toxicological characteristics of a particular substance used during decontamination. These documents, generally included in site health and safety plans, shall be kept on site at all times during field operations.

Organic-Free/Analyte-Free Water - Tap water that has been treated so that the water meets the analyte-free water criteria and contains no detectable organic compounds. Organic-free/analyte-free water shall be stored only in clean glass, Teflon™, or stainless steel containers that can be closed when not in use.

PFAS – Per- and polyfluoroalkyl substances are a group of man-made chemicals that includes PFOA, PFOS, GenX, and many other chemicals.

Potable Water - Tap water may be obtained from any municipal system. Chemical analysis of the water source may be required before it is used for decontamination purposes.

Sampling Equipment - Equipment that comes into direct contact with the sample media. Such equipment includes split spoon samplers, well casing and screens, and spatulas or bowls used to homogenize samples.

Soap - Low-sudsing, nonphosphate detergent such as Liquinox™.

Solvent Rinse - Pesticide grade, or better, isopropanol, acetone, or methanol.

2.2 Associated Procedures

- SOP 1-1 – *Surface Water Sampling*
- SOP 1-3 – *Surface Soil Sampling*
- SOP 1-4 – *Subsurface Soil Sampling*
- SOP 1-5 – *Groundwater Sampling Using Bailers*
- SOP 1-7 – *Wipe Sampling*
- SOP 1-9 – *Tap Water Sampling*
- SOP 1-11 – *Sediment/Sludge Sampling*
- SOP 1-12 – *Low Flow (Low-Stress) Groundwater Sampling*
- SOP 1-13 – *Drum Sampling*
- SOP 1-14 – *Lagoon Sampling*
- SOP 1-15 – Procedures for Determination of Screening-Level Elemental Concentrations in Soil and Sediment using Field Portable X-Ray Fluorescence Spectrometry
- SOP 2-2 – *Guide to Handling Investigation-Derived Waste*
- SOP 3-1 – *Geoprobe® Sampling*

3.0 Responsibilities

The project manager or designee, generally the field team leader (FTL), ensures that field personnel are trained in the performance of this procedure and that decontamination is conducted in accordance with this SOP and site-specific work plans. The FTL may also be required to collect and document rinsate samples (also known as equipment blanks) to provide quantitative verification that these procedures have been correctly implemented.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance project plan (QAPP).

4.0 Required Equipment

- Stiff-bristle scrub brushes
- Plastic buckets and troughs
- Soap
- Nalgene or Teflon sprayers or wash bottles or 2- to 5-gallon, manual-pump sprayer (pump sprayer material must be compatible with the solution used)
- Plastic sheeting, plastic bags, and/or aluminum foil to keep decontaminated equipment clean between uses
- Disposable wipes, rags, or paper towels
- Potable water*
- Analyte-free water
- PFAS-free water, as determined by regulatory needs of the project and obtained from your laboratory
- Organic-free/analyte-free water
- Gloves, safety glasses, and other protective clothing as specified in the site-specific health and safety plan
- High-pressure pump with soap dispenser or steam-spray unit (for large equipment only)
- Appropriate decontamination solutions pesticide grade or better and traceable to a source (e.g., 10 percent and/or 1 percent nitric acid [HNO_3], acetone, methanol, isopropanol, hexane)
- Tools for equipment assembly and disassembly (as required)
- 55-gallon drums or tanks for temporary storage of decontamination water (as required)
- Pallets for drums or tanks holding decontamination water (as required)

* Potable water may be required to be tested for contaminants before use. Check field plan for requirements.

4.1 PFAS Materials Considerations

Consider the PFAS-specific sampling requirements is needed during the planning phase because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. This means that the development of project data quality objectives (DQOs), and selection of action levels and reporting limits are impacted with the inclusion of sampling for PFAS analysis.

Before implementing TSOP 4-5 for field equipment decontamination where samples for PFAS analysis may be collected, it is important to review current regulatory standards to determine whether site- or project-specific changes to TSOP 1-5 should be included in project planning documents to align with the latest regulatory standards and sampling guidance. CDM Smith Regulatory Updates can be located in the InfoCenter. Specific state and federal regulatory limits updates can be found at:
https://cdmsmith.libguides.com/PFAS_InfoCenter.

Because of the evolving nature of PFAS regulation and guidance, the information provided here is based on our current knowledge. Some of the recommendations made here may reflect an overly cautious approach to avoid cross-contamination by removing items from the immediate sampling environment. As additional information about PFAS is confirmed the checklist included at the end of this document will be revised to reflect the recommended practices for PFAS sampling. Procedures and Regulatory Updates will be provided separately. Awareness of these concerns is essential to ensure our field sampling teams accurately document field activities they are performing or overseeing.

5.0 Procedures

All reusable equipment (nondedicated) used to collect, handle, or measure samples shall be decontaminated before coming into contact with any sampled media or personnel using the equipment. Decontamination of equipment shall occur either at a central decontamination station or at portable decontamination stations set up at the sampling location, drill site, or monitoring well location. The centrally located decontamination station shall include an appropriately sized bermed and lined area on which equipment decontamination shall occur and shall be equipped with a collection system and storage vessels. In certain circumstances, berming is not required when small quantities of water are being generated and for some short duration field activities (i.e., pre-remedial sampling). Equipment shall be transported to and from the decontamination station in a manner to prevent cross contamination of equipment and/or area. For example, precautions taken may include enclosing augers in plastic wrap while being transported on a flatbed truck.

The decontamination area shall be constructed so that contaminated water is either collected directly into appropriate containers (5-gallon buckets or steel wash tubs) or within the berms of the decontamination area that then drains into a collection system. Water from the collection system shall be transferred into 55-gallon drums or portable tanks for temporary storage. Typically, decontamination water shall be staged until sampling results or waste characterization results are obtained and evaluated and the proper disposition of the waste is determined (SOP 2-2, *Guide to Handling Investigation-Derived Waste*). The exact procedure for decontamination waste disposal shall be discussed in the work plan. Also, solvent and acid rinse fluids may need to be segregated from other investigation-derived wastes.

All items that shall come into contact with potentially contaminated media shall be decontaminated before use and between sampling and/or drilling locations. If decontaminated items are not immediately used, they shall be covered either with clean plastic or aluminum foil depending on the size of the item. All decontamination procedures for the equipment being used are as follows:

General Guidelines

- Potable, analyte-free water shall be free of all contaminants of concern. Following the field QA sampling procedure described in the sampling plan, analytical data from the water source may be required.
- If sampling for PFAS compounds, PFAS-free water will need to be obtained from your project selected laboratory. (Note: PFAS free water, if needed, must be obtained from your selected project laboratory and the analyte list and detection limits of PFAS will be site-specific and dependent on latest regulatory updates from applicable state and federal regulators.)
- PFAS containing materials should be avoided. (See PFAS Materials Table at the end of this document)

- Sampling equipment that has come into contact with oil and grease shall be cleaned with methanol or other approved alternative to remove the oily material. This may be followed by a hexane rinse and then another methanol rinse. Regulatory or client requirements regarding solvent use shall be stated in the sampling plan.
- All solvents and acids shall be pesticide grade or better and traceable to a source. If provided, certificates of analyses should be placed in the project files. The corresponding lot numbers shall be recorded in the appropriate logbook.

Note: Solvents and acids are potentially hazardous materials and must be handled, stored, and transported accordingly. Solvents shall never be used in a closed building. See the site-specific health and safety plan and/or the chemical's MSDS for specific information regarding the safe use of the chemical.

- Decontaminated equipment shall be allowed to air dry before being used.
- Documentation of all equipment type, date, time, and method of decontamination along with associated field QA sampling shall be recorded in the appropriate logbook.
- Gloves, boots, safety glasses, and any other personnel protective clothing and equipment shall be used as specified in the site-specific health and safety plan.

5.1 Heavy Equipment Decontamination

Heavy equipment includes drilling rigs, well development rigs, and backhoes. Follow these steps when decontaminating this equipment:

1. Establish a bermed decontamination area that is large enough to fully contain the equipment to be cleaned. If available, an existing wash pad or appropriate paved and bermed area may be used; otherwise, use one or more layers of heavy plastic sheeting to cover the ground surface and berms. All decontamination pads shall be upwind of the area under investigation.

2. With the rig in place, spray areas (rear of rig or backhoe) exposed to contaminated media using a hot water high-pressure sprayer. Be sure to spray down all surfaces, including the undercarriage.

3. Use brushes, soap, and potable water to remove dirt whenever necessary.

4. Remove equipment from the decontamination pad and allow it to air dry before returning it to the work site.

5. After decontamination activities are completed, collect all contaminated wastewater, plastic sheeting, and disposable gloves, boots, and clothing in separate containers or receptacles. All receptacles containing contaminated items must be properly labeled for disposal as detailed in the field plan. Liquids and solids must be drummed separately.

5.2 Downhole Equipment Decontamination

Downhole equipment includes hollow-stem augers, drill pipes, rods, stems, etc. Follow these steps when decontaminating this equipment:

1. Set up a centralized decontamination area, if possible. This area shall be set up to collect contaminated rinse waters and to minimize the spread of airborne spray.

2. Set up a "clean" area upwind of the decontamination area to receive cleaned equipment for air-drying. At a minimum, clean plastic sheeting must be used to cover the ground, tables, or other surfaces on which decontaminated equipment is to be placed. All decontamination pads shall be upwind of any areas under investigation.

3. Place the object to be cleaned on aluminum foil or plastic-covered wooden sawhorses or other supports. The objects to be cleaned shall be at least 2 feet above the ground to avoid splashback when decontaminating.

4. Using soap and potable water in the hot water high-pressure sprayer (or steam unit), spray the contaminated equipment. Aim downward to avoid spraying outside the decontamination area. Be sure to spray inside corners and gaps especially well. Use a brush, if necessary, to dislodge dirt.

5. If using soapy water, rinse the equipment using clean, potable water. If using hot water, the rinse step is not necessary if the hot water does not contain a detergent. If the hot water contains a detergent, this final clean water rinse is required.

6. Using a suitable sprayer, rinse the equipment thoroughly with analyte-free water.

7. Remove the equipment from the decontamination area and place in a clean area upwind to air dry.

8. After decontamination activities are completed, collect all contaminated wastewaters, plastic sheeting, and disposable gloves, boots, and clothing in separate containers or receptacles. All receptacles containing contaminated items must be properly labeled for disposal. Liquids and solids must be drummed separately.

5.3 Sampling Equipment Decontamination

Follow these steps when decontaminating sampling equipment:

1. Set up a decontamination line on plastic sheeting. The decontamination line shall progress from "dirty" to "clean." A clean area shall be established upwind of the decontamination wash/rinse activities to dry the equipment. At a minimum, clean plastic sheeting must be used to cover the ground, table, or other surfaces that the decontaminated equipment is placed for drying.

2. Disassemble any items that may trap contaminants internally. Do not reassemble the items until decontamination and air drying are complete.

3. Wash the items with potable water and soap using a stiff brush as necessary to remove particulate matter and surface films. The items may be steam cleaned using soap and hot water as an alternative to brushing. Note: Polyvinyl chloride or plastic items shall not be steam cleaned. Items that have come into contact with concentrated and/or oily contaminants may need to be rinsed with a solvent such as hexane and allowed to air dry prior to this washing step.

4. Thoroughly rinse the items with potable water.

5. The specific chemicals and/or fluids to be used in the decontamination process will be defined in the sampling plan. If sampling for metals, typically the potable water and soap wash is followed by a potable water rinse then an analyte-free water rinse; alternatively, an acid solution (e.g., 10 percent nitric acid) rinse followed by a rinse using analyte-free water may be specified in some instances. If sampling for organic compounds, thoroughly rinse the items with solvent (e.g., isopropanol) followed by a rinse using organic-free/analyte-free water. Again, the specific chemicals used in any acid rinse or solvent rinse phases shall be specified in the sampling plan. Any acid rinsate and solvent rinsate must each be containerized separately. Acids and solvents are potentially hazardous materials and care must be exercised when using these chemicals to prevent adverse health affects (e.g., skin burns, irritation to the eyes and respiratory system). Appropriate personal protective equipment must be worn when using these chemicals. The use of acids and solvents for decontamination should be carefully considered. These chemicals (including spent rinsate) must be managed and stored appropriately. Special measures such as proper labels, paperwork, notification, etc. may be required when transporting or shipping these chemicals.

6. Allow the items to air dry completely.

7. After drying, reassemble the parts as necessary and wrap the items in clean plastic wrap or in aluminum foil.

8. After decontamination activities are completed, collect all contaminated waters, used solvents and acids, plastic sheeting, and disposable personal protective equipment. Place the contaminated items in properly labeled drums for disposal. Liquids and solids must be drummed separately. Refer to site-specific plans for labeling and waste management requirements.

5.4 Pump Decontamination

Follow the manufacturer's recommendation for specified pump decontamination procedures. At a minimum, follow these steps when decontaminating pumps:

1. Set up the decontamination area and separate "clean" storage area using plastic sheeting to cover the ground, tables, and other surfaces. Set up four containers: the first container shall contain dilute (nonfoaming) soapy water, the second container shall contain potable water, the third container shall be empty to receive wastewater, and the fourth container shall contain analyte-free water.

2. The pump shall be set up in the same configuration as for sampling. Submerge the pump intake (or the pump, if submersible) and all downhole-wetted parts (tubing, piping, foot valve) in the soapy water of the first container. Place the discharge outlet in the wastewater container above the level of the wastewater. Pump soapy water through the pump assembly until it discharges to the waste container. Scrub the outside of the pump and other wetted parts with a metal brush.

3. Move the pump assembly to the potable water container while leaving discharge outlet in the waste container. All downhole-wetted parts must be immersed in the potable water rinse. Pump potable water through the pump assembly until it runs clear.

4. Move the pump intake to the analyte-free water container. Pump the water through the pump assembly. Pump the volume of water through the pump specified in the field plan. Usually, three pump-and-line-assembly volumes shall be required.

5. Decontaminate the discharge outlet by hand, following the steps outlined in Section 5.3.

6. Remove the decontaminated pump assembly to the clean area and allow it to air dry upwind of the decontamination area. Intake and outlet orifices shall be covered with aluminum foil to prevent the entry of airborne contaminants and particles.

5.5 Low Stress (Low Flow) Sampling Pump Decontamination

Sampling equipment used for Low Stress (Low Flow) Groundwater Sampling (SOP 1-12) must be decontaminated thoroughly each day before use (daily decontamination) and after each well is sampled (between-well decontamination). All non-disposable equipment, including the pump (support cable and electrical wires which are in contact with the sample) will be decontaminated as described below. Dedicated, in-place pumps and tubing must be thoroughly decontaminated using "daily decontamination" procedures prior to their initial use or installation.

5.5.1 Prior to Sampling Event Decontamination

Please Note: Steps 5 through 13 should only be performed once (for each pump that is to be used) before the commencement of a particular sampling event by a person qualified to disassemble pumps.

1. Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and thoroughly flush other equipment with potable water.

2. Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Liquinox™, for 5 minutes and thoroughly flush other equipment with fresh detergent solution. Use the detergent sparingly.

3. Rinse: Operate pump in a deep basin of potable water for 5 minutes and thoroughly flush other equipment with potable water for 5 minutes.

4. Analyte-Free Rinse: Operate pump in a deep basin of analyte-free water to pump out 1 to 2 gallons of this final rinse water. (Note: PFAS free water, if needed, must be obtained from your selected project laboratory and the analyte list and detection limits of PFAS will be site-specific and dependent on latest regulatory updates from applicable state and federal regulators.)

5. Disassemble pump.

6. Wash pump parts (inlet screen, shaft suction interconnector, motor lead assembly, stator house): Place the disassembled parts of the pump into a deep basin containing 8 to 10 gallons of non-phosphate detergent solution. Scrub all pump parts with a test tube brush.

7. Rinse pump parts with potable water for five minutes.

8. Rinse the pump parts with demonstrated analyte-free water.

9. If sampling for metals, an acid rinse may be specified in the sampling plan; if so, place impeller assembly in a large glass beaker and rinse with 1% nitric acid (HNO3).

10. Rinse impeller assembly with potable water for five minutes.

11. If sampling for organics, a solvent rinse may be specified; if so, place impeller assembly in a large glass bleaker and rinse with isopropanol or appropriate organic solvent specified in the site-specific plan.

12. Thoroughly rinse impeller assembly with demonstrated analyte-free water.

13. Reassemble pump.

5.5.2 Daily and Between-Well Decontamination

1. Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and thoroughly flush other equipment with potable water for five minutes.

2. Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Liquinox™, for 5 minutes and thoroughly flush other equipment with fresh detergent solution. Use the detergent sparingly.

3. Rinse: Operate pump in a deep basin of potable water for 5 minutes and thoroughly flush other equipment with potable water for five minutes.

4. Final Rinse: Operate pump in a deep basin of analyte-free water to pump out 1 to 2 gallons of this final rinse water.

5.6 Instrument Probe Decontamination

Instrument probes used for field measurements such as pH meters, conductivity meters, etc. shall be decontaminated between samples and after use with analyte-free, or better, water.

5.7 Waste Disposal

Refer to site-specific plans and SOP 2-2 for waste disposal requirements. The following are guidelines for disposing of wastes:

- All wash water, rinse water, and decontamination solutions that have come in contact with contaminated equipment are to be handled, packaged, labeled, marked, stored, and disposed of as investigation-derived waste.
- Small quantities of decontamination solutions may be allowed to evaporate to dryness.
- If large quantities of used decontamination solutions shall be generated, each type of waste shall be contained in separate containers.
- Unless otherwise required, plastic sheeting and disposable protective clothing may be treated as solid, nonhazardous waste.

- Waste liquids shall be sampled, analyzed for contaminants of concern in accordance with disposal regulations, and disposed of accordingly.
- PFAS disposal requirements are being initiated by many disposal facilities in anticipation of regulatory initiatives on the state and federal level.

5.7.1 PFAS Considerations for IDW disposal

Currently, PFAS characterization and disposal requirements are being initiated by many disposal facilities in anticipation of regulatory initiatives on the state and federal level. These evolving regulatory standards for PFAS must be considered in the implementation of many SOPs including SOP 2-2 and SOP 4-5. These same concerns must be considered in the development of general project planning documents such as: work plans, sampling and analysis plans, quality assurance project plans, data management plans, accident prevention plans, health and safety plans and laboratory statements of work used to guide the collection of samples for PFAS analysis.

- A consideration of the PFAS-specific sampling requirements is needed during the project planning phase because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. This means that the development of project data quality objectives (DQOs), and selection of action levels, reporting limits are all impacted with the inclusion of sampling for PFAS analysis.

- Before implementing the IDW (SOP 2.2) for collection of samples for PFAS waste characterization analysis for disposal purposes, it is important to review current disposal facility requirements and state and federal regulatory standards to determine whether site- or project-specific changes to this SOP should be included in project planning documents to align with the latest regulatory standards and sampling guidance. CDM Smith Regulatory Updates can be located at the INFOCENTER. Specific State and Federal Regulatory Limit updates can be found here: https://cdmsmith.libguides.com/PFAS_InfoCenter

6.0 Restrictions/Limitations

Nitric acid and polar solvent rinses are necessary only when sampling for metals or organics, respectively. These steps shall not be used, unless required, because of the potential for acid burns and ignitability hazards.

If the field equipment is not thoroughly rinsed and allowed to completely air dry before use, volatile organic residue, which interferes with the analysis, may be detected in the samples. The occurrence of residual organic solvents is often dependent on the time of year sampling is conducted. In the summer, volatilization is rapid, and in the winter, volatilization is slow. Check with your EPA region, state, and client for approved decontamination solvents.

7.0 References

American Society for Testing and Materials. 2015. *Standard Practice for Decontamination of Field Equipment at Waste Sites*, ASTM D5088-15. January 15.

Puls, R.W. and M.J. Barcelona. 1996. Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures, EPA/540/S-95/504.

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_____. 1992. *Standard Operating Safety Guidelines*; Publication 9285.1-03. June.

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CDM Smith Regulatory Updates can be located at the INFOCENTER. Specific State and Federal Regulatory Limit updates can be found here: https://cdmsmith.libguides.com/PFAS_InfoCenter

PFAS Sampling Checklist

Development of PFAS sampling guidance is necessary because cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the parts per trillion (ppt) range. The levels of awareness for PFAS cross contamination vary by the opportunities of introducing PFAS into the environment media under investigation.

1. Critical: Items in direct contact of environmental media under investigation. These can include, but not limited to, sample containers, sampling parts and equipment, drilling equipment, well construction items and materials, parts and equipment for hydrogeological testing, in-situ treatment parts and equipment.

2. Very Important: PPE, personal hygiene that are used by sampling personnel.

3. Important: Items used in coolers for shipping and transporting PFAS samples.

4. Less important/Awareness level concern: Activities in the staging area away from immediate PFAS investigation area.

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
Field Clothing or PPE				
Clothing or boots containing "water resistance" or "stain-treated" fabrics				
Cloths washed with fabric softeners				Fabric softeners may contain PFAS
New and unwashed clothing				fabric treatment may contain PFAS
Uncoated Tyvek				USEPA PFAS sampling guidance from Region 2 prohibits use of Tyvek
Coated Tyvek				
PVC or wax-coated fabrics				
Neoprene				
Synthetic and natural fibers (preferably cotton)				
Steel-toed boots made with polyurethane and PVC				If it is not possible to find PFAS free steel-toed footwear, PFAS-free over boots may be worn. The over boots must be put on and the hands washed after putting the over boots on prior to the beginning of the sampling activities. Over boots may only be removed in the staging area and after the sampling activities have been completed
Well laundered clothes				several times from time of purchase
Well washed cotton coveralls				washed several times

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
Personnel Hygiene and Protective Skin Products				
Sunscreens				Good to use: Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, and baby sunscreens that are “free” or “natural
Insect Repellents				Good to use: Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics
International Brands of sunscreens and insect repellents				Must be evaluated on a case-by-case basis
Field Sampling Items				
Water proof field paper or books				Use loose plain paper
Post-it notes				
Aluminum foil				
Brand-name markers				Sharpie may be used to label sample bottles in the staging area, but markers should not be used in the immediate sampling environment
Off-brand markers				
Ball point pens				
plastic clipboards				NJ DEP sampling guidance, use metal clipboard
Plastic table cover				
Sampling Equipment				
Item containing high-density polyethylene (HDPE)				
Item containing polypropylene				PP sample bottles must be used for drinking-water samples in accordance with USEPA method 537.1.1
Item containing polyurethane				
Item containing Polyvinyl chloride (PVC)				
Item containing silicon				

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
Item made of stainless steel				
Alconox®				
Citronex®				
Liquinox®				
Powderless nitrile gloves				
HDPE Hydrasleeves or sonic core bags				
Neoprene				
Crisco® or other vegetable-based greases for lubricating parts				
Item containing PTFE				Items or equipment that contains PTFE parts that will be in direct contact with sampling media
Item containing Teflon®				Field sampling items or equipment that contains Teflon® and that will be in direct contact with the sampling media
Item containing fluoropolymer				
Low-density polyethylene (LDPE)				Items or equipment that contains LDPE parts and that will be in direct contact with the sampling media
Viton® O-rings				Viton® O-rings used in pressure washers used for sampling equipment decontamination
Glass sample containers				
Field filter				Field filtration should be avoided regardless of filter types
Decon 90				
Items containing fluorosurfactants				
Teflon-bearing plumber's tape				
Blue (or chemical) ice				Later data (unpublished) suggest no cross contamination from blue ice. The category may be changed after data are published
Water ice				Double bag in polyethylene bags
Internal valves and equipment parts for sampling or decon				

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
Methanol or other solvents				
LDPE plastic bags (e.g., Ziploc® bags)				For larger biota sampling, Ziploc bags may be used, but collecting an equipment blank is recommended because these bags may be made of LDPE
Drilling fluids				
LDPE sonic core sample bags				Manufactured by Boart Longyear and Hole Products
Equipment with moving parts that may be lubricated with PFAS containing lubricants or greases				
Rental equipment				Must be verified to have no PFAS-bearing parts prior to use
Others				
Food wrappers				Field personnel must wash hands after having food wrapped with grease repelling paper

(1) If an item which may contain PFAS but alternative is not available, the item should be tested for PFAS before use

(2) This mostly refers to the immediate sampling environment, particularly, the item is in contact with environmental media to be sampled

(3) There are no standard operation procedures on how an item can be verified, please contact PFAS experts for advices on the best practice of testing a potential PFAS containing item.

Update Version: October 2019

Control of Measurement and Test Equipment

SOP 5-1
Revision: 11
Date: August 2020

Approved: Ernest Ashley **Technical Review:** Jeniffer Oxford

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to establish the baseline requirements, procedures, and responsibilities inherent to the control and use of all measurement and test equipment (M&TE). Contractual obligations may require more specific or stringent requirements be implemented.

2.0 Background

2.1 Definitions

Note: Definitions are often promulgated or codified in state or local statutes, regulations, or ordinances and can vary between regulatory agencies. Definitions should be verified against the definitions provided by agencies regulating the work when applicable.

Traceability - The ability to trace the history, application, or location of an item and like items or activities by means of recorded identification

2.2 Associated Procedures

- SOP 4-1, *Field Logbook Content and Control*
- CDM Smith Quality Requirements – As Required Activity, *Procuring M&TE* https://cdmsmithonline.sharepoint.com/sites/PM/Projects/PDS/Pages/PDS.aspx#
- Manufacturer's operating and maintenance and calibration procedures

2.3 Discussion

M&TE may be government furnished (GF), rented or leased from an outside vendor, or purchased. It is essential that accountable and high-integrity measurements result from using this equipment. To facilitate that, the equipment shall be used with full understanding of and in compliance with the instructions and specifications included in the manufacturer's operations and maintenance and calibration procedures, and in accordance with any other related project-specific requirements.

3.0 Responsibilities

All staff responsible for the direct control and/or use of M&TE need to know, understand, and implement the following requirements, as well as any other related project-specific requirements.

Project Manager - The project manager (PM) or designee (equipment coordinator, quality assurance specialist, field team leader, etc.) is responsible for initiating and tracking the following requirements.

Field Team Leader (FTL) - Read/review field plans and coordinate assigned tasks with the field team leader before conducting the field work

The M&TE requisitioner is responsible for:

- Determining project-specific technical and quality requirements for M&TE
- Determining if acceptance testing will be performed
- Determining the accuracy, precision, range, and units required for M&TE
- Determining if the item requires calibration. ***Note***: If calibration is required, then one must also document a determination whether calibration traceability to national standards is required.
- Determining the responsible party for calibrating the M&TE, such as the supplier or CDM Smith
- Determining if M&TE may contain material with potential for per- and polyfluoroalkyl substances (PFAS) contamination
- Submitting the purchase requisition via iProcurement

- Determining if purchased items are acceptable
- Arranging and documenting acceptance testing, if required

Personnel identifying nonconforming items affecting quality are responsible for segregating the items and removing them from use. Additional project-specific responsibilities may include labeling or tagging nonconforming items, documenting the nonconformance, and communicating the deficiency to the PM, field team leader, or Project Technical Leader (PTL).

***Note*:** Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance plan.

4.0 Requirements for M&TE

- Review and implement M&TE-related project-specific requirements
- Obtain maintenance and calibration procedures if they are missing or incomplete
- Attach or include the maintenance and calibration procedures with the M&TE
- Prepare and record maintenance and calibration in an equipment log or a field log as appropriate (Figure 1)
- Maintain M&TE records
- Label M&TE requiring routine or scheduled calibration (when required)
- Perform maintenance and calibration using appropriate procedures and calibration standards
- Identify and act on nonconforming M&TE

5.0 Procedures

5.1 Determine if Other Project-Specific Requirements Apply (All M&TE)

The PM or designee shall determine if M&TE related project-specific requirements apply. If M&TE related project-specific requirements apply, obtain a copy of them and review and implement as appropriate. Refer to Figure 2 for a list of per- and polyfluoroalkyl substances (PFAS)-related considerations.

5.2 Obtain Operating and Maintenance and Calibration Documents

A. GF M&TE to be procured:
Requisitioner - Specify that the maintenance and calibration procedures are included with equipment

B. GF M&TE acquired from a property transfer:
Receiver - Inspect the M&TE to determine if maintenance and calibration procedures are included with the item. If missing or incomplete, order the appropriate documentation from the manufacturer.

C. M&TE rented or leased from an outside vendor:
Requisitioner - Specify that the maintenance and calibration procedures, the latest calibration record, and the calibration standards certification be included. If this information is not delivered with the M&TE, ask the procurement division to request it from the vendor.

D. All M&TE
Receiver - Inspect the M&TE to determine that there are no obvious defects, and the required tolerances for accuracy, precision, range and units meet those requested

Requisitioner - Specify that the M&TE material list be included with equipment

Receiver - When sampling for PFAS analysis, inspect M&TE material list prior to use to verify that no PFAS-bearing parts are included

5.3 Prepare and Record Maintenance and Calibration Records

All M&TE:

PM or Designee - Record all maintenance and calibration events in a field log unless other project-specific requirements apply.

GF M&TE only (does not apply to rented or leased M&TE):

If an equipment log is a project-specific requirement, perform the following:

Receiver - Notify the PM or designee for the overall property control of the equipment upon receipt of an item of M&TE.

PM or Designee and User:

- Prepare a sequentially page numbered equipment log for the item using the maintenance and calibration form (or equivalent) (Figure 1)
- Record all maintenance and calibration events in an equipment log
- Refer to Figure 2, PFAS Sampling Materials Checklist, if applicable

5.4 Label M&TE Requiring Calibration (GF M&TE only - does not apply to rented or leased M&TE)

If calibration labeling is a project-specific requirement, perform the following:

FTL or Designee and User:

- Read the maintenance and calibration procedures to determine the calibration frequency required.
- If an M&TE item requires calibration before use, affix a label to the item stating, "Calibrate Before Use."
- If an M&TE item requires calibration at other scheduled intervals, e.g., monthly, annually, etc., affix a label listing the date of the last calibration, the date the item is next due for a calibration, the initials of the person who performed the calibration, and a space for the initials of the person who shall perform the next calibration.

5.5 Operating, Maintaining or Calibrating an M&TE Item (All M&TE)

FTL or Designee and User - Operate, maintain, and calibrate M&TE in accordance with the manufacturer's maintenance and calibration procedures. Record maintenance and calibration actions in the equipment log or field log. Handle and store M&TE using good judgement and the manufacturer's or vendor's recommendation.

5.6 Shipment

A. GF M&TE:

Supplier - Inspect the item to ensure that maintenance and calibration procedures are attached or included with the shipping case, and that a copy of the most recent equipment log entry page (if required) is included with the shipment. If the maintenance and calibration procedures and/or the current equipment log page (if required) is missing or incomplete, do not ship the item.

B. M&TE that is rented or leased from an outside vendor:

Supplier - Inspect the item to ensure that the maintenance and calibration procedures and latest calibration and standards certification records are included prior to shipment. If any documentation is missing or incomplete, do not ship the item. Immediately contact the procurement division and request that they obtain the documentation from the vendor.

Inspect the M&TE to verify that no PFAS containing materials are used for the item.

Some M&TE equipment must remain upright to maintain calibration. Such M&TE should be shipped only in containers labeled appropriately with "This End Up" labels.

Receiver - Some M&TE equipment must remain upright to maintain calibration. Upon receipt, inspect the container to verify that it is upright per "This End Up" labels. If it is not upright, notify the PM and vendor. Immediately contact the vendor and request a replacement for any missing items.

When M&TE is to be used to support sample collection for PFAS analysis, inspect the M&TE to verify that no PFAS containing materials are used for the item. Immediately contact the vendor and request a replacement item.

5.7 Records Maintenance

GF M&TE:

FTL or Designee - Create a file on the initial receipt of an M&TE item or calibration standard. Organize the files by contract origin and by M&TE item and calibration standard. Store all files in a cabinet, file drawer, or other appropriate storage media at the pertinent warehouse/onsite field trailer or office location. Scan copies and store on ProjectWise.

Receiver - Forward the original packing slip to the procurement division and a photocopy to the FTL or designee for storage on ProjectWise.

FTL or Designee and User:

- Maintain all original documents in the equipment file except for the packing slip and field log.
- File the photocopy of the packing slip in the M&TE file.
- Record all maintenance and calibration in an equipment log or field log (as appropriate). File the completed equipment logs in the M&TE records. Forward completed field logs to the PM for inclusion in the project files on ProjectWise.

M&TE rented or leased from an outside vendor:

Receiver - Forward the packing slip to the procurement division.

User:

- Forward the completed field log to the PM for inclusion in the project files on ProjectWise.
- Retain the most current maintenance and calibration record and calibration standards certifications with the M&TE item and forward previous versions to the PM for inclusion in the project files on ProjectWise.

5.8 Traceability of Calibration Standards (All M&TE)

FTL or Designee and User:

- When ordering calibration standards, request nationally recognized standards as specified or required. Request commercially available standards when not otherwise specified or required. Or, request standards in accordance with project-specific requirements.
- Require certifications for standards that clearly state the traceability.
- Require Safety Data Sheets be provided with standards.
- Monitor standards that are perishable and consume or dispose of them on or before the expiration date.

5.9 M&TE That Fails Calibration (Any M&TE item that cannot be calibrated or adjusted to perform accurately)

FTL or Designee

- Immediately discontinue use and tag and segregate the item from other equipment. Notify the appropriate PM and take action to replace the nonconforming items.
- Review the current and previous maintenance and calibration records to determine if the validity of current or previous measurement and test results could have been affected. Share the review results with the appropriate PM(s).

6.0 Restrictions/Limitations

On an item-by-item basis, exemptions from the requirements of this SOP may be granted by Headquarters health and safety manager and/or Headquarters quality assurance manager. All exemptions shall be documented and included in the equipment records.

7.0 Regulatory Considerations

Consider the evolving regulatory standards for per- and polyfluoroalkyl substances (PFAS) when implementing this SOP. Also consider them and during the development of project-specific sampling and analysis plans, and quality assurance project plans used to collect PFAS analysis samples.

Before implementing this SOP for control of M&TE related to the collection of samples for PFAS analysis, it is important to review current regulatory standards to determine whether any site- or project-specific changes related to control of M&TE should be included in project planning documents. CDM Smith Regulatory, as well as specific state and federal regulatory limits, can be found on the PFAS InfoCenter: https://cdmsmith.libguides.com/PFAS_InfoCenter

8.0 Other Procedural Cautions

Cross-contamination is a prominent concern for data quality, particularly with PFAS action levels in the low parts per trillion (ppt) range. Thus, special care is required to select appropriate M&TE when sampling for PFAS analysis. Sites with PFAS sampling need to include the following considerations and awareness.

- Wear powderless nitrile gloves and change them frequently.
- Avoid polytetrafluoroethylene (PTFE), low-density polyethylene (LDPE), sticky notes, waterproof field book, and aluminum foil
- Avoid using markers, if possible, during recording of M&TE results. Use only regular ink pens. If needed, write over regular ink with marker after the sample containers are sealed.
- Consult the materials checklists for equipment concerns.
- Evaluate the parts and equipment used for hydrogeological testing, and in-situ testing against the list in Figure 2.

Refer to Figure 2, *PFAS Sampling Materials Checklist,* for acceptable materials and those that will need verification prior to sampling for PFAS.

9.0 References

American Society for Quality/ American National Standard Institute. 2014. *Quality Management Systems for Environmental Information and Technology Programs – Requirements with Guidance for Use*. ASQ/ANSI E4:2014.

CDM Smith. 2018. Firmwide *Quality Manual.* Revision 5. February.

Figure 1

CDM Smith A subsidiary of Camp Dresser & McKee Inc.

Maintenance and Calibration

Date: Time: (a.m./p.m.)	
Employee Name:	Equipment Description:
Contract/Project:	Equipment ID No.:
Activity:	Equipment Serial No.:

Maintenance

Maintenance Performed:

Comments:

Signature: Date:

Calibration/Field Check

Calibration Standard:	Concentration of Standard:
Lot No. of Calibration Standard:	Expiration Date of Calibration Standard:
Pre-Calibration Reading:	Post-Calibration Reading:
Additional Readings:	Additional Readings:
Additional Readings:	Additional Readings:
Pre-Field Check Reading:	Post-Field Check Reading:

Adjustment(s):

Calibration: □ Passed □ Failed

Comments:

Signature: Date:

Figure 2
PFAS Materials Checklist

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
Sampling Equipment				
Item containing high-density polyethylene (HDPE)				
Item containing polypropylene				
Item containing polyurethane				
Item containing Polyvinyl chloride (PVC)				Polypropylene sample bottles must be used for drinking-water samples in accordance with EPA method 537.1.1
Item containing silicon				
Item made of stainless steel				
Alconox®				
Citronex®				
Liquinox®				
Powderless nitrile gloves				
HDPE Hydrasleeves or sonic core bags				
Neoprene				
Crisco® or other vegetable-based greases for lubricating parts				
Item containing PTFE				Items or equipment that contains PTFE parts that will be in direct contact with sampling media
Item containing Teflon®				Field sampling items or equipment that contains Teflon® and that will be in direct contact with the sampling media
Item containing fluoropolymer				
Low-density polyethylene (LDPE)				Items or equipment that contains LDPE parts and that will be in direct contact with the sampling media
Viton® O-rings				Viton® O-rings used in pressure washers used for sampling equipment decontamination
Glass sample containers				
Field filter				Field filtration should be avoided regardless of filter types
Decon 90				
Items containing fluorosurfactants				
Teflon-bearing plumber's tape				
Blue (or chemical) ice				Later data (unpublished) suggest no cross contamination from blue ice. The category may be changed after data are published.

Item	Good to Use	Need Verification (2)(3)	Should Avoid (1)(2)	Comments
Water ice				Double bag in polyethylene bags
Item	**Good to Use**	**Need Verification (2)(3)**	**Should Avoid (1)(2)**	**Comments**
Internal valves and equipment parts for sampling or decontamination				
Methanol or other solvents				
LDPE plastic bags (e.g., Ziploc® bags)				For larger biota sampling, Ziploc bags may be used, but collecting an equipment blank is recommended because these bags may be made of LDPE
Blue (or chemical) ice				
Drilling fluids				
LDPE sonic core sample bags				Manufactured by Boart Longyear and Hole Products
Equipment with moving parts that may be lubricated with PFAS containing lubricants or greases				
Rental equipment				Must be verified to have no PFAS-bearing parts prior to use

(1) If an item may contain PFAS but an alternative is not available, the item should be tested for PFAS before use.
(2) This mostly refers to the immediate sampling environment, particularly, the item is in contact with environmental media to be sampled.
(3) There are no standard operation procedures on how an item can be verified, please contact PFAS experts for advice on best practices for testing a potential PFAS containing item.

Appendix B

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Reviewed Date: 10/5/2023 1:28:19 PM10/5/2023 1:28:19 PM10/5/2023 1:28:19 PM

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TITLE: ANALYSIS OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) IN AQUEOUS, SOLIDS, AND BIOSOLID SAMPLES BY LC-MS/MS

KEY WORDS: **Not applicable.**

COMMENTS: ***Italicized items indicate changes from the last revision. As the source method is in draft and subject to change, this SOP reflects the EMT development and procedure based on the draft 1633 method, current errata update sheets, EMT method development and DoD QSM version 5.4, Table B-24 as of the time of this revision. Other additions for specifics in the standard preparations and other changes to allow method updates after the time of SOP draft writing to be included in upcoming revisions.***

Added this line for training

WRITTEN BY: **Matt Gregory** **5/24/2022**

APPROVALS:

ORGANICS MANAGER: _____
Greg Pronger

TECHNICAL DIRECTOR: _____
Matt Gregory

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QUALITY ASSURANCE DIRECTOR:

Sabina Stankevicius

ANALYSIS OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) IN AQUEOUS, SOLIDS, AND BIOSOLID SAMPLES BY LC-MS/MS

1. SCOPE AND APPLICATION

1.1. Source method 1633, the base for the SOP, is for use in the Clean Water Act (CWA) for the determination of the per- and polyfluoroalkyl substances (PFAS) in Table 6 in aqueous, solids, soil, biosolids, or sediment samples by liquid chromatography/mass spectrometry (LC-MS/MS).

1.2. This method calibrates and quantifies PFAS analytes using isotopically labeled standards. Where linear and branched isomers are present in the sample and either qualitative or quantitative standards containing branched and linear isomers are commercially available, the PFAS analyte is reported as a single analyte consisting of the sum of the linear and branched isomer concentrations.

1.3. The instrumental portion of this SOP is for use by analysts experienced with LC-MS/MS or under the close supervision of such qualified persons. Each laboratory that uses this method must demonstrate the ability to generate acceptable results using the Initial Demonstration of Capability (IDC) procedures found later in this document.

1.4. By their nature, PFAS present analytical challenges unique to this class of analytes. For example, PFAS analytes readily adhere to the walls of the sample containers and may also stratify in the container. EPA has included procedures in the method that must be employed to address such challenges and are included in the necessary sections of this SOP.

1.5. This method is “performance-based” that means modifications may be made without additional EPA review to improve performance (e.g., overcome interferences, or improve the sensitivity, accuracy, or precision of the results) provided that all performance criteria in this method are

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met. For CWA (wastewater) uses, additional flexibility is described at 40 CFR 136.6. Changes in performance, sensitivity, selectivity, precision, recovery, etc., that result from modifications within the scope of 40 CFR Part 136.6, and IDC section of SOP and Method must be documented, as well as how these modifications compare to the specifications in this method. Changes outside the scope of 40 CFR Part 136.6 and IDC section of this method may require prior review or approval.

2. SUMMARY OF METHOD

2.1. Samples are prepared and extracted using method-specified procedures. Sample extracts are subjected to cleanup procedures designed to remove interferences. Analyses of the sample extracts are conducted by LC-MS/MS in the multiple reaction monitoring (MRM) mode. Sample concentrations are determined by isotope dilution or extracted internal standard quantification using isotopically labeled compounds added to the samples before extraction.

2.2. For extraction, aqueous samples are spiked with isotopically labeled standards, extracted using solid-phase extraction (SPE) cartridges and undergo cleanup using carbon before analysis. Solid samples are spiked with isotopically labeled standards, extracted into basic methanol, and cleaned up by carbon and SPE cartridges before analysis.

2.3. This method can measure the analytes as either their anions or neutral forms. The default approach for Clean Water Act uses of the method is to report the analytes in their acid or neutral forms, using the equations in the calculation section, although the differences between the anion and acid form concentrations are minimal. Other project-specific reporting schemes may be used where required. EMT to calibrate and report based on the acid forms unless requested otherwise for project or regulatory requirement. The standards being purchased through Wellington give the acid values that are used for compounds in salt or anion form. Some venders do not list if acid or salt form, so EMT to keep with venders where the difference can be seen and appropriate true values used.

2.4. Individual PFAS analytes are identified through peak analysis of the quantification and confirmation ions, where applicable.

2.5. Quantitative determination of target analyte concentrations is made with respect to an isotopically labeled PFAS standard; the concentrations are then used to convert raw peak areas in sample chromatograms to final concentrations.

2.6. Results for target analytes are recovery corrected by the method of quantification (i.e., either isotope dilution or extracted internal standard quantification). Isotopically labeled compound recoveries are determined by comparison to the responses of one of seven non-extracted

internal standards (the “recovery” standards) and are used as general indicators of overall analytical quality.

2.7. The quality of the analysis is assured through reproducible calibration and testing of the extraction, cleanup, and LC-MS/MS systems through the analysis of QC samples and Blanks.

3. DEFINITIONS

3.1. Extraction batch: All samples prepared and extracted together (soil matrix separate from water and leachate matrix) up to a maximum of 20 field samples. The reagents, solvents, and SPE should be verified PFAS clean prior to use and is again verified with the Method (reagent) blank. Every extraction batch must include a Method blank, Matrix duplicate (AFFF or project required if PFAS present to calculate RPD values, LCS (OPR), Low Level LCS (LLOPR), and an MS/MSD pair. This evaluates the validity of the sample processing procedure and is an EMT “Batch”.

3.2. Analysis batch: Refer to the Instrumental analysis section for the analytical sequence summary of QC and samples required in a sequence. Initial source from Section 13.3 in Draft 1633.

3.3. Refer to the EMT “Quality Assurance Manual” for definition of terms used in this SOP or the parent method of 1633 for any uncertainties.

3.4. Instrument sensitivity check (ISC) – solution used to check the sensitivity of the instrument. The solution contains the native compounds at the concentration of the LOQ.

3.5. IPR – Initial precision and recovery; four aliquots of a reference matrix spiked with the analytes of interest and labeled compounds and analyzed to establish the ability of the laboratory to generate acceptable precision and recovery. An IPR is performed prior to the first time this method is used and any time the method or instrumentation is modified.

3.6. Method Detection Limit (MDL) – The minimum measured concentration of a substance that can be reported with 99% confidence that the measured analyte concentration is distinguishable from method blank results (40 CFR 136, Appendix B).

3.7. MESA – Mining Enforcement and Safety Administration

3.8. Minimum level of quantitation (ML) – The lowest level at which the entire analytical system must give a recognizable signal and acceptable calibration point for the analyte. The ML represents the lowest concentration at which an analyte can be measured with a known level of confidence. It may be equivalent to the concentration of the lowest calibration standard, assuming that all method-specified sample weights, volumes, and cleanup procedures have been employed.

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Alternatively, the ML may be established by multiplying the MDL (pooled or un-pooled, as appropriate) by 3.18 and rounding the result to the number nearest to 1, 2, or 5 x 10n, where n is zero or an integer (see 68 FR 11770). During development and at start of method, EMT will assign the lowest ICAL point as the ML *for all compounds except 6:2 FTS in solids where the 2nd lowest ICAL point is used due to background and the calculated MDL level.*

3.9. Reagent water – Water demonstrated to be free from the analytes of interest and potentially interfering substances at the method detection limit for the analyte.

3.10. MS – Mass spectrometer or mass spectrometry

3.11. Matrix Spike/Matrix Spike Duplicate (MS/MSD) – Aliquots of field samples that have been fortified with a known concentration of target compounds, prior to sample preparation and extraction, and analyzed to measure the effect of matrix interferences. The use of MS/MSD samples is generally not required in isotope dilution methods because the labeled compounds added to every sample provide more performance data than spiking a single sample in each preparation batch.

3.12. OPR – Ongoing precision and recovery standard (OPR); a method blank spiked with known quantities of analytes. The OPR is analyzed exactly like a sample. Its purpose is to assure that the results produced by the laboratory remain within the limits specified in this method for precision and recovery.

3.13. Relative standard deviation (RSD) – The standard deviation multiplied by 100 and divided by the mean. Also termed “coefficient of variation.”

3.14. Relative Standard Error (RSE) – The standard error of the mean divided by the mean and multiplied by 100.

3.15. RF – Response factor. See Section 10.3.3.2.

3.16. RR – Relative response. See Section 10.3.3.2.

3.17. RT – Retention time; the time it takes for an analyte or labeled compound to elute off the HPLC/UPLC column

3.18. Should – This action, activity, or procedural step is suggested but not required.

3.19. Signal-to-noise ratio (S/N) – The height of the signal as measured from the mean (average) of the noise to the peak maximum divided by the width of the noise.

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3.20. SPE – Solid-phase extraction; a technique in which an analyte is extracted from an aqueous solution or a solid/tissue extract by passage over or through a material capable of reversibly adsorbing the analyte. Also termed liquid-solid extraction.

3.21. Stock solution – A solution containing an analyte that is prepared using a reference material traceable to EPA, NIST, or a source that will attest to the purity and authenticity of the reference material.

3.22. **MS-MS Terms**

MS-MS or sometimes referred to as QQQ is the use of two mass-spectrometers in tandem with a collision cell between. Conceptually, for this analysis we have two mass-specs operating in SIM mode. The first selects the compound which is allowed to pass to the reaction cell. This would be the parent ion. All other ions are diverted. The reaction cell causes the ion to be fragmented. These ions are channeled to the next quadrupole. Here, only ions characteristic of the compound, the product ions, are allowed to pass through to the detector. All other ions are filtered out. Historically, the collision cell was a quadrupole and hence the term QQQ.

3.22.1. Multiple Reaction Monitoring (MRM). Also known as selected reaction monitoring (SRM). A type of mass spectrometry where a parent mass of the compound is fragmented through MS/MS and then specifically monitored for a single fragment ion.

3.22.2. Parent or Precursor Ion. For the purpose of this method, the parent ion is the deprotonated molecule ([M-H]-) of the method analyte. In MS/MS, the parent ion is mass selected and fragmented by collisionally activated dissociation to produce distinctive product ions of smaller m/z.

3.22.3. Product Ion (Quant ion). The product ion is generated by fragmentation of the parent ion in the collision cell. These ions are used for quantification and confirmation purposes.

3.22.4. Isotopically labeled compound – An analog of a target analyte in the method which has been synthesized with one or more atoms in the structure replaced by a stable (non-radioactive) isotope of that atom. Common stable isotopes used are 13C (Carbon-13) or Deuterium (D or 2H). These labeled compounds do not occur in nature, so they can be used for isotope dilution quantitation or other method-specific purposes.

3.22.5. Isotope dilution (ID) quantitation – A means of determining a naturally occurring (native) compound by reference to the same compound in which one or more atoms has been isotopically enriched. The labeled PFAS are spiked, prior to extraction, into each sample and allow identification and correction of the concentration of the native compounds in the analytical process.

3.22.6. Internal standard quantitation – A means of determining the concentration of (1) a naturally occurring (native) compound or isotopically labeled compounds by reference to a compound other than its labeled analog and (2) a labeled compound by reference to another labeled compound. The internal standard is added after extraction.

3.22.7. Extracted Internal Standard (EIS). This is the isotopically labeled congener of the native PFOA / PFAS compound.

3.22.8. Non-extracted Internal Standard (NIS). Compound spiked post extraction and clean-up, just before injection.

4. INTERFERENCE

4.1. Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and elevated baselines causing misinterpretation of chromatograms. Specific selection of reagents and solvents may be required. All need to be screened prior to use in blanks to verify PFAS free or below any level of concern to cause issues in analysis or false positives (</= ½ of LOQ limit or half of the ML level).

4.2. All Clean all equipment prior to, and after each use to avoid PFAS cross-contamination. Typical cleaning solvents used include water, methanol, and methanolic ammonium hydroxide. The residual PFAS content of disposable plastic ware and filters must be verified by batch/lot number and may be used without cleaning if PFAS levels are less than half the Minimum Level. Do not use aluminum foil to cover glass as PFAS can be transferred from the foil to the glass.

4.2.1 All glass equipment that is used in the preparation or storage of reagents is cleaned by washing with detergent and potential baking in a muffle furnace. After detergent washing, glassware should be rinsed immediately with reagent water. Prior to use, baked glassware must be solvent rinsed and then air dried. A solvent rinse procedure using methanolic ammonium hydroxide (1%), toluene, and methanol is recommended. If regular wash blanks do not have levels of PFAS above half ML, the kiln baking may not be necessary. Trial and experience will dictate use.

4.2.2 All parts of the SPE manifold must be cleaned between samples by sonicating in methanolic ammonium hydroxide (1%) and air drying prior to use if parts fit in a sonicator. Smaller parts, like the needles, adapters, reservoirs, and stopcocks associated with the manifold require rinsing with tap water prior to sonicating in methanolic ammonium hydroxide (1%) and air drying. When in use, after loading the

samples but prior to elution procedures, the chamber must be rinsed with methanolic ammonium hydroxide (1%).

4.3. Aqueous samples coming into contact with glass must be avoided as many PFAS analytes adsorb to a glass surface. Standards mixed in organic solvent in glass in acceptable. Evaporating samples in glass tubes may result in poor recoveries.

4.4. All materials used in the analysis must be demonstrated to be free from interferences by running method blanks at the beginning and with each sample batch (samples started through the extraction process on a given analytical batch to a maximum of 20 field samples).

4.4.1 The reference matrix must simulate, as closely as possible, the sample matrix being tested. Ideally, the reference matrix should not contain PFAS in detectable amounts (or above half the ML) but should contain potential interferants (non-target) in the concentrations expected to be found in the samples to be analyzed.

4.4.2 When a reference matrix that simulates the sample matrix under test is not available, reagent water can be used to simulate water samples and Ottawa sand and/or reagent-grade sand can be used to simulate soils.

4.5. When major contamination of the system occurs, the system needs to be cleaned and flushed until all background and contamination are eliminated. Some parts may need replacement if contamination is severe.

4.6. Interferences co-extracted from samples will vary considerably from source to source, depending on the diversity of the site being sampled. Interfering compounds may be present at concentrations several orders of magnitude higher than the native PFAS. Because low levels of PFAS are measured by this method, elimination of interferences is essential. The cleanup can be used to reduce or eliminate these interferences and thereby permit reliable determination of the PFAS at the levels required. The most frequently encountered interferences are fluoropolymers; however, when analyzing whole fish samples, bile salts (e.g., Taurodeoxycholic Acid [TDCA]) can interfere in the chromatography. For this reason, analysis of a standard containing TDCA is required as part of establishing the initial chromatographic conditions. At the onset of EMT development and at time of SOP writing, water and soil matrices will be the focus and tissue excluded at the start. During development, EMT also used TCDCA and TUDCA as well based on DoD QSM and February 8, 2022 1633 errata sheet.

4.7. Each piece of reusable glassware may be numbered or marked to associate that glassware with the processing of a particular sample. This may assist the laboratory in tracking possible sources of contamination for individual samples, identifying glassware associated with highly

contaminated samples that may require extra cleaning (furnace), and determining when glassware should be discarded.

4.8. Isotopic dilution analogue solutions may contain native analytes if purity is not up to required levels. Each new source should be verified to not contain any native analytes greater than 1/2 of the ML (covered by the reagent blank analysis or can run as individual spiked solutions upon opening to verify no contributions present as dilution levels to be used in analysis).

4.9. Blank subtraction is not permitted for any contamination issue from a sample result.

5. SAFETY

5.1. All samples handled shall be considered hazardous and the appropriate PPE must be worn when running this test (safety glasses, gloves, and a lab coat). Use care in choosing PPE that the items do not contain or have been treated with PFAS.

5.2. Refer to the company SDS library or online. This information is available to all analysts at all times.

5.3. The use of laboratory equipment and chemicals exposes the analyst to several potential hazards therefore, good laboratory technique and safety practices must be practiced at all times including the use of safety glasses, laboratory coats, and acid resistant gloves when handling samples or reagents or when in the vicinity of others handling these items and again taking care in making sure items used do not contain PFAS.

5.4. Spilled samples and reagents shall be cleaned up from laboratory surfaces immediately. Acidic and Alkaline spills must use spill kit "pigs" for caustic spills.

5.5. All additional company safety practices and procedures must be followed at all times.

5.6. The toxicity or carcinogenicity of each reagent used in this method has not been precisely defined. Each chemical compound shall be treated as a potential health hazard. Waste acids and solvents need to be collected in the proper containers and disposed of according to the specific material. PFOA has been described as a likely carcinogen so again, care must be taken when using or handling any and all laboratory reagents, standards, and samples.

NOTE: Please refer to the latest version of EMT's Chemical Hygiene Plan (CHP) for more comprehensive and authoritative safety information. The information provided in this section is to be used as guidance. The information given in the CHP supersedes the information provided here.

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6. EQUIPMENT AND SUPPLIES

NOTE: Unless indicated as mandatory, all references to manufacturer and catalog number are provided as examples of acceptable items. Containers and equipment MUST not have Teflon seals or liners. Due to potential adsorption of analytes onto glass, polypropylene containers are to be used for sample preparation and extraction. Other plastic materials (e.g., polyethylene) that meet the QC requirements may be substituted.

6.1. A full set of tools including screwdrivers, wrenches, fuse pullers, Allen wrenches, extra fuses, ferrules, and the instrument manual(s).

6.2. Sample containers: 500, 250, and 125 mL HDPE or polypropylene bottles fitted with polypropylene or linerless HDPE screw caps for PFAS samples (500 ml waters or soils and 100 ml for Leachates) with 250 or 125 potential for the solids and screening. *Soils to use 90-100 ml specimen containers, individually wrapped and pre-tested to be PFAS free.*

6.3. Polypropylene bottles: 4-mL narrow-mouth polypropylene bottles (VWR Cat. No.: 16066-960 or equivalent) for autosampler

6.4. HDPE bottles with linerless HDPE or polypropylene cap; 60, 100, or 125 ml as required

6.5. Centrifuge tubes: 15-mL conical polypropylene tubes with polypropylene screw caps for storing standard solutions and for collection of the extracts. (Thomas Scientific Cat. No.: 2602A10 or equivalent)- “collection tubes”. 50 ml disposable polypropylene for samples.

6.6. Autosampler vials: Polypropylene autosampler vials (ThermoFisher Cat. No.: C4000-11) with polypropylene caps (ThermoFisher Cat# C5000-50 or equivalent). Polypropylene caps do not seal, so need to be replaced for storage or re-analysis due to evaporation potential from a pierced cap.

6.7. Polypropylene graduated cylinders: 10, 25, 50, 100, 250, 500 and 1000-mL cylinders (or equivalent polypropylene certified volumetric measuring container)

6.8. Volumetric flasks, class A, various volumes- as required in SOP for volumes made

6.9. Plastic pipets: Henke-Ject or Norm-Ject in polypropylene or HDPE, 5 to 10 ml or equivalent

6.10. Micro syringes: 0.5 to 1000-µL ranges with certified accuracy of 1%. Certification statements shall be saved to be available at any time upon request.

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6.11. Disposable glass pipets

6.12. Mechanical pipettes: Multiple ranges with certified accuracy of 1%. Certification statements shall be saved to be available at any time upon request. The pipette must be calibrated each day it is used. Use with polypropylene or HDPE tips.

6.13. Analytical balance: Capable of weighing to the nearest 0.0001 g (0.1 mg). The balance must be calibrated each day it is used.

6.14. Top loading balance: Capable of weighing to the nearest 0.01 g (10 mg). The balance must be calibrated each day it is used.

6.15. Vortex mixer

6.16. Nutating mixer, TCLP rotator, *or other mixing device* to evenly mix soil samples. TCLP rotator *followed by constructed rotator to hold sample batch* used to mix samples from start of EMT soil sample development

6.17. Centrifuge capable of 3000 rpm and holding 50 ml tubes, ELMI CM-75 Plus or equivalent

6.18. pH paper, narrow range in at least 0.5 unit readability to check sample pH between 6.0 to 7.0 prior to SPE and cleanup

6.19. Silanized glass wool (Sigma-Aldrich, Cat # 20411 or equivalent) – store in a clean glass jar and rinsed with methanol (2 times) prior to use.

6.20. Disposable syringe filter, 25-mm, 0.2-µm Nylon or Polypropylene membrane, PALL/Acrodisc or equivalent

6.21. Glass fiber filter, 47 mm, 1 µm, PALL A/E or equivalent (used in lab for TSS) with appropriate sized weighing pan for filter

6.22. **Solid Phase Extraction (SPE) and Evaporation Apparatus**

6.22.1. SPE Cartridges: (Waters Oasis WAX 150 mg, Cat # 186002493, *Phenomenex Strata-X-AW 150 mg, Cat # 88-5038-SCH,* or equivalent). The SPE sorbent must have a pKa above 8 so that it remains positively charged during the extraction.

6.22.2. Vacuum extraction manifold with vacuum: a manual vacuum manifold with flow and vacuum control. LRBs must be rotated among the ports during routine analyses thereafter.

6.22.3. Sample delivery system: SPE Empty Tubes, sample reservoir, 75mL, polypropylene (Restek Cat# 26015 or equivalent). SPE Connector, 1, 3, 6, 10, or 15mL, polypropylene (Restek Cat# 26007 or equivalent). LRBs must be rotated among the ports during routine analyses thereafter. Plastic reservoirs are difficult to rinse during elution and their use may lead to lower recovery.

Note: *The initial SPE stop cocks used had contamination for 6:2 FTS. Switching to a polycarbonate source had eliminated this issue.*

6.22.4. Extract concentration system: N-Evap or Turbo Vap system, PFAS free. An N-Evap was initially used during EMT method development initial solids extraction. *Removed from soil process due to low recoveries of volatile PFAS compound in evaporation steps from initial draft 1633 method.*

6.23. **Liquid Chromatography/ Tandem Mass spectrometry system (LC-MS-MS)**

6.23.1. Analytical Column: Agilent RRHD Eclipse plus, C18, 2.1 x 100 mm or equivalent. Must be able to provide adequate resolution, peak shape, capacity, accuracy, and precision as designated by the source method. Use of guard column may be warranted if running more complex matrix samples with same column to expand column life (Agilent Zorbax RRHD Eclipse Plus C18, 2.1 mm, 1.8 um or equivalent).

6.23.2. Delay column: Agilent Infinity PFC Delay column, 4.6 x 30 mm (Part number 5062-8100)

6.23.3. Data system: Agilent Mass Hunter Software Suite Kit 10.1 with PFAS MRM DB Kit Version 1.0 (at the time of the SOP writing) to acquire, store, reduce and output mass data to the LIMS. Software must have capability to process stored data by recognizing LC peaks within given retention time (RT) windows allowing integration of the ion abundance of any specific ion within specified times or scan number limits. The software must be able to calculate relative response factors, construct linear regression or quadratic calibrations, and calculate the analyte concentrations.

6.23.4. LC-MS-MS system: Agilent 1290 Infinity II LC with 6495C Triple Quadrapole. The LC system must be capable of reproducibly injecting up to 10 uL aliquots and performing binary linear gradients at a constant flow rate near the flow rate of 0.3 ml/minute used for the method development. The MS/MS system must be capable of producing unique product ions (a fragment ion produced in the MS/MS by collisionally activated dissociation of the precursor ions) for the analytes within the specific RT segments.

6.23.5. LC/MS interface: is negative ion electrospray ionization (ESI) capable of meeting or exceeding the method requirements. See Table 2 for the interface conditions.

6.24. Oven capable of holding temperature at *103 to 105*^{0} C for solids/ moisture determinations

6.25. Desiccators

6.26. Muffle furnace capable of holding temperature of reaching and holding 450^0 C within two hours for potential glassware cleaning if needed due to elevated blanks. Potential use for EMT PFAS analysis/ cleaning steps as needed.

6.27. Freezers capable of maintaining </= -20^0 C for sample storage

6.28. Sonicator

7. REAGENTS AND STANDARDS

7.1. Reagents and Standards Labeling Requirements

All reagents and standards must be entered into the standards/reagent module in Element. All pertinent information defining and characterizing the standard or reagent must be entered. Critical information would be manufacturer, manufacturer lot, and expiration date. If a standard, solvent, and analyte concentration must be entered. The certificate of analysis is scanned and attached to the Element entry.

7.1.1. Commercially purchased standard and reagent hold times are as defined by the manufacturer.

7.1.2. Reagent grade or better chemicals must be used. Unless otherwise indicated, all reagents must conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society (ACS), where such specifications are available. Other grades may be used if the reagent is demonstrated to be free of analytes and interferences and all requirements of the IDC are met when using these reagents.

7.1.3. Reagents prepared by the laboratory may be stored in either glass or HDPE containers. Proper cleaning procedures (Section 4.2) must be followed prior to using the containers.

7.2. Reagent water: Laboratory reagent water, test by lot/batch number for residual PFAS content. It may be necessary prior to use to flush the system prior to collection to rinse out any build-up of analytes in the system's tubing or use commercially obtained/ purified water.

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7.3. Methanol: High purity, demonstrated to be free of analytes and interferences (Fisher LC/MS grade or equivalent). Verified by lot number before use, store at room temperature.

7.4. Acetonitrile: UPLC grade or equivalent, verified before use, store at room temperature

7.5. Ammonium acetate: High purity, demonstrated to be free of analytes and interferences (Sigma-Aldrich HPLC grade or equivalent) used by EMT to verify 537.1 and 533. Ultra LC/MS grade if issues. Store at 2 to 8^0 C and replace after two years from opening.

7.6. Carbon: EnviCarb® 1-M-USP or equivalent, verified by lot number before use, store at room temperature. Loose carbon allows for better adsorption of interferant organics.

7.7. Potassium hydroxide: certified ACS or equivalent, store at room temperature, replace after 2 years

7.8. Concentrated ammonium hydroxide reagent: NH4OH, CASRN 1336-21-6, approximately 56.6% in water as ammonium hydroxide (w/w), approximately 28% in water as ammonia, approximately 14.5 N (Fisher Scientific, Cat. No. A669, Certified ACS Plus grade, or equivalent)

7.9. 5 mM Ammonium acetate/ Reagent water (for eluent): To prepare 1 L, add 0.385 g ammonium acetate to 1 L of reagent water. This solution is volatile and must be replaced at least once a week. More frequent replacement may be necessary if unexplained loss in sensitivity or retention time shifts are encountered and attributed to loss of the ammonium acetate.

7.10. Ammonium hydroxide - certified ACS+ grade or equivalent, 30% in water, store at room temperature

7.11. **Methanolic ammonium hydroxide solutions**

7.11.1. Methanolic ammonium hydroxide (0.3%) - add ammonium hydroxide (1 mL, 30%) to methanol (99 mL), store at room temperature, replace after 1 month

7.11.2. Methanolic ammonium hydroxide (1%) - add ammonium hydroxide (3.3 mL, 30%) to methanol (97 mL), store at room temperature, replace after 1 month

7.11.3. Methanolic ammonium hydroxide (2%) - add ammonium hydroxide (6.6 mL, 30%) to methanol (93.4 mL), store at room temperature, replace after 1 month

7.12. Aqueous ammonium hydroxide (3%): add ammonium hydroxide (10 mL, 30%) to reagent water (90 mL), store at room temperature, replace after 3 months

7.13. Methanolic potassium hydroxide (0.05 M) – add 3.3 g of potassium hydroxide to 1 L of methanol, store at room temperature, replace after 3 months

7.14. Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid - add ammonium hydroxide (3.3 mL, 30%), reagent water (1.7 mL) and acetic acid (0.625 mL) to methanol (92 mL), store at room temperature, replace after 1 month. This solution is used to prepare the instrument blank

7.15. Toluene: HPLC grade, verified by lot number before use. Store at room temperature.

7.16. Formic acid: (greater than 96% purity or equivalent), verified by lot number before use, store at room temperature.

7.17.**Formic acid solutions**

7.17.1. Formic acid (aqueous, 0.1 M) - dissolve formic acid (4.6 g) in reagent water (1 L), store at room temperature, replace after 2 years

7.17.2. Formic acid (aqueous, 0.3 M) - dissolve formic acid (13.8 g) in reagent water (1 L), store at room temperature, replace after 2 years

7.17.3. Formic acid (aqueous, 5% v/v) - mix 5 mL formic acid with 95 mL reagent water, store at room temperature, replace after 2 years

7.17.4. Formic acid (aqueous, 50% v/v) - mix 50 mL formic acid with 50 mL reagent water, store at room temperature, replace after 2 years

7.17.5. Formic acid (methanolic 1:1, 0.1 M formic acid/methanol) - mix equal volumes of methanol and 0.1 M formic acid, store at room temperature, replace after 2 years

7.18.Acetic acid (glacial): ACS grade or equivalent, stored at room temperature

7.19.Acetic acid (0.1%): dissolve acetic acid (1 mL) in reagent water (1 L), store at room temperature, replace after 3 months. This reagent is used only for sample extract dilution.

7.20. Reference matrices: Reagent waters for water matrix and Ottawa or reagent grad sand for solid samples.

7.21. Bile Salts: The salts of TDCA, TCDCA, and TUDCA for interferant retention time shifting check of PFOS with LC conditions. Prepared at 1 ug/ml (mg/L) in same solvent as ICAL standards.

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Required changing of mobile phase during development due to TCDCA within 1 minute of PFAS using 5 5 mM Ammonium acetate and Methanol. Also see Figure 1 at end of SOP.

7.22. EMT mobile phase (eluent) is a 2 mM Ammonium acetate with 95:5 water/ acetonitrile and straight acetonitrile blended over time of the sample injection. See Table 1 in Section 17.

7.23. Mass calibration standard as recommended by instrument manufacturer

7.24. **Nitrogen (N2), used for the following purposes:**

7.24.1. Nitrogen aids in aerosol generation of the ESI liquid spray and is used as collision gas in some MS/MS instruments. The nitrogen used must meet or exceed instrument manufacturer's specifications. A PEAK genius XE70 Nitrogen generator is used for the aerosol generation and an ultra-high purity compressed cylinder is used for the collision cell.

7.24.2. Nitrogen is used to concentrate sample extracts (Ultra High Purity or equivalent).

7.25. **Standard solutions**

7.25.1. Purchase of commercial standard solutions or mixtures is highly recommended for this method; however, when these are not available, preparation of stock solutions from neat materials may be necessary. If the chemical purity is 98% or greater, the weight may be used without correction to calculate the concentration of the standard. For start-up and development, EMT is purchasing prepared standard mixes from Wellington Laboratories with catalog numbers for each in associated category below.

7.25.2. When not being used, store standard solutions in the dark at less than 4 °C unless the vendor recommends otherwise in screw-capped vials. Place a mark on the vial at the level of the solution so that solvent loss by evaporation can be detected. Replace solution if solvent loss has occurred.

7.25.3. The laboratory must maintain records of the certificates for all standards for traceability purposes. Copies of the certificates must be provided as part of the data packages in order to check that proper calculations were performed (to be scanned in and the PDF stored with the standard and reagent entries in the LIMS system.

7.25.4. Extracted Internal Standard (EIS) – (isotopically labeled compounds): Prepare the EIS solution containing the isotopically labeled compounds listed in Table 7 and below as extracted internal standards in methanol from stock mix. An aliquot of EIS (EMT using 20

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uL) is added to each sample prior to extraction. Table below presents the nominal amounts of EIS compounds added to each water sample as an example and second for the initial EMT ICAL for waters. The list of isotopically labeled compounds in Table 7 represents the compounds that were available at the time EMT developed the method. Wellington Laboratories mix “MPFAC-HIF-ES” used for development.

7.25.5. Non-Extracted Internal Standard (NIS) - The NIS solution containing isotopically labeled compounds from Table 7 as non-extracted internal standards is prepared in methanol from stock. An aliquot of NIS solution (EMT using 20 uL) is added to each sample prior to analysis. Table below presents the nominal amounts of NIS compounds added to each sample. Wellington Laboratories mix “MPFAC-HIF-IS” was used for method development.

EIS and NIS additions with levels for samples based on draft method 1633 Tables 3 and 4:

Extracted Internal Standards (EIS):	Initial Amount Stock in 20 uL addition (ug/L)- Water and Solids	Instrument reading (ug/L) for EIS in samples as "Internal Standards". Water and Solid	Value as "Surrogate" in ng/L spiked to 500 ml water sample:	Value as "Surrogate" in ng/g spiked with 5 g-Dry soil sample:
13C4-PFBA	40	10	80	10

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13C5-PFPeA	20	5	40	5
13C5-PFHxA	10	2.5	20	2.5
13C4-PFHpA	10	2.5	20	2.5
13C8-PFOA	10	2.5	20	2.5
13C9-PFNA	5	1.25	10	1.25
13C6-PFDA	5	1.25	10	1.25
13C7-PFUnA	5	1.25	10	1.25
13C2-PFDoA	5	1.25	10	1.25
13C2-PFTeDA	5	1.25	10	1.25
13C3-PFBS	10	2.5	20	2.5
13C3-PFHxS	10	2.5	20	2.5
13C8-PFOS	10	2.5	20	2.5
13C2-4:2FTS	20	5	40	5
13C2-6:2FTS	20	5	40	5
13C2-8:2FTS	20	5	40	5
13C8-PFOSA	10	2.5	20	2.5
D3-NMeFOSA	10	2.5	20	2.5
D5-NEtFOSA	10	2.5	20	2.5
D3-NMeFOSAA	20	5	40	5
D5-NEtFOSAA	20	5	40	5
D7-NMeFOSE	100	25	200	25
D9-NEtFOSE	100	25	200	25
13C3-HFPO-DA	40	10	80	10

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Non-extracted Internal Standards (NIS) Waters and Solids:	Initial amount with 5 uL added to collection vessel (ug/ml [mg/L]):	Final reading in samples (ug/L):
13C3-PFBA	1	5
13C2-PFHxA	0.5	2.5
13C4-PFOA	0.5	2.5
13C5-PFNA	0.25	1.25
13C2-PFDA	0.25	1.25
18O2-PFHxS	0.5	2.5
13C4-PFOS	0.5	2.5

7.25.6. Native Standards Solution - Prepare a spiking solution, containing the method analytes listed in Table 7, in methanol from prime stocks. The solution is used to prepare the calibration standards and to spike the known reference QC samples that are analyzed with every batch. Quantitative standards containing a mixture of branched and linear isomers must be used for method analytes if available. Currently, these include PFOS, PFHxS, NMeFOSAA, and NEtFOSAA. EMT is using multiple stock mixes from Wellington Laboratories at development to match Draft 1633 and isomer requirements. Standard mix catalog numbers in use to get all 40 target compounds are: PFAC-MXF, PFAC-MXG, PFAC-MXH, PFAC-MXI, and PFAC-MXJ. EMT will continue to monitor for the release of new branched standards if and as they may come available. At time of method development, the above isomers were available and used.

7.25.7. Calibration standard solutions – A series of 10 calibration solutions containing the target analytes and the labeled extracted internal standards (EIS) and non-extracted internal standards (NIS) is used to establish the initial calibration of the analytical instrument. The concentration of the method analytes in the solutions vary to encompass the working range of the instrument, while the concentrations of the EIS and NIS remain constant. The calibration solutions are prepared using methanol, methanolic ammonium hydroxide (2%), water, acetic acid and the method analyte and isotopically labeled compound standard solutions. After dilution, the final solutions will match the solvent mix of sample extracts, which contain methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid. Calibration standard solutions do not undergo solid phase extraction/cleanup.

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7.25.8. A minimum of six calibrations standards are required for a valid analysis when using a linear calibration model, with at least five of the six calibration standards being within the quantitation range (from the LOQ to the highest calibration standard). EMT is setting 10 calibration levels during development. If a second-order calibration model is used, a minimum of seven calibration standards are required, with at least six of the seven calibration standards within the quantitation range. The lowest level calibration standard must meet a signal-to-noise ratio of 3:1 and be at a concentration less than or equal to the LOQ. All initial calibration requirements must be met (QC recoveries as well as RSD </= 20% or RSE </= 20% depending on curve fit. An instrument sensitivity check (ISC) standard at the concentration of the lowest calibration standard within the quantitation range is required to be analyzed at the beginning of the analytical run. A mid-level calibration solution is analyzed at least every ten samples or less, on an ongoing basis for the purpose of calibration verification. A mid-level calibration verification (CV) standard must also be analyzed after all sample analyses in order to bracket the analytical batch.

Note: Additional calibration standards, at levels lower than the lowest calibration standard listed in the method or LOQ may be added to accommodate a lower limit of quantitation if the instrument sensitivity allows. Calibration standards at the high end of the calibration may be eliminated if the linearity of the instrument is exceeded or at the low end if those calibration standards do not meet the S/N ratio criterion of 3:1 as long as the required number of calibration points is met. All analytes with commercially available stable isotope analogues must be quantified using isotope dilution.

7.25.9. Qualitative Standards - Standards that contain mixtures of the branched and linear isomers of the method analytes and that are used for comparison against suspected branched isomer peaks in field samples. These qualitative standards are not required for those analytes where the quantitative standards already contain the branched and linear isomers. Qualitative standards that are currently commercially available (EMT using Wellington) include PFOA, PFNA, PFOSA, NMeFOSA, NEtFOSA, NEtFOSE, and NMeFOSE.

7.25.10. Instrument Blank – During the analysis of a batch of samples, a solvent blank is analyzed after samples or standards containing high level of target compounds (calibration CCV) to monitor carryover from the previous injection. The injection blank consists of the solution in Section 7.13 fortified with the EIS and NIS for quantitation purposes. Target compounds must be less than ½ the LOQ to be considered passing.

7.25.11. Stability of solutions – Standard solutions used for quantitative purposes need to be assayed periodically (approximately every 6 months) against certified standard reference materials (SRMs) from the National Institute of Science and Technology (NIST), if available, or certified reference materials from a source that will attest to the authenticity and

concentration, to assure that the composition and concentrations have not changed. Standards will be run against second source ICV standards to ensure integrity. Manufacturer suggested expiration times will also be followed.

8. SAMPLE COLLECTION, PRESERVATION AND STORAGE

8.1. **Sample collection**: Samples must be collected in plastic bottles: polypropylene bottles fitted with polypropylene screw-caps, or polyethylene bottles with polypropylene screw caps. Discard sample bottles after a single use. The bottle volume should approximate the volume of the sample. EMT generally will be using 500 ml capacity sized bottles for waters and solids and 100 ml for leachates. All steps and measures must be taken to avoid any PFAS contamination due to clothing, PPE, sampling equipment, and other potential sources of PFAS.

8.2. **Water and Leachate (aqueous) samples**

8.2.1. Samples that flow freely are collected as grabs or in refrigerated bottles using automatic sampling equipment. Collect 500 mL of sample (other than leachates) in an HDPE bottle. Do not fill the bottle past the shoulder- allowing room for expansion during frozen storage.

Note: Collect at least two aliquots of all aqueous samples to allow sufficient volume for the determination of percent solids and for pre-screening. The second aliquot may be collected in a smaller sample container. Because target analytes are known to bind to the interior surface of the container, the entire aqueous sample collected must be prepared and analyzed with subsampling avoided when possible. If a sample volume smaller than 500 mL is to be used for analysis, collect the sample in an appropriately sized HDPE container.

8.2.2. Leachate samples can present significant challenges and only 100 mL of sample is collected for the analysis. Collect two 100-mL leachate sample aliquots in a similar manner as described above.

8.2.3. Maintain all aqueous samples protected from light at 0 - 6 º C from time of collection until delivered to the laboratory. Samples must be shipped as soon as practical with sufficient ice to maintain temperature below 6 º C during transport and be received within 48 hours of collection. The temperature must be 0 - 6 º C upon receipt. Once received, the samples must be stored at ≤ -20 º C until sample preparation.

8.2.4. Aqueous samples should be analyzed as soon as possible; however, samples may be held in the laboratory for up to 90 days from collection, when stored at ≤ -20 º C and protected from light. When stored at 0 - 6 º C and protected from light, aqueous samples may be held for up to 28 days, with the caveat that issues were observed with certain perfluorooctane

sulfonamide ethanols and perfluorooctane sulfonamidoacetic acids after 7 days. These issues are more likely to elevate the observed concentrations of other PFAS compounds via the transformation of these precursors if they are present. EMT will use the frozen storage technique for aqueous samples.

8.3. **Solid (soils, sediments, biosolids) samples**

8.3.1. Collect samples as grabs using *90-100 ml specimen* and fill no more than ¾ full.

8.3.2. Maintain solid samples protected from light at 0 - 6 C from the time of collection until received by the lab. The temperature must be 0 - 6 º C upon receipt. Once received, the samples must be stored at ≤ -20 º C until sample preparation.

8.3.3. Solid samples may be held for up to 90 days, if stored in the dark at either 0 - 6 º C or ≤ -20 º C, with the caveat that samples may need to be extracted as soon as possible if NFDHA is an important analyte. EMT will use the frozen storage technique for solid samples.

8.3.4. Biosolids samples may be held for up to 90 days, if stored in the dark at 0 - 6 º C or at -20 º C. Because microbiological activity in biosolids samples at 0 - 6 ºC may lead to production of gases which may cause the sample to be expelled from the container when it is opened, as well as producing noxious odors, EPA recommends that samples be frozen if they need to be stored for more than a few days before extraction. EMT will use the frozen storage technique for these samples.

8.4. **Extract Hold times:** Store sample extracts in the dark at less than 0 - 4 º C until analyzed. If stored in the dark at less than 0 - 4 º C, sample extracts may be stored for up to 90 days, with the caveat that issues were observed for some ether sulfonates after 28 days. These issues may elevate the observed concentrations of the ether sulfonates in the extract over time. Samples may need to be extracted as soon as possible if NFDHA is an important analyte. EMT will employ a 28 day Hold time for the extracts.

NOTE: *For TSS and PMoist sample containers, they are to be stored at 0 to 6^0 C with a Hold time of 7 days to coincide with current solids methods that EMT analyzes. Draft 1633 did not include specifics for these methods.*

9. QUALITY CONTROL

9.1 The minimum requirements of this method consist of an initial demonstration of laboratory capability, analysis of samples spiked with isotopically labeled compounds to evaluate and document data quality, and analysis of standards and blanks as tests of continued performance. Laboratory performance is compared to the established performance criteria to determine if the results of analyses meet the performance characteristics of the method and this SOP. If the

method is to be applied to a sample matrix other than water, the appropriate alternative reference matrix is substituted for the reagent water matrix (Ottawa sand for solids) in all performance tests.

9.1.1 Each time a modification is made to this method, the lab is required to repeat the IDC procedures. If calibration affected by the change, the instrument must be recalibrated. Once the modification is demonstrated to produce results equivalent or superior to results produced by the source method, that modification may be used routinely as long as the other QC requirements are met.

NOTE: The laboratory is required to maintain records of any modifications made to this method. These records include the following; at a minimum (also see Draft 1633 section 9.1.2.2): names of analysts and data reviewers that verified data, target compounds by name and CAS #, results from all QC comparing the modifications to original method, data that would allow an independent reviewer the ability to validate the determinations in the final results with modification (must be able to recreate extraction and analysis in entirety).

9.1.2 Analyses of method blanks are required on an on-going basis to demonstrate the extent of background contamination in any reagents or equipment used to prepare and analyze field samples.

9.1.3 The laboratory must spike all samples with isotopically labeled compounds to monitor performance. When results of these spikes indicate atypical method performance for samples, the samples are diluted to evaluate whether the performance issue is caused by the sample matrix.

9.1.4 The laboratory must, on an ongoing basis, demonstrate that the analytical system is in control through calibration verification and the analysis of ongoing precision and recovery standards (OPR), spiked at low (LLOPR) and mid-level (Regular OPR), and blanks.

9.2 **Initial Demonstration of Capability (IDC):** The IDC must be successfully performed before analyzing any field samples or data reporting. Before running IDC, the analyst must have a successful calibration that meets the method requirements. To establish the ability to generate acceptable precision and recovery, the lab must perform the following for each matrix to be analyzed.

9.2.1 **Initial Demonstration of Precision and Accuracy (IDP and IDA)**

9.2.1.1 Extract, concentrate, and analyze four aliquots of the matrix types to be tested (water, solid), spiked with 200 uL of the native standard solution mix, 50 uL of the EIS solution mix, and 50 uL of NIS solution mix. At least one method blank, matching the matrix

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being analyzed, must be prepared with the IPR batch. In the event that more than one MB was prepared and analyzed with the IPR batch, all blank results must be reported. All sample processing steps that are to be used for processing samples, including preparation and extraction, cleanup, and concentration must be included.

9.2.1.2 Using the results of the set of four analyses, compute the average percent recovery of the extracts and the relative standard deviation (RSD) of the concentration for each target and EIS compound.

9.2.1.3 For each native and isotopically labeled compound, compare RSD and % recovery with the corresponding limits for initial precision and recovery in Table B-24 of DoD QSM for the OPR recoveries (40 to 150% or until in-house limits generated) and standard EMT RSD or 15% or less. If RSD and Recovery for all compounds meet the acceptance criteria, system performance is acceptable, and analysis of blanks and samples may begin. If any individual RSD exceeds the precision limit or any individual recovery falls outside the range the system performance is unacceptable for that compound. Correct the problem and repeat the study.

$$\%\text{RSD} = \frac{\text{Standard Deviation of Measured Concentrations}}{\text{Average Concentration}} \times 100$$

$$\%\text{Recovery} = \frac{\text{Average Measured Concentration}}{\text{Fortified Concentration}} \times 100$$

9.2.2 Method detection limit (**MDL**): Each laboratory must establish MDLs for all the analytes using the MDL procedure at 40 CFR Part 136, Appendix B. An MDL determination must be performed for all compounds for all matrices. The minimum level of quantification (ML) is then calculated by multiplying the MDL by 3.18 and rounding the result to the nearest 1, 2 or 5 x 10n, where n is zero or an integer or the lowest point in the calibration (see also Section 13.3) Examples of matrix-specific detection limits are listed in Table 6 of the draft 1633 method.

9.3 To assess method performance on each sample matrix, the laboratory must spike all samples with the isotopically labeled compound solution mix (EIS) and all sample extracts with the NIS spiking solution mix.

9.3.1 Calculate the percent recovery of the isotopically labeled compound using the non-extracted internal standard (NIS) method and the equation in Section 12.2

9.3.2 The recovery of each isotopically labeled compound must be within 20 to 150% for the EIS and 30 to 150% for the NIS (DoD QSM Table B-24). If the recovery of any compound falls

outside of these limits, method performance is unacceptable for that compound in that sample. Additional cleanup procedures must then be employed to attempt to bring the recovery within the normal range. If the recovery cannot be brought within the normal range after all cleanup procedures have been employed, water samples are diluted, and smaller amounts of soils, biosolids, sediments, and other matrices are to be prepared and analyzed.

9.4 Recovery of isotopically labeled compounds from samples must also be assessed and records maintained.

9.4.1 After the analysis of 30 samples of a given matrix type (water, soil, biosolids,, etc.) for which the isotopically labeled compounds pass the tests in Section 9.3, compute the recovery (R) and the standard deviation of the percent recovery (SR) for the isotopically labeled compounds only. Express the assessment as a percent recovery interval from R - 2SR to R +2SR for each matrix. For example, if R = 90% and SR = 10% for five analyses of soil, the recovery interval is expressed as 70 to 110%.

9.4.2 Update the accuracy assessment for each isotopically labeled compound in each matrix on a regular basis (follow guidance set by EMT and other methods at every twenty or more new data points).

9.5 **Method blanks**: A method blank is analyzed with each sample batch to demonstrate freedom from contamination. The matrix for the method blank must be similar to the sample matrix for the batch (reagent waters for water and sand for solids).

9.5.1 Analyze the cleaned extract of the method blank aliquot before the analysis of the OPR standards.

9.5.2 If any PFAS is found in the blank at a concentration greater than the ML, at a concentration greater than 1/3 the regulatory compliance limit, or at a concentration greater than 1/10 the concentration in a sample in the extraction batch, whichever is greatest, analysis of the samples must be halted, and the problem corrected. Other project-specific requirements may apply. If the contamination is traceable to the extraction batch, samples affected by the blank must be re-extracted and analyzed provided enough sample is available and still within holding time.

If continued re-testing has repeated blank contamination, it must be documented and report the failures with qualifiers and or case narratives unless the failures are not required to be reported as determined by the regulatory/control authority. Results associated with blank contamination for an analyte regulated in a discharge cannot be used to demonstrate regulatory compliance.

9.6 The specifications contained in this method can be met if the apparatus used is calibrated properly and then maintained in a calibrated state. The standards used for initial calibration, calibration verification, and for initial and ongoing precision and recovery may be prepared from the same source; however, the use of a secondary source for calibration verification is highly recommended when available. If standards from a different vendor are not available, a different lot number from the same vendor can be considered a secondary source.

9.7 Depending on specific program requirements, field replicates may be collected to determine the precision of the sampling technique, and spiked samples may be required to determine the accuracy of the analysis when the extracted internal standard method is used.

9.8 Matrix spikes generally are not required for isotope dilution methods because any deleterious effects of the matrix should be evident in the recoveries of the isotopically labeled compounds spiked into every sample. However, because some of the compounds are quantified by a non-analogous isotopically labeled compound (example- PFPeS is quantified by 13C3-PFHxS), the analysis of matrix spike samples may help diagnose matrix interferences for specific compounds. Samples that require DoD analysis must follow the QSM guidance that requires an MS/MSD per batch with recoveries meeting in-house LCS or project limits if supplied with RPD results </= to 30%.

10. CALIBRATION AND STANDARDIZATION

10.1 **Mass Calibration:** The mass spectrometer must undergo mass calibration to ensure accurate assignments of m/z by the instrument. This mass calibration must be performed at least annually to maintain instrument sensitivity and stability. Mass calibration must be repeated on an as-needed basis (when QC failures occur, ion masses fall outside of the instrument required mass window, major instrument maintenance performed, or if the instrument is moved). Mass calibration must be performed using the calibration compounds and procedures prescribed by the manufacturer. The procedures used for mass calibration and mass calibration verification must evaluate an ion range that encompasses the ion range (precursor, quant, confirmation) of the analytes of interest of this method. Multiple Reaction Monitoring (MRM) analysis is required to achieve better sensitivity than full-scan analysis. The ions to be monitored for each native compound, isotopically labeled compound, and NIS are given in Table 9 that were used during development.

10.1.1 Optimize the response of the precursor ion [M-H]- or [M-CO2] for each analyte following the manufacturer's guidance. MS parameters (e.g., source voltages, source and desolvation temperatures, gas flow, etc.) must be methodically changed until optimal analyte responses are determined. Typically, carboxylic acids have similar MS/MS conditions and sulfonic acids have similar MS/MS conditions. However, since analytes may

have different optimal parameters, some compromise on the final operating conditions may be required.

10.1.2 Establish suitable operating conditions using the manufacturer's instructions and see Table 3 for the MS conditions used during the EMT development of this method.

10.1.3 In the absence of manufacturer-specific instructions and acceptance criteria, the procedure in Method 1633 may be used for mass calibration. EMT following Agilent procedures for the method development.

10.1.4 **Mass Calibration Verification:** A mass calibration verification must be performed following mass calibration, prior to standards and samples analysis. Mass verification checks must also be performed after any subsequent mass calibrations. Each laboratory must follow the instructions for their individual instrument software to confirm the mass calibration, mass resolution, and peak relative response. Mass calibration verification must be performed using standards whose mass range brackets the masses of interest (quantitative and qualitative ions).

10.1.4.1 Check the instrument mass resolution to ensure that it is at least unit resolution. Inject a mid-level CAL standard under LC-MS/MS conditions to obtain the retention times of each method analyte. Divide the chromatogram into retention time windows each of which contains one or more chromatographic peaks (two peaks if branched and linear isomers present). During MS/MS analysis, fragment a small number of selected precursor ions ([M-H]-) for the analytes in each window and choose the most abundant product ion. The product ions (also the quantitation ions) chosen during EMT method development are in Table 9. Unit resolution is demonstrated when the value of the peak width at half-height is within 0.5 ± 0.1 amu or Da.

10.1.4.2 Check the mass calibration by measuring the amount of peak drift from the expected masses. If the peak apex has shifted more than approximately 0.1 Da, then the instrument will need to be recalibrated following the manufacturer's instructions.

10.2 **Chromatographic Conditions:** Establish LC operating parameters that optimize resolution and peak shape. EMT LC conditions can be found in Table 2. Modifying the solvent composition of the standard or extract by increasing the aqueous content to better focus early eluting compounds on the column is not permitted.. The peak shape of the early eluting compounds may be improved by increasing the volume of the injection loop or increasing the aqueous content of the initial mobile phase composition.

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Note: LC system components, as well as the mobile phase constituents, may contain many of the analytes in this method. Thus, these PFAS will build up on the head of the LC column during mobile phase equilibration. To minimize the background PFAS peaks and to keep baseline levels constant, the time the LC column sits at initial conditions must be kept constant and as short as possible (while ensuring reproducible retention times). In addition, priming the mobile phase and flushing the column with at least 90% methanol before initiating a sequence may help to reduce potential background contamination.

10.2.1 **Retention time calibration**

10.2.1.1 Inject compound solution(s) to determine its retention time. The laboratory may want to inject compounds separately the first time they perform the calibration. All native compounds for which there is an isotopically labeled analog will elute slightly before or with the labeled analog. Store the retention time (RT) for each compound in the data system.

10.2.1.2 Once RT windows have been confirmed for each analyte, once per ICAL and at the beginning of the analytical sequence, the position of each method analyte, EIS analyte, and NIS analyte peaks shall be set using the midpoint standard of the ICAL curve when ICAL is performed. When ICAL is not performed, the initial CV retention times or the midpoint standard of the ICAL curve can be used to establish the RT window position.

10.2.1.3 Method analyte, EIS analyte, and NIS analyte RTs must fall within 0.4 minutes of the predicted retention times from the midpoint standard of the ICAL or initial daily CV, whichever was used to establish the RT window position for the analytical batch. All branched isomer peaks identified in either the calibration standard or the qualitative (technical grade) standard must fall within in the retention time window for that analyte.

10.2.1.4 For all method analytes with exact corresponding isotopically labeled analogs, method analytes must elute within 0.1 minutes of the associated EIS.

10.2.1.5 When establishing the chromatographic conditions, it is important to consider the potential interference of bile salts during analyses. Inject a standard containing the bile salts during the retention time calibration process and adjust the conditions to ensure that the bile salts do not coelute with any of the target analytes, EIS, or NIS standards. Analytical conditions must be set to allow a separation of at least 1 minute between the bile salts and PFOS.

10.3 Initial Calibration: Initial calibration is performed using at least six standards, with at least five of

the six calibration standards being within the quantification. (If a quadratic calibration model is used, then one additional concentration is required.) The initial calibration solutions contain the entire suite of isotopically labeled compounds, NISs, and target compounds. Calibration is verified with a calibration verification (CV) standard at least once every ten field samples or less, by analysis of a mid-level calibration solution. Calibration verification uses the mean RRs or RFs determined from the initial calibration to calculate the analyte concentrations in the verification standard.

10.3.1 Prior to the analysis of samples, and after the mass calibration check has met all necessary criteria, each LC-MS/MS system must be calibrated at a minimum of 6 standard concentrations. This method calibrates and quantifies 40 PFAS target analytes, using the isotopically labeled compounds added to the sample prior to extraction, by one of the two approaches below:

10.3.1.1 True isotope dilution quantification (ID), whereby the response of the target compound is compared to the response of its isotopically labeled analog. Twenty-four target compounds are quantified in this way.

10.3.1.2 Extracted internal standard quantification (EIS), whereby the response of the target compound is compared to the response of the isotopically labeled analog of another compound with chemical and retention time similarities. Sixteen target compounds are quantified in this way.

10.3.1 **Initial calibration frequency:** Each LC-MS/MS system must be calibrated whenever the laboratory takes corrective action that might change or affect the initial calibration criteria, or if either the CV or Instrument Sensitivity Check (ISC) acceptance criteria have not been met.

10.3.2 **Initial calibration procedure:** Prepare calibration standards containing the native compounds, EIS, and NIS. For the EIS and NIS levels, see Section 7.25.5. For targets, the majority of compounds are at the following levels for the 10 standards: 0.2, 0.5, 1.0, 2.0 5.0, 10.0, 20.0, 30.0, 40.0, and 50 ug/L Some compounds are elevated and other are close- but acid values used for levels as applicable. Analyze each calibration standard by injecting 2.0 uL (this volume may be changed to improve performance, but the same volume must be used for ICAL, QC samples, and samples once optimized). 2.0 uL was used by EMT during development.

10.3.3 **Initial calibration (ICAL) calculations for verification**

10.3.4.1 **Instrument sensitivity:** Sufficient instrument sensitivity is established if a signal-to-noise ratio ≥ 3:1 can be achieved when analyzing the lowest concentration standard within the quantitation range that the laboratory includes in its assessment of calibration linearity.

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10.3.4.2 **Response Ratios (RR) and Response Factors (RF):** The response ratio (RR) for each compound calibrated by isotope dilution is calculated according to the equation below, separately for each of the calibration standards, using the areas of the quantitation ions (Q1) with the m/z shown in Table 10. RR is used for the 24 compounds quantified by true isotope dilution.

$$RR = \frac{Area_n \times M_l}{Area_l \times M_n}$$

Where:

$Area_n$ = the measured area of the Q1 m/z for the native (unlabeled) PFAS

$Area_l$ = the measured area at the Q1 m/z for the corresponding isotopically labeled PFAS added to the sample before extraction

M_l = the mass of the isotopically labeled compound in the calibration standard

M_n = the mass of the native compound in the calibration standard

Similarly, the response factor (RF) for each unlabeled compound calibrated by extracted internal standard is calculated according to the equation below. RF is used for the 16 compounds quantified by extracted internal standard.

$$RF = \frac{Area_s \times M_{EIS}}{Area_{EIS} \times M_s}$$

Where:

$Area_s$ = the measured area of the Q1 m/z for the target (unlabeled) PFAS

$Area_{EIS}$ = the measured area at the Q1 m/z for the isotopically labeled PFAS used as the extracted internal standard (EIS)

M_{EIS} = the mass of the isotopically labeled PFAS used as the extracted internal standard (EIS) in the calibration standard

M_s = the mass of the target (unlabeled) PFAS in the calibration standard

A response factor (RFs) is calculated for each isotopically labeled compound in the calibration standard using the equation below. RFs are used for the 24 isotopically labeled compounds quantified by non-extracted internal standard.

$$RF_S = \frac{Area_l \times M_{NIS}}{Area_{NIS} \times M_l}$$

Where:

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Area $_{I}$ = the measured area of the Q1 m/z for the isotopically labeled PFAS standard added to the sample before extraction
Area $_{NIS}$ = the measured area at the Q1 m/z for the isotopically labeled PFAS used as the non-extracted internal standard (NIS)
M $_{NIS}$ = the mass of the isotopically labeled compound used as the non-extracted internal standard (NIS) in the calibration standard
M $_{I}$ = the mass of the isotopically labeled PFAS standard added to the sample before extraction

Note: other calculation approaches may be used, such as linear regression or non-linear regression based on the capability of the data system used by the laboratory.

10.3.2 **Instrument linearity:** One of the following two approaches must be used to evaluate the linearity of the instrument calibration. The instrument software will show the RSD values on the isotopes and RSE values for the target analytes

Option 1: Calculate the relative standard deviation (RSD) of the RR or RF values for the initial calibration standards for each native compound and isotopically labeled compound. The RSD must be ≤ 20% to establish instrument linearity.

Option 2: Calculate the relative standard error (RSE) of the initial calibration standards for each native compound and isotopically labeled compound. The RSE for all method analytes must be ≤ 20% to establish instrument linearity.

10.3.3 **Initial calibration corrective actions:** If the instrument sensitivity or the instrument linearity criteria for ICAL are not met, inspect the system for problems and take corrective actions to achieve the criteria. This may require the preparation and analysis of fresh calibration standards. All initial calibration criteria must be met before any samples or required blanks are analyzed.

10.3.4 **Bile salts interference check:** the laboratory must analyze a TDCA-TUCDA-TUDCA bile salt standard after the initial calibration and prior to the analysis of samples to check for interferences caused by bile salts. If interference is present, the chromatographic conditions must be modified to eliminate the interference from the salts by changing the retention time of the salt peaks such that they fall outside the retention window for PFOS by at least one minute, and the initial calibration repeated.

11. PROCEDURE (Sample preparation and extraction, Clean-up and concentration, Instrument analysis, and performance tests during operation)

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11.1 **Determination of percent solids:** For aqueous samples that contain particles and for solid samples, percent solids are to be determined. This section describes the sample preparation procedures for aqueous samples with < 50 mg solids and solid (soil, sediment or biosolids) samples.

Note: It is highly recommended that the laboratory pre-screens all samples prior to performing the analysis (see Appendix A at end of SOP). For aqueous samples, use the secondary container provided for percent solids to perform the pre-screening. If high levels of PFAS are present in the sample, a lower volume is required for analysis.

The laboratory may subsample the aqueous samples as described in Appendix B at end of SOP; however, subsampling must meet project-specific requirements. The laboratory must notify the client before proceeding with subsampling. Once the laboratory becomes familiar with the levels of PFAS in the client samples, the samples should be collected in the appropriate sample container size to avoid subsampling. The sample data report must state when subsampling has been employed.

11.1.1 Determination of percent suspended solids for aqueous liquids and multi-phase samples consisting of mainly an aqueous phase:

11.1.1.1 Desiccate and weigh a glass fiber filter and weighing pan to three significant figures.

11.1.1.2 Filter *at least* 10.0 ± 0.02 mL of well-mixed sample through the filter.

11.1.1.3 Dry the filter *overnight at 103 to 105°* C and cool in a desiccator.

11.1.1.4 Calculate percent solids as follows:

$$\% \text{ Solids} = \frac{\text{Weight of sample aliquot after drying (g)} - \text{weight of filter (g)}}{10 \text{ g}}$$

NOTE: *Also refer to most current version of EMT SOP 047 for TSS full procedure.*

11.1.2 Solids (excluding tissues) sample solids determination:

11.1.2.1 Weigh 5 to 10 g of sample to three significant figures in a tared beaker or weighing dish.

11.1.2.2 Dry *overnight at 103 to 105°* C, and cool in a desiccator.

11.1.2.3 Calculate percent solids as follows:

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$$\% \text{ Solids} = \frac{\text{Weight of sample aliquot after drying (g)}}{\text{Weight of sample aliquot before drying (g)}} \times 100$$

NOTE: *Also refer to most current version of EMT SOP 045 for PMoist/ % TS full procedure.*

11.1.2.4 For PFAS analysis, use 5 g of Dry weight sample. For example, if a sample is determined to be 90% solid (10% moisture), then 5.56 g of sample would be required (5 g divided by TS%/100).

11.2 **Aqueous sample processing:** This method is applicable to aqueous samples containing up to 50 mg of suspended solids per sample. The procedure requires the preparation of the entire sample for PFAS. Smaller sample volumes may be analyzed for samples containing solids greater than specified for this method, or when unavoidable due to high level of PFAS; however subsampling should be avoided. Typical sample size is 500 mL. The sample is to be analyzed in its entirety and should not be filtered. Leachate samples are analyzed using a 100 mL sample so they must not be included in the same sample preparation batch as aqueous samples analyzed which are analyzed using 500 mL sample volumes. Volumes per batch must be consistent or separated.

11.2.1 Homogenize the sample by inverting the sample 3 to 4 times and allowing the sample to settle. Do not filter the sample. The standard procedure is to analyze the entire sample including a methanol rinse of the container.

11.2.2 The volume of the aqueous sample analyzed is determined by weighing the full sample bottle and then the empty sample bottle to find the difference which equals the sample volume. Weigh each sample bottle (with the lid) to 0.1 g.

11.2.3 Prepare a method blank and two OPRs (LCS) using PFAS-free water in HDPE bottles. Select a volume of water that is typical of the samples in the batch. Spike one OPR sample with native standard solution at 2x the LOQ (LLOPR- low level). This aliquot will serve to verify the LOQ. Spike the other OPR sample at the concentration of the mid-level calibration point. This aliquot will serve as the traditional OPR (or LCS).

Note: If matrix spikes are required for a specific project, spike the field sample bottles designated for use as MS/MSD samples with native standard solution at a concentration 3 to 5 times the background concentration determined during screening of the unspiked sample. If screening was not performed, then spike those samples at the concentration of the mid-level calibration point.

11.2.4 Spike an aliquot of EIS solution directly into the sample in the original bottle (or subsampled

bottle) as well as to the bottles prepared for the QC samples. Mix by swirling the sample container.

11.2.5 Check that the pH is 6.5 ± 0.5. If necessary, adjust pH with 50% formic acid or ammonium hydroxide (or with 5% formic acid and 3% aqueous ammonium hydroxide for smaller adjustment if needed). The extract is now ready for solid-phase extraction (SPE) and cleanup (Section 11.4).

11.3 **Solid sample processing (excluding tissues):** Use a stainless spoon to mix the sample in its original jar. If it is impractical to mix the sample within its container then transfer the sample to a larger container. Remove rocks, invertebrates, and foreign objects. Vegetation can either be removed from the sample before homogenization or cut into small pieces and included in the sample, based on project requirements. Mix the sample thoroughly, stirring from the bottom to the top and in a circular motion along the sides of the jar, breaking particles to less than 1 mm by pressing against the side of the container. The homogenized sample should be even in color and have no separate layers. Store the homogenized material in its original container or in multiple smaller containers. Determine the percent solids.

Note: The maximum sample weight for sediment or soil is 5 g dry weight. The maximum sample weight for biosolids is 0.5 g dry weight. Small amounts of reagent free water used for method blanks (10% of sample weight or less) can be added to unusually dry samples. This is an option, not a requirement.

11.3.1 Weigh out an aliquot of solid sample (based on dry weight- see also 11.1.2.4, not dried, into a 50 mL polypropylene centrifuge tube. Because biosolids samples are analyzed with a 0.5 g sample, they must not be included in the same sample preparation batch as solid samples analyzed with 5 g sample masses. Gram size per batch must be consistent or separated.

11.3.2 Prepare batch QC samples using 5 g of reference solid matrix wetted with 2.5 g of reagent water for the method blank and two OPRs (use 0.5 g of reference solid with 0.25 g of reagent water for biosolids sample batches). The addition of reagent water to the sand provides a matrix closer in composition to a real world sample. Spike one OPR sample with native standard solution at 2x the LOQ (LLOPR or low level LCS). This aliquot will serve to verify the LOQ. Spike the other OPR sample at the concentration of the mid-level calibration point. This aliquot will serve as the traditional OPR (LCS).

Note: If matrix spikes are required for a specific project, spike the field sample aliquots designated for MS/MSD samples with native standard solution at the concentration 3 to 5 times the background concentration determined during screening of the unspiked sample. If screening was not performed, then spike those samples at the concentration of the mid-level calibration point.

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11.3.3 Spike an aliquot of EIS solution directly into each centrifuge tube containing the aliquoted field and QC samples. Vortex the sample to disperse the standard and allow to equilibrate for at least 30 minutes.

11.3.4 Add 10 mL of 0.3% methanolic ammonium hydroxide to each centrifuge tube. Vortex to disperse, then shake for 30 minutes on a variable speed mixing table. Centrifuge at 2800 rpm for 10 minutes and transfer the supernatant to a clean 50 mL polypropylene centrifuge tube.

11.3.5 Add 15 mL of 0.3% methanolic ammonium hydroxide to the remaining solid sample in each centrifuge tube. Vortex to disperse, then shake for 30 minutes on a variable speed mixing table. Centrifuge at 2800 rpm for 10 minutes and decant the supernatant from the second extraction into the centrifuge tube with the supernatant from the first extraction.

11.3.6 Add another 5 mL of 0.3% methanolic ammonium hydroxide to the remaining sample in each centrifuge tube. Shake by hand to disperse, centrifuge at 2800 rpm for 10 minutes and decant the supernatant from the third extraction into the centrifuge tube with supernatant from the first and second extractions.

11.3.7 Using a 10 mg scoop, add 10 mg of carbon to the combined extract, mix by occasional hand shaking for no more than five minutes and then centrifuge at 2800 rpm for 10 minutes.

11.3.8 Immediately decant the extract into a 500 mL bottle and dilute to approximately 500 mL with reagent water. Check that the pH is 6.5 ±0.5 and adjust as necessary with 50% formic acid or 30% ammonium hydroxide (or with 5% formic acid and 3% aqueous ammonium hydroxide for smaller adjustment). The extracts are ready for SPE and cleanup (Section 11.4). ***Note****: This step removed concentration steps using TurboVap in the EPA 1633 draft method due to loss of volatile compounds.*

11.4 **Extraction, Cleanup, and Concentration of samples:** All matrices (including batch QC) must undergo SPE and carbon cleanup to remove potential interferences. Sample elution as well as any further extract treatment is matrix specific and covered in upcoming sections.

Note: Carbon cleanup is required. Carbon cleanup may remove analytes if the sample has a very low organic carbon content (this is unusual for non-drinking water environmental samples). This will be apparent if the isotope dilution standard recoveries are significantly higher on the reanalysis. If the laboratory can demonstrate that the carbon cleanup is detrimental to the sample analysis (by comparing results when skipping the carbon cleanup during reanalysis), then the carbon cleanup may be skipped for that specific sample.

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Note: Sections 11.4.1 through 11.4.5 apply to all matrix types.

11.4.1 Pack clean silanized glass wool to half the height of the WAX SPE cartridge barrel.

11.4.2 Set up the vacuum manifold with one WAX SPE cartridge plus a reservoir and reservoir adaptor for each cartridge for each sample and QC aliquot.

11.4.3 Pre-condition the cartridges by washing them with 15 mL of 1% methanolic ammonium hydroxide followed by 5 mL of 0.3M formic acid (do not use the vacuum for this step). Do not allow the WAX SPE to go dry. Discard the wash solvents.

11.4.4 Pour the sample into the reservoir (do not use a pipette), taking care to avoid splashing while loading. Adjust the vacuum and pass the sample through the cartridge at 5 mL/min. Retain the empty sample bottle and allow it to air dry for later rinsing. Discard eluate.

Note: For aqueous samples, in the event the SPE cartridge clogs during sample loading, place a second pre-conditioned cartridge and continue loading the remaining sample aliquot using the same reservoir. Proceed to Section 11.4.5.

11.4.5 Rinse the walls of the reservoir with 5 mL reagent water two times followed by 5 mL of 1:1 0.1M formic acid/methanol and pass the rinses through the cartridge under vacuum. Dry the cartridge by pulling air through for 15 seconds. Discard the rinse solution. Continue to the elution and concentration steps based on the matrix type (waters in 11.4.6 or solids in 11.4.7).

11.4.6 **Elution and extract concentration of aqueous samples**

Note: If two cartridges were used, perform Sections 11.4.1 through 11.4.5 with each cartridge. Filter the eluates through a 25 mm, 0.2-µm syringe filter. Combine both sets of filtered eluates into a clean tube then add the NIS solution, and vortex to mix. Transfer 350 uL of the filtered extract into a 1 mL polypropylene micro vial and mark the level. Add another 350 uL portion and using a gentle stream of nitrogen (with water bath set to 40º C), concentrate to the 350 uL mark and the sample is ready for analysis. This concentration step is only applicable to situations where two SPE cartridges were eluted, each with 5 mL of elution solvent.

11.4.6.1 Place clean polypropylene collection tubes inside the manifold, ensuring that the extract delivery needles do not touch the walls of the tubes. DO NOT add NIS to these collection tubes.

11.4.6.2 Rinse the inside of the sample bottle with 5 mL of the 1% methanolic ammonium hydroxide and using a glass pipette, transfer the rinse to the SPE reservoir, washing

the walls of the reservoir. Use vacuum to pull the elution solvent through the cartridge and into the collection tubes.

Note: Air dry the empty sample bottle after the rinse is transferred. Weigh the empty bottle with the cap on and subtract from the weight with the sample determined earlier to calculate the sample volume.

11.4.6.3 Add 25 uL of concentrated acetic acid to each sample eluted in the collection tubes and vortex to mix. Add 10 mg of carbon to each sample and batch QC extract, using an approximately 10 mg scoop. Hand-shake occasionally for no more than 5 minutes. It is important to minimize the time the sample extract is in contact with the carbon. Immediately vortex for 30 seconds and then centrifuge at 2800 rpm for 10 minutes.

11.4.6.4 Add NIS solution to a clean collection tube. Place a syringe filter (25 mm filter, 0.2 µm nylon membrane) on a 5 mL polypropylene syringe. Take the plunger out and carefully decant the sample supernatant into the syringe barrel. Replace the plunger and filter the entire extract into the new collection tube containing the NIS standard. Vortex to mix and transfer a portion of the extract (should have approximately 4 ml) into a 1 mL polypropylene micro vial for LC-MS/MS analysis. Cap the collection tube containing the remaining extract (approximately 4 ml- making about a 125 time concentration with the sample volume staring at approximately 500 ml) and store at 0 to 4 °C. The sample is ready for analysis.

11.4.7 **Elution and extract concentration of solid samples**

11.4.7.1 Add NIS solution to a clean polypropylene collection tube for each sample and QC aliquot and place them into the manifold rack, ensuring the extract delivery needles are not touching the walls of the tubes.

11.4.7.2 Rinse the inside of the *sample bottle* using 5 mL of 1% methanolic ammonium hydroxide, then using a glass pipette, transfer the rinse to the reservoir, washing the walls of the reservoir. Use the vacuum to pull the elution solvent through the cartridge and into the collection tubes.

11.4.7.3 Add 25 uL of concentrated acetic acid to each sample extract in its collection tube and swirl to mix. Place a syringe filter (25 mm filter, 0.2 µm nylon membrane) on a 5 mL polypropylene syringe. Take the plunger out and carefully decant about 1 mL of sample extract into the syringe barrel. Replace the plunger and filter into a 1 mL polypropylene micro vial for LC-MS/MS analysis. Cap the collection tube containing the remaining extract and store at 0 - 4° C (the final extract volume should match the

earlier determination based on solid/ moisture content from 7 to 10 ml). The sample is ready for analysis.

11.5 **Instrument analysis:** Analysis of sample extracts for PFAS by LC-MS/MS is performed on an ultrahigh performance liquid chromatograph coupled to a triple quadrupole (QQQ) mass spectrometer, running with the manufacturer's software. The mass spectrometer is run with unit mass resolution in the multiple reaction monitoring (MRM) mode.

11.5.1 Perform the mass calibration and establish the operating conditions, and perform an initial calibration (ICAL) prior to analyzing samples. Repeat the Bile salts interference check before analyzing any field samples to ensure outside 1 minute PFOS isomer RT window.

11.5.2 Only after all instrument QC performance criteria are met may the blanks, MDLs, IPRs/OPRs, and samples be analyzed.

11.5.3 After a successful ICAL has been completed, the analytical sequence for a batch of samples analyzed during the same time period is as follows. The volume injected for samples and QCs must be identical to the volume used for calibration. Standards and sample extracts must be brought to room temperature and vortexed prior to aliquoting into an instrument vial in order to ensure homogeneity of the extracts and standards.

1. Instrument Blank
2. Instrument Sensitivity Check (ISC)
3. Calibration Verification Standard (ICV after an ICAL or CV/ CCV- ICV Must be second source)
4. Qualitative Identification Standard (Contains available Linear and Branched isomers to confirm RT within 0.4 minutes of ICAL or opening CV/ CCV standard
5. Instrument Blank (</= ½ LOQ)
6. Method Blank
7. Low-level OPR (LLOPR- Low level LCS)
8. OPR (LCS)
9. Bile salt check standard
10. Samples (10 or fewer)
11. Calibration Verification Standard (CV/CCV)
12. Instrument Blank
13. Samples (10 or fewer)
14. Calibration Verification Standard (CV/ CCV)
15. Instrument Blank

Note: If the results are acceptable, the closing calibration verification solution (#14 above) may be used as the opening solution for the next analytical sequence.

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11.5.4 If the response exceeds the calibration range for any sample, extracts are diluted as per Section 12.3 to bring all target responses within the calibration range.

Note: If the analytes that exceed the calibration range in the original analysis are known to not be of concern for the specific project (e.g., are not listed in a permit or as a target), then the laboratory may consult with the client regarding the possibility of reporting that sample from the undiluted analysis.

11.6 **Performance QC tests during routine operations:** The following performance tests must be successfully completed as part of each routine instrumental analysis shift described in Section 11.5.3 above.

11.6.1 MS resolution: A mass calibration must be performed prior to analysis of the calibration curve. LC-MS/MS system performance is checked by performing MS resolution verification after the mass calibration. MS resolution must be verified prior to any samples or QC. If the requirements cannot be met, the problem must be corrected before analyses can proceed. If any of the samples in the previous shift may be affected by poor mass resolution, the extracts of those samples must be re-analyzed.

11.6.2 **Instrument sensitivity check (ISC):** The signal-to-noise ratio of the ISC standard must be greater than or equal to 3:1 and within 30% recovery of the target value. If the requirements cannot be met, the problem must be corrected before analyses can proceed.

Note: An interim limit of 70 to 130% for 90% of the native and isotopically labeled compounds should be used, with the other recoveries achieving 50-150%. All must be 70 to 130% for DoD samples.

11.6.3 **Calibration verification (CV or CCV):** After a passing MS resolution and a successful initial calibration (ICAL) is achieved, prior to the analysis of any samples, analyze a mid-level calibration standard.

11.6.3.1 The calibration is verified by analyzing a CV (CCV) standard at the beginning of each analytical sequence, every ten samples or less, and at the end of the analytical sequence.

11.6.3.2 Calculate concentration for each native and isotopically labeled compound in the CV/ CCV using the equation in Section 12.2. The recovery of native and isotopically labeled compounds for the CV/ CCVs must be within 70 - 130%.

11.6.3.3 If the CV/ CCV criterion above is not met, recalibrate the LC-MS/MS instrument and try again. Continued issues with passing QC may warrant corrective actions or preventative maintenance.

11.6.4 **Retention times and resolution**

11.6.4.1 For all method analytes with exact corresponding isotopically labeled analogs, method analytes must elute within ± 0.1 minutes of the associated EIS.

11.6.4.2 The retention times of each native and isotopically labeled compound must be within ± 0.4 minutes of the ICAL or CV/ CCV used to establish the RT windows for the samples and batch QC.

11.6.5 **Ongoing precision and recovery (OPR)**

11.6.5.1 After verification, analyze the extract of the OPR (LCS) solutions (low level and mid-range) prior to analysis of samples from the same batch to ensure the analytical process is under control.

11.6.5.2 Compute the percent recovery of the native compounds by the appropriate quantification method depending on the compound. Compute the percent recovery of each isotopically labeled compound by the non-extracted internal standard method.

$$\% \text{ Recovery} = \frac{\text{Concentration recovered (ug/ L)}}{\text{Concentration spiked (ug/ L)}} \times 100$$

11.6.5.3 For the native compounds and isotopically labeled compounds, compare the recovery to the project specific limits if given, or 40 to 150% until in-house limits set. If all compounds meet the acceptance criteria, system performance is acceptable, and analysis of blanks and samples may proceed. If, however, any individual concentration falls outside of the given range, the extraction/concentration processes are not being performed properly for that compound. In this event, correct the problem, re-prepare, extract, and clean up the sample batch and repeat the ongoing precision and recovery test.

11.6.5.4 If desired (required for DoD), add results that pass the specifications in 11.6.5.3 to initial and previous ongoing data for each compound in each matrix (creating in-house limits). Update QC (control) charts to form a graphic representation of continued laboratory performance. Develop a statement of laboratory accuracy for each compound in each matrix type by calculating the average percent recovery (R) and the standard deviation of percent recovery (SR). Express the accuracy as a recovery

interval from R - 2SR to R + 2SR. For example, if R = 95% and SR = 5%, the accuracy is 85 to 105%.

11.6.6 **Instrument blank: Instrument blank:** at the beginning of the analytical sequence and after the analysis of high concentration samples (examples: highest calibration standard or CV/ CCV), analyze an instrument blank to ensure no instrument contamination or memory effect has occurred (targets less than ½ LOQ level).

11.6.7 **Method blank:** after the analysis of the solvent blank and prior to the analysis of samples, analyze a method blank.

11.6.8 **Qualitative identification** standard: contains all available isomers (branched and linear) and is analyzed at the beginning of each analytical sequence to confirm the retention times of each linear and known branched isomer or isomer group.

11.6.9 **Instrument sensitivity (Note: optional):** this step is recommended as a follow-up step if the ISC does not meet criteria. Compare the NIS peak areas from the QC and field samples to the average area of the corresponding NIS on the calibration standards to check for possible bad injections of the NIS solution or loss of instrument sensitivity. The QC and field sample NIS areas should be within 50 to 200% of that in the standards. If the areas are low for all the samples and QC in the batch, it suggests a loss of instrument sensitivity while low areas on only some QC or field samples suggests possible bad injections of just those specific samples being affected.

11.7 **Instrument operation:** due to the complexities of analysis by LC-MS/MS and number of steps and screens involved, as of first revision of SOP refer to manufacturer's manuals, training files, and videos for instruction on instrument operation. A future appendix or separate SOP may be added with an outline of general operations for the LC-MS/MS set up and analysis.

11.7.1 ***Instrument equilibration prior to start of analysis:*** *Instrument must be equilibrated and stable prior to any analysis for consistent and reliable results. After turning instrument on, it will display "Ready" then run a solvent flush. After completion of the solvent flush wait until instrument pressure is approximately 500 to 600 bar and stable that means the system has come into equilibrium. If lower (below 500, try refreshing the acetonitrile).*

12. DATA ANALYSIS AND CALCULATIONS

12.1 **Qualitative determination and peak identification:** a native or isotopically labeled compound is identified in a standard, blank, sample, or QC sample when all of the criteria below are met.

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12.1.1 Peak responses must be at least three times the background noise level (signal to noise [S/N] 3:1). If the S/N ratio is not met due to high background noise, the laboratory must correct the issue (such as to perform instrument troubleshooting to check and if needed replacements or cleaning required). If the S/N ratio is not met but the background is low, then the analyte is to be considered a non-detect.

12.1.2 Target analyte, EIS analyte, and NIS analyte RTs must fall within ± 0.4 minutes of the predicted retention times from the midpoint standard of the ICAL or initial daily CV/ CCV, whichever was used to establish the RT window position for the analytical batch. The retention time window used must be of sufficient width to detect earlier-eluting branched isomers. For all method analytes with exact corresponding isotopically labeled analogs, method analytes must elute within ± 0.1 minutes of the associated EIS. During EMT development, all were well within 0.1 minute with some compounds having same RT. Refer to Table 9 at end of SOP for the Retention times during start-up.

12.1.3 The laboratory must follow the identification requirements specified by the client for the project if requested. In the event there are no project-specific requirements, the following general requirements apply. For concentrations at or above the method LOQ, the total (branched and linear isomer) quantification ion response to the total (branched and linear isomer) confirmation ion response ratio (DoD Ion Ratio) must fall within ± 50% of the ratio observed in the mid-point initial calibration standard. If project-specific requirements involve reporting sample concentrations below the LOQ (or ML), the response ratio must also fall within ± 50% of the ratio observed in the initial daily CV/ CCV.

The response of all isomers in the quantitative standards should be used to define ratio. In samples, the total response should include only the branched isomer peaks that have been identified in either the quantitative or qualitative standard. If standards (either quantitative or qualitative) are not available for purchase for branched isomers, only the linear isomer can be identified and quantitated in samples. The ratio requirement does not apply for PFBA, PFPeA, NMeFOSE, NEtFOSE, PFMPA, and PFMBA because suitable (not detectable or inadequate S/N) secondary transitions are unavailable.

12.1.4 If the field sample result does not all meet the criteria stated in Sections 12.1.2 through 12.1.3, and all sample preparation avenues (extract cleanup, sample dilution, etc.) have been exhausted, the result may only be reported with a data qualifier alerting the data user that the result could not be confirmed because it did not meet the method-required criteria and therefore should be considered an estimated value. If the criteria listed above are not met for the standards, the laboratory must stop analysis of samples and correct the issue. Notification of the project manager and supervisor also needed.

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12.2 **Quantitative determination:** concentrations of the target analytes are determined with respect to the extracted internal standard (EIS) which is added to the sample prior to extraction. The EIS is quantitated with respect to a non-extracted internal standard (NIS), as shown in Table 2 of the Draft 1633 method and also has all references in the LIMS analyte table as well as included in this SOP as Table 10, using the response ratios or response factors from the most recent multi-level initial calibration. Other equations may be used if the laboratory demonstrates that those equations produce the same numerical result as produced by the equations below:

For the native analytes:

$$Concentration\ (ng/L\ or\ ng/g) = \frac{Area_n\ M_l}{Area_l(\overline{RR}\ or\ \overline{RF})} \times \frac{1}{W_S}$$

Where:
Area $_n$ = the measured area of the Q1 m/z for the native (unlabeled) PFAS
Area $_l$ = the measured area at the Q1 m/z for the isotopically labeled PFAS (EIS). See note below.
M $_l$ = the mass of the isotopically labeled compound added (ng)
RR = Average response ratio used to quantify target compounds by the isotope dilution method
RF = Average response factor used to quantify target compounds by the extracted internal standard method
W_S = Sample volume (L) or weight (g)

For the “1”, EMT is using 4 ml final volume assumption based on draft method and single laboratory verification study based on the levels of targets added and final “true values”.

Note: For better accuracy, PFTrDA is quantitated using the average of the areas of labeled compounds 13C2-PFTeDA and 13C2-PFDoA.
And for the EIS analytes:

$$\text{Concentration (ng/L or ng/g)} = \frac{\text{Area}_{\text{l}}\ \text{M}_{\text{nis}}}{\text{Area}_{\text{nis}}\ \text{RF}_{\text{s}}} \times \frac{1}{\text{W}_{\text{s}}}$$

Where:
Area $_l$ = the measured area at the Q1 m/z for the isotopically labeled PFAS (EIS)
Area $_{nis}$ = the measured area of the Q1 m/z for the non-extracted internal standard (NIS)
M $_{nis}$= the mass of the added non-extracted internal standard (NIS) compound (ng)
WS = Sample volume (L) or weight (g)
RF $_s$ = Average response factor used to quantify the isotopically labeled compound by the non-extracted internal standard method

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Results for native compounds are recovery corrected by the method of quantification. Extracted internal standard (EIS) recoveries are determined similarly against the non-extracted internal standard (NIS) and are used as general indicators of overall analytical quality. EIS recoveries shall be 20 to 150% and NIS recoveries shall be 40 to 150%.

The instrument measures the target analytes as either their anions or neutral forms. The default approach for Clean Water Act uses of the method is to report the analytes in their acid or neutral forms, using the following equation to convert the concentrations. EMT reporting compounds as the acid form and using Wellington Laboratories standards that list the acid concentrations as needed if compound is in a salt or anion form. As the acid concentrations already in place as needed into the ICAL, the equation below is not needed, but included for reference and example.

$$C_{Acid} = C_{Anion} \times \frac{MW_{Acid}}{MW_{Anion}}$$

Where:
C_{Anion} = the analyte concentration in anion form
MW_{Acid} = the molecular weight of the acid form
MW_{Anion} = the molecular weight of the anion form

12.3 **Sample dilutions**

12.3.1 If the quant (Q1) area for any compound exceeds the calibration range of the system, dilute a subsample of the sample extract with the methanolic ammonium hydroxide and acetic acid solution by a factor no greater than 10x and adjust the amount of the NIS in the diluted extract, then analyze the diluted extract. If the responses for each EIS in the diluted extract meet the S/N and retention time requirements and the EIS recoveries from the analysis of the diluted extract are greater than 5%, then the compounds associated with those EISs may be quantified using isotope dilution. Use the EIS recoveries from the original analysis to select the dilution factor, with the objective of keeping the EIS recoveries in the dilution above that 5% lower limit (if the EIS recovery of the affected analyte in the undiluted analysis is 50%, then the sample cannot be diluted more than 10:1; if the EIS recovery of the affected analyte in the undiluted analysis is 30%, then the sample cannot be diluted more than 6:1). Adjust the compound concentrations, detection limits, and minimum levels to account for the dilution.

12.3.2 If the EIS responses in the diluted extract do not meet those S/N and retention time requirements, then the compound cannot be measured reliably by isotope dilution in the diluted extract. In such cases, take a smaller aliquot of any affected aqueous sample and dilute it to 500 mL with reagent water and analyze the diluted aqueous sample, or analyze a smaller aliquot of a solid sample. Adjust the compound concentrations, detection limits, and minimum levels to account for the dilution.

12.3.3 If a dilution greater than 10x is indicated, then must analyze a diluted aqueous sample or a smaller aliquot of a solid sample. Report recoveries of all associated EIS compounds for all field samples and QC standards. If a sample extract was diluted and analyzed, report the EIS recoveries from both the original analysis and the analysis of the dilution.

12.3.4 If the recovery of any isotopically labeled compound is outside of the acceptance limits (EIS 20 to 150% and NIS 40 to 150%), a diluted aqueous sample or smaller aliquot must be analyzed. If the recovery of any isotopically labeled compound in the diluted sample is outside of the normal range, the method does not apply to the sample being analyzed and the result may not be reported or used for permitting or regulatory compliance purposes. In this case, an alternative column could be employed to resolve the interference. If all cleanup procedures in this method and an alternative column have been employed and isotopically labeled compound recovery remains outside of the normal range, extraction and/or cleanup procedures that are beyond this scope of this method will be required to analyze the sample. Due to the "re-start" of the method required by a column change, the project manager and client are to be notified that the sample fails criteria to be analyzed by the current EMT method.

13. REPORTING

13.1 **Reporting of analytical results:** the data reporting practices described here are focused on EMT client monitoring needs. Analytes are reported in their acid forms using the acid concentrations given by the vender in the ICAL standards as needed and the abbreviated analyte names in Table 6.

13.2 In general, report results for aqueous samples in ng/L and results for solid samples in ng/g, on a dry-weight basis, and report the percent solids for each sample separately. Other units may be used if required in a permit or for a project. Report all QC data with the sample results.

13.3 **Reporting level:** unless specified otherwise by a regulatory authority or in a discharge permit, results for analytes that meet the identification criteria are reported down to the concentration of the ML established by the laboratory through calibration of the instrument. The ML level may be the lowest point of the calibration or the MDL multiplied by 3.18 and rounding. The EPA considers the terms "reporting limit," "quantitation limit," "limit of quantitation," and "minimum level" to be synonymous for this method.

13.3.1 Report a result for each analyte in each field sample or QC standard at or above the ML to 3 significant figures. Report a result for each analyte found in each field sample or QC

standard below the ML as "<ML," where ML is the concentration of the analyte at the ML, or as required by the regulatory/control authority or permit. EMT LIMS will be set to address.

13.3.2 Report a result for each analyte in a blank at or above the MDL to 3 significant figures. Report a result for each analyte found in a blank below the MDL as "<MDL," where MDL is the concentration of the analyte at the MDL, or as required by the regulatory/control authority or permit. EMT LIMS will be set to address.

13.3.3 Report a result for an analyte found in a sample or extract that has been diluted at the least dilute level at which the area at the quantitation m/z is within the calibration range (above the ML for the analyte and below the highest calibration standard) and with isotopically labeled compound recoveries within their acceptance criteria. This may require reporting results for some analytes from different analyses (report undiluted and diluted samples with diluted report for only affected compounds over ICAL initially).

13.3.4 Report recoveries of all associated EIS compounds for all field samples and QC standards.

13.4 Results from tests performed with an analytical system that is not in control (any required QC has outliers) must be documented and reported (as a qualifier on results and or case narrative), unless the failure is not required to be reported as determined by the regulatory/control authority (not a target compound of concern). Results associated with a QC failure cannot be used to demonstrate regulatory compliance. QC failures do not relieve a discharger or permittee of reporting timely results. If the holding time would be exceeded for a reanalysis of the sample, the regulatory/control authority should be consulted for disposition.

13.5 **LIMS general reporting procedure**

13.5.1 To start for LIMS, open preparation batch (Batch-Bench sheets) and enter the required data after selecting samples in the batch and proper container ID's. Specify the time of preparation, analyst, reagents, spiking solutions, assign QC references as needed after creating all needed batch QC.

13.5.2 Create the Sequence table by pulling in analyzed samples created in the Batch-Bench sheets, assign instrument, run times, assign internal standards Isotopes, and create all needed instrument QC. Organize sequence to match the run order.

13.5.3 Upload the quantitated sample results into LIMS through DataTool. If a sample has been diluted, make sure that the dilution factor is calculated and entered correctly in the DF column to modify the reporting limits.

13.5.4 Make sure that each sample has the correct references to the Method blanks, LCS, CCV, and the MS and MSD.

13.5.5 Review and ensure that the data recoveries and quality control meet the objectives of the method and SOP. Any uncertainties of outliers consult with supervisor on whether the data is reportable or re-runs are required.

13.5.6 Add the appropriate flags and comments to the sample data (if applicable and allowable according to the source method and this SOP). Possible flags may include (but are not limited to): method blank contamination levels and affected compounds (if elevated blank and non-detected samples only), recovery issues, or MS/MSD results indicating matrix effects. Refer to Quality control section as many qualifiers are not allowed until after re-runs are performed for confirmations or elevated compounds in the field blank with detects in field samples creates the need for a potential re-sampling event.

13.5.7 Refer to the most current version of EMT SOP # 261 for more details.

14. Method Performance

14.1 **Demonstration of Capability (DOC)** is performed for each combination of sample preparation and determinative methods. The DOC is performed prior to data reporting, annually, and whenever significant changes in instrumentation or personnel are made. Initial Demonstration of Capability (IDC) studies must be performed when a new analyst begins to perform the analysis.

14.2 **Continuing Demonstration of Capabilities**: Performed annually for each analyst for each test. The study is performed the same way as the Initial Demonstration of Capability studies.

14.3 **Method detection limit (MDL)/ Detection Limit (DL):** See also IDC section of SOP, detection limit is defined as the statistically calculated minimum concentration that can be measured with 99% confidence that the reported value is greater than zero. The DL is compound dependent and is dependent on extraction efficiency, sample matrix, fortification concentration, and instrument performance. Seven preserved, extracted LFB replicates are analyzed for the IMDL and then ongoing and MDL blanks are generated and reviewed according to the most recent version of EMT SOP 218.

14.4 **Limit of Detection/ Quantitation (LOD/LOQ)** verification studies must be performed quarterly for all analytes of interest as per the current Department of Defense Quality Systems Manual (QSM). The LOD study verifies method sensitivity and the LOQ study verifies method precision and bias. Refer to SOP #218 for more information.

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14.5 Method performance is detailed in the EMT Quality Assurance Manual, which includes sections on Method Startup, Reporting Limits, Method Detection Limits (MDLs), Method Control, and Initial Demonstrations of Capability (IDC)

15. POLLUTION PREVENTION AND WASTE MANAGEMENT

15.1 Collect expired standards and neat materials that will be lab packed and disposed every 3 months.

13.1 Spent solvent that is no longer reclaimable is collected and disposed of by a licensed waste handler and stored properly until disposal.

15.2 Refer to most current revision of EMT SOP #245 for sample and waste disposal and storage procedures.

16. DEVIATIONS

16.1 Where variances occur between Draft 1633 and the EMT procedure is predominantly in instrument optimization, conditions, mobile phase, and column choice based upon the manufacturer recommendations (Agilent); these are reflected in Section 17 tables (development conditions). Modifications were done during EMT method development and IDC studies were performed with the modifications in place to confirm the QC objectives of the source method were met. Method parameters involving sample collection and preservation, sample extraction, and quality control requirements were not changed from the draft method of 1633.

16.2 Methylene chloride, Acetone, and Aluminum foil left out as only needed in tissue processing and foil regarded to have issues for methods 533 and 537.1. EMT is currently not developing tissue analysis at time of this initial SOP writing and development for water and solid samples. May be a future undertaking.

16.3 In section 15.4.2 the draft method states to report values at or above ML to 3 significant figures and at or above MDL to 2 significant figures. The current EMT LIMS system has one setting for the analysis method, so EMT will set to 3 significant figures.

16.4 For water sample calculations, EMT is adding in an assumed final extract volume of 4 ml based on the spiked and final levels listed in the draft 1633 method and the single laboratory study values listed. This should also lessen the amount of correction by the isotopic dilution, giving better recoveries and baseline of results while also allowing better determinations of extraction issues by removing the larger “correction” needed without a final volume use in the calculation.

As EMT did Method 533 prior, the final 1 ml volume use gives the isotopes a much better baseline of recoveries to monitor the extraction process and calculate concise true values that matched the single laboratory values. Any slight variance is then covered by the isotopic dilution.

16.5 Acids- anions/ salts reporting: EMT is not using the conversions to acid for compounds in Section 12.2 as the standards purchased for use for ICAL and standards (from Wellington Laboratories) lists the acid concentrations as required for compounds in another form and the acid values are the values used for ICAL and standard true values.

16.6 EMT at start of soil sample extraction development used a TCLP rotator versus a nutating mixer to mix and homogenize the samples during the preparation and extraction process.

16.7 Initial soil studies had low recoveries for two of the deuterated compounds, NEtFOSA and NMeFOSA that could not be recovered above 20% with any evaporation technique changes or lowered batch temperatures due to compound volatility. At SPE cartridge manufacturer recommendations, the concentration/ evaporation of solids prior to SPE was removed and solid samples were diluted instead to lower the Methanol percent so the SPE cartridge would not be overwhelmed and catch all PFAS as required. The soils are basically being treated as the water matrix after the soil extraction and prior to the SPE. This treats the extracts like the water samples, eliminates glassware issues and some potential contamination sources. This process also reduces soil prep time significantly with recoveries that meet and exceed the draft method.

16.8 Solids drying temperature set for 103 to 105^0 C versus 110^0 C in draft method and also overnight versus 12 hours to match current TSS and % TS determinations following Standard methods 2540 so that samples can be batched together for better laboratory through-put. Also added sample storage and hold times for the solids analysis to match EMT current procedures as there were no specifics listed in draft 1633.

17. TABLES, DIAGRAMS, FLOW CHARTS, INSTRUMENT MAINTENANCE, TROUBLE SHOOTING

*17.1 **Instrument maintenance:** The instrument will receive an annual PM performed by the manufacturer with any other issues covered under contract. For the lab personnel, only a weekly cleaning of the AJS ESI interface with 2-propanol is necessary.*

NOTE: Conditions listed in tables below were used during the in-house method development and for the initial IDC studies to verify performance satisfies requirement of the source method.

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TABLE 1: LC MOBILE PHASE METHOD CONDITIONS

Time (minutes)	% 2 mM Ammonium acetate in 95:5 water/ acetonitrile:	% Acetonitrile:	Flow:
Initial (0)	98.0	2.0	0.4 mL/ min
0.2	98.0	2.0	0.4 mL/ min
4	70.0	30.0	0.4 mL/ min
7.0	45.0	55.0	0.4 mL/ min
9.0	25.0	75.0	0.4 mL/ min
12.0	5.0	95.0	0.4 mL/ min
13.4	98.0	2.0	0.4 mL/ min
13.8	98.0	2.0	0.4 mL/ min
14.0	98.0	2.0	0.4 mL/ min

TABLE 2: LC METHOD CONDITIONS

Parameter:	SOP based on Draft 1633 & Errata sheets and Agilent applications
LC:	Agilent 1290 Infinity II
Delay column:	Agilent Infinity PFC Delay column, 4.6 x 30 mm (Part number 5062-8100)
Analytical column:	Agilent RRHD Eclipse plus, C18, 2.1 x 100
Column Temperature:	40 C
Mobile phase:	Refer to Table 1
Run time (approximate):	16 minutes/ sample- 14.0 analytical, 2.0 post
Injection volume (uL):	2.0
Flow rate:	0.4 mL/ minute

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TABLE 3: ESI and MS/MS METHOD CONDITIONS

Parameter:	SOP based on Draft 1633 & Errata sheets and Agilent applications
MS/MS:	Agilent 6495C "QQQ"
Ionization mode/ Polarity:	Negative
Capillary needle voltage:	Positive 0 V, Negative 3000 V
Nozzle voltage:	Positive 0 V, Negative 0 V
Nebulizer pressure (psi):	25
N2 Drying gas/ Desolvation temperature:	250 C
N2 Drying/ Desolvation gas flow (in L/ minute):	5.0
Sheath gas temperature:	375 C
Sheath gas flow rate (in L/ minute):	11.0

TABLE 4: INITIAL DEMONSTRATION OF CAPABILITY (IDC) QUALITY CONTROL REQUIREMENTS

Requirement	Specification and Frequency	Acceptance Criteria
Initial Demonstration of Precision and Recovery (IPR)	For each matrix type, analyze four extracted replicate standards and a Method blank	Calculate the average percent recovery and RSD for target and EIS compounds. Compound recoveries must fall into corresponding ranges in Table 5 of Method 1633
Method Detection limit (MDL) studies	At start-up of method (IMDL) and then ongoing MDL and MDL blank studiesCalculate average recovery for replicates used in IDP.	Refer to most current version of EMT SOP 218. Matrix specific limit examples in Table 6 of Method 1633

TABLE 5: ONGOING QUALITY CONTROL REQUIREMENTS

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QC Requirements (1633 Draft and DoD QSM 5.4 Table B-24):	Specifications, Frequency, and Acceptance:
Ion Transitions (Precursor - Product)	If standard available containing branched and linear isomers for an analyte, the quant ion used must match the ion used from Table 2 in 1633 unless interferences render product ion unusable as quant ion.
Ion Ratio / Ion Response ratio	For all analytes detected in a field sample (Branched and Linear isomers). "I" Flag failures. Refer to SOP body text for details- Section 12.1.3
Mass Calibration	Annually and on as-needed basis- follow manufacturer's instruction
Mass Calibration Verification	After mass calibration performed and prior to analysis. Refer to SOP body text for details
Initial Calibration (ICAL)	Minimum 6 calibration standards for linear and 7 standards for quadratic. If RSD used, must be </= to 20% or RSE of the ICAL must be </= 20%. Also refer to SOP body test for more details
Retention Time (RT) window	After ICAL and at the beginning of analytical sequence. Use midpoint ICAL or opening CV/ CCV to verify RT within 0.4 minutes and isotopically labelled isotopes within 0.1 minute of associated EIS.
Qualitative Identification Standard (available Branched and Linear isomer RT window confirmation)	At start of analysis prior to field samples containing available branched and linear isomers to confirm RT, all analytes must be within 0.4 minutes of predicted RT from midpoint of ICAL or opening CV (CCV)
Bile salt Standards (TCDA, TCDCA, and TUDCA)	After ICAL and prior to samples, Required for all DoD matrix tyes, RT interference check, for PFOS, the bile salts peak(s) must fall out of PFOS RT window by at least 1 minute (for all PFOS isomers). If not, modify conditions until passes and recalibrate.
Extracted Internal Standard (EIS) Analytes (Surrogates)	All ICAL standards, batch QC and field samples. Recovery must be within 20 to 150% until in-house limits are created. In-house limit cannot be lower than 20%.

Non-extracted Internal Standard (NIS) analytes (Internal Standards)	All ICAL standards, batch QC and field samples. Areas MUST be greater than 30% of the averaged area of the ICAL standards. Limits set to 30 to 150% at time of development
Instrument Sensitivity Check (ISC) - at LOQ level	Daily, prior to analysis, within 30% recovery, for 90% of all compounds- outliers within 50% as interim for signal to noise ration of at least 3:1. At level of lowest ICAL standard.
Initial Calibration Verification (ICV)	After each ICAL and prior to analysis, **MUST** be second source, within 30% recovery, midpoint of ICAL
Calibration Verification (CV or CCV)	At the beginning and after every 10 samples, then to close analysis run. At mid-level of ICAL and must be within 30%.
Instrument Blank (IB, ICB, CCB)	Daily prior to analysis and following highest standard, following each CCV, and following any sample with analytes exceeding ICAL range. MUST be </= 1/2 LOQ
Method Blank (MB, BLK)	One per prep batch. For DoD: No detects can be> 1/2 LOQ, > 1/10 level of sample detects, or 1/10 of the regulatory limit- whichever is greater. For 1633: Must be less than ML (LOQ), less than 1/3 regulatory limit, or less than 10% of any sample detect.
Limit of Quantitation Verification (LLOPR) = Low Level LCS	Prior to analyzing samples, one per prep batch, recoveries within project limits or in-house limits if not provided. Starting limits are to be 40 to 150% until limits generated. Limit cannot go lower than 40%.
Ongoing Precision Recovery (OPR) = LCS	One per prep batch, recoveries within project limits or in-house limits if not provided. Starting limits are to be 40 to 150% until limits generated. In-house limit cannot go lower than 40%.
Matrix Duplicate (DUP)	For AFFF samples, not currently developed at time of SOP writing
Matrix Spike (MS/MSD)	One per prep batch (if project required) - needed by DoD work, recoveries must be within in-house LCS limits if project limits not provided. The RPD must be </= 30%

TABLE 6: Target PFAS compounds for this SOP by family (underlined CAS # to use- for the acid form of the target compounds):

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Perfluoroakyl carboxylic acids		
PFBA	375-22-4 / *45048-62-2*	**Target**
PFDA	335-76-2 / *73829-36-4*	**Target**
PFDoA or PFDoDA	307-55-1 / *171978-95-3*	**Target**
PFHpA	375-85-9 / *120885-29-2*	**Target**
PFHxA	307-24-4 / *92612-52-7*	**Target**
PFNA	375-95-1 / *72007-68-2*	**Target**
PFOA	335-67-1 / *45285-51-6*	**Target**
PFPeA	2706-90-3 / *45167-47-3*	**Target**
PFTA (or PFTeDA)	376-06-7 / *365971-87-5*	**Target**
PFTrDA	72629-94-8 / *862374-87-6*	**Target**
PFUdA, PFUnA or PFUndA	2058-94-8 / *196859-54-8*	**Target**
Perfluoroakyl sulfonic acids		
PFBS	375-73-5 / *45187-15-3*	**Target**
PFDoS or PFDoDS	79780-39-5 / *343629-43-6*	**Target**
PFDS	335-77-3 / *126105-34-8*	**Target**
PFHpS	375-92-8 / *146689-46-5*	**Target**
PFHxS	355-46-4 / *108427-53-8*	**Target**
PFNS	68259-12-1 / *474511-07-4*	**Target**
PFOS	1763-23-1 / *45298-90-6*	**Target**
PFPeS	2706-91-4 / *175905-36-9*	**Target**
Fluorotelomer sulfonic acids		
4:2FTS	757124-72-4	**Target**
6:2FTS	27619-97-2	**Target**
8:2FTS	39108-34-4	**Target**
Perfluorooctane sulfonamides		
NEtFOSA	*4151-50-2*	**Target**

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NMeFOSA	*31506-32-8*	**Target**
PFOSA	*754-91-6*	**Target**
Perfluorooctane sulfonamidoacetic acids		
NEtFOSAA	2991-50-6	**Target**
NMeFOSAA	2355-31-9	**Target**
Perfluorooctane sulfonamide ethanols		
NEtFOSE	*1691-99-2*	**Target**
NMeFOSE	24448-09-7	**Target**
Per- and Polyfluoroether carboxylic acids		
ADONA (or NaDONA)	919005-14-4	**Target**
HFPO-DA (HFPO Dimer and Ammonium salt = "**GenX**")	13252-13-6	**Target**
NFDHA	151772-58-6	**Target**
PFMBA	863090-89-5	**Target**
PFMPA	377-73-1	**Target**
Ether sulfonic acids		
11CL-PF3OUdS	763051-92-9	**Target**
9CL-PF3ONS	75642-58-1	**Target**
PFEESA	113507-82-7	**Target**
Fluorotelomer carboxylic acids		
3:3 FTCA	356-02-5	**Target**
5:3 FTCA	914637-49-3	**Target**
7:3 FTCA	812-70-4	**Target**
Internal Standards, Isotopes, and Surrogates		
d3-N-MeFOSAA	**2355-31-9**	**Extracted ISTD**
d3-NMeFOSA	**(no listing)**	**Extracted ISTD**
d5-NEtFOSAA	**2991-50-6**	**Extracted ISTD**
d5-NEtFOSA	**(no listing)**	**Extracted ISTD**

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d7-NMeFOSE	(no listing)	Extracted ISTD
d9-NEtFOSE	(no listing)	Extracted ISTD
13C2-4:2FTS	757124-72-4	Extracted ISTD
13C2-6:2FTS	27619-97-2	Extracted ISTD
13C2-8:2FTS	39108-34-4	Extracted ISTD
13C4- PFOA	(no listing)	Non-extracted ISTD
13C3-HFPO-DA	1352-13-6	Extracted ISTD
13C3-PFBS	375-73-5	Extracted ISTD
13C4-PFHpA	375-85-9	Extracted ISTD
13C5-PFHxA	307-24-4	Extracted ISTD
13C5-PFPeA	2706-90-3	Extracted ISTD
13C5- PFNA	(no listing)	Non-extracted ISTD
13C9-PFNA	375-95-1	Extracted ISTD
13C3- PFBA	(no listing)	Non-extracted ISTD
13C4-PFBA	375-22-4	Extracted ISTD
13C2-PFDA	335-76-2	Non-extracted ISTD
13C2-PFTeDA	(no listing)	Extracted ISTD
13C6-PFDA	(no listing)	Extracted ISTD
13C2-PFDoA	307-55-1	Extracted ISTD
13C2-PFHxA	307-24-4	Non-extracted ISTD
13C3-PFHxS	355-46-4	Extracted ISTD
13C8-PFOA	335-67-1	Extracted ISTD
13C8-PFOS	1763-23-1	Extracted ISTD
13C8-PFOSA	(no listing)	Extracted ISTD
13C4-PFOS	1763-23-1	Non-extracted ISTD
13C7-PFUnA	2058-94-8	Extracted ISTD
18O2- PFHxS	(no listing)	Non-extracted ISTD

TABLE 7: Precursor, Product, and Confirmation ions used for EMT development from Draft 1633:

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Target Compounds:	Precursor (Parent) Ion:	Product (Quant) Ion:	Confirmational Ion mass:	Typical Ion ratio:
Perfluoroakyl carboxylic acids				
PFBA	212.8	168.9	NA	NA
PFDA	512.9	469.0	219.0	5.50
PFDoA (or PFDoDA)	613.1	569.0	319.0	10.00
PFHpA	363.1	319.0	169.0	3.50
PFHxA	313.0	269.0	118.9	13.00
PFNA	463.0	419.0	219.0	4.90
PFOA	413.0	369.0	169.0	3.00
PFPeA	263.0	219.0	68.9	NA
PFTA (or PFTeDA)	713.1	669.0	168.9	6.00
PFTrDA	663.0	619.0	168.9	6.70
PFUnA (or PFUndA)	563.1	519.0	269.1	6.90
Perfluoroakyl sulfonic acids				
PFBS	298.7	79.9	98.8	2.10
PFDoS (or PFDoDS)	699.1	79.9	98.8	1.90
PFDS	599.0	79.9	98.8	1.90
PFHpS	449.0	79.9	98.8	1.70
PFHxS	398.7	79.9	98.9	1.90
PFNS	548.8	79.9	98.8	1.90
PFOS	498.9	79.9	98.8	2.30
PFPeS	349.1	79.9	98.9	1.80
Fluorotelomer sulfonic acids				
4:2FTS	327.1	307.0	80.9	1.70
6:2FTS	427.1	407.0	80.9	1.90
8:2FTS	527.1	507.0	80.8	3.00
Perfluorooctane sulfonamides				

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NEtFOSA	526.0	219.0	169.0	0.63
NMeFOSA	511.9	219.0	169.0	0.66
PFOSA	498.1	77.9	478.0	47.00
Perfluorooctane sulfonamidoacetic acids				
NEtFOSAA	584.2	419.1	526.0	1.20
NMeFOSAA	570.1	419.0	483.0	2.00
Perfluorooctane sulfonamide ethanols				
NEtFOSE	630.0	58.9	NA	NA
NMeFOSE	616.1	58.9	NA	NA
Per- and Polyfluoroether carboxylic acids				
ADONA (or NaDONA)	376.9	250.9	84.8	2.80
HFPO-DA ("**GenX**")	284.9	168.9	184.9	1.95
NFDHA	295.0	201.0	84.9	1.46
PFMBA	279.0	85.1	NA	NA
PFMPA	229.0	84.9	NA	NA
Ether sulfonic acids				
11CL-PF3OUdS	630.9	450.9	632.9-452.9	3.00
9CL-PF3ONS	530.8	351.0	532.8-353.0	3.20
PFEESA	314.8	134.9	82.9	9.22
Fluorotelomer carboxylic acids				
3:3 FTCA	241.0	177.0	117.0	1.70
5:3 FTCA	341.0	237.1	217.0	1.16
7:3 FTCA	441.0	316.9	336.9	0.69
Extracted Internal Standards				
d3-NMeFOSAA	573.2	419.0	NA	NA
d3-NMeFOSA	515.0	219.0	NA	NA
d5-NEtFOSAA	589.2	419.0	NA	NA
d5-NEtFOSA	531.1	219.0	NA	NA
d7-NMeFOSE	623.2	58.9	NA	NA

d9-NEtFOSE	639.2	58.9	NA	NA
13C2-4:2FTS	329.1	80.9	309	NA
13C2-6:2FTS	429.1	80.9	409	NA
13C2-8:2FTS	529.1	80.9	509	NA
13C3-HFPO-DA	286.9	168.9	184.9	NA
13C3-PFBS	302.1	79.9	98.9	NA
13C4-PFHpA	367.1	322.0	NA	NA
13C5-PFHxA	318.0	273.0	120.3	NA
13C5-PFPeA	268.3	223.0	NA	NA
13C9-PFNA	472.1	427.0	NA	NA
13C4-PFBA	216.8	171.9	NA	NA
13C2-PFTeDA	715.2	670.0	NA	NA
13C6-PFDA	519.1	474.1	NA	NA
13C2-PFDoA	615.1	570.0	NA	NA
13C3-PFHxS	402.1	79.9	98.8	NA
13C8-PFOA	421.0	376.0	NA	NA
13C8-PFOS	507.1	80.0	98.9	NA
13C8-PFOSA	506.1	77.8	NA	NA
13C7-PFUnA	570.0	525.1	NA	NA
Non-Extracted Internal Standards				
13C4- PFOA	417.1	172.0	NA	NA
13C5- PFNA	468.0	423.0	NA	NA
13C3- PFBA	216.0	172.0	NA	NA
13C2-PFDA	515.1	470.0	NA	NA
13C2-PFHxA	315.1	270.0	119.4	NA
13C4-PFOS	502.8	79.9	98.9	NA
18O2- PFHxS	403.0	83.9	NA	NA

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TABLE 8: Study results from Draft 1633 for MDL, ML, and half ML levels (not EMT derived), as example:

Compound:	Aqueous (ng/L):			Solid (ng/g):		
	MDL:	ML:	1/2 ML:	MDL:	ML:	1/2 ML:
PFBA	0.33	6.4	3.2	0.401	0.8	0.4
PFPeA	0.196	3.2	1.6	0.021	0.4	0.2
PFHxA	0.318	1.6	0.8	0.02	0.2	0.1
PFHpA	0.221	1.6	0.8	0.029	0.2	0.1
PFOA	0.302	1.6	0.8	0.037	0.2	0.1
PFNA	0.221	1.6	0.8	0.086	0.2	0.1
PFDA	0.333	1.6	0.8	0.031	0.2	0.1
PFUnA	0.264	1.6	0.8	0.033	0.2	0.1
PFDoA	0.379	1.6	0.8	0.059	0.2	0.1
PFTrDA	0.238	1.6	0.8	0.038	0.2	0.1
PFTeDA	0.264	1.6	0.8	0.032	0.2	0.1
PFBS	0.245	1.6	0.8	0.014	0.2	0.1
PFPeS	0.204	1.6	0.8	0.015	0.2	0.1
PFHxS	0.217	1.6	0.8	0.018	0.2	0.1
PFHpS	0.137	1.6	0.8	0.057	0.2	0.1
PFOS	0.327	1.6	0.8	0.067	0.2	0.1
PFNS	0.303	1.6	0.8	0.046	0.2	0.1
PFDS	0.334	1.6	0.8	0.04	0.2	0.1
PFDoS	0.179	1.6	0.8	0.038	0.2	0.1
4:2 FTS	2.281	6.4	3.2	0.282	0.8	0.4
6:2 FTS	3.973	6.4	3.2	0.116	0.8	0.4
8:2 FTS	1.566	6.4	3.2	0.225	0.8	0.4
PFOSA	0.227	1.6	0.8	0.068	0.2	0.1
NMeFOSA	0.196	1.6	0.8	0.049	0.2	0.1
NEtFOSA	0.585	1.6	0.8	0.038	0.2	0.1
NMeFOSA	0.586	1.6	0.8	0.03	0.2	0.1
NEtFOSAA	0.324	1.6	0.8	0.044	0.2	0.1

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NMeFOSE	1.191	16	8	0.203	2	1
NEtFOSE	1.022	16	8	0.247	2	1
HFPO-DA	0.406	6.4	3.2	0.136	0.8	0.4
ADONA	0.779	6.4	3.2	0.057	0.8	0.4
PFEESA	0.137	3.2	1.6	0.018	0.4	0.2
PFMPA	0.177	3.2	1.6	0.033	0.4	0.2
PFMBA	0.117	3.2	1.6	0.029	0.4	0.2
NFDHA	1.384	3.2	1.6	0.084	0.4	0.2
9CLPF3NS	0.871	6.4	3.2	0.038	0.8	0.4
11CLPF3UDS	0.819	6.4	3.2	0.071	0.8	0.4
3:3 FTCA	0.721	8	4	0.06	1	0.5
5:3 FTCA	5.066	40	20	0.363	5	2.5
7:3 FTCA	5.942	40	20	0.308	5	2.5

TABLE 9: Precursor and Product (Quant) ions used for EMT development and Optimizations (in order of Precursor ion) at EMT method start-up:

Target Compound	ISTD ?	Precursor Ion	MS1 Res	Product (Quant) Ion	MS2 Res	Frag (V)	CE (V)	Cell Acc (V)	RT (min)	RT Window	Polarity
PFBA	No	213	Unit/Enh (6490)	169	Unit/Enh (6490)	166	7	2	3.364	1	Negative
13C3-PFBA	Yes	216	Unit/Enh (6490)	172	Unit/Enh (6490)	166	7	2	3.364	1	Negative
13C4-PFBA	Yes	217	Unit/Enh (6490)	172	Unit/Enh (6490)	166	7	2	3.364	1	Negative
PFMPA	No	229	Unit/Enh (6490)	85	Unit/Enh (6490)	166	11	3	4.013	1	Negative
3-3 FTCA	No	241	Unit/Enh (6490)	177	Unit/Enh (6490)	166	4	2	4.33	1	Negative
3-3 FTCA	No	241	Unit/Enh (6490)	117	Unit/Enh (6490)	166	40	2	4.33	1	Negative
PFPeA	No	263	Unit/Enh (6490)	219	Unit/Enh (6490)	166	7	2	4.773	1	Negative
PFPeA	No	263	Unit/Enh (6490)	68.9	Unit/Enh (6490)	166	48	2	4.773	1	Negative
13C5-PFPeA	Yes	268	Unit/Enh (6490)	223	Unit/Enh (6490)	166	7	2	4.773	1	Negative
PFMBA	No	279	Unit/Enh (6490)	85	Unit/Enh (6490)	166	11	3	5.087	1	Negative

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HFPO-DA	No	285	Unit/Enh (6490)	185	Unit/Enh (6490)	166	19	5	5.93	1	Negative
HFPO-DA	No	285	Unit/Enh (6490)	169	Unit/Enh (6490)	166	3	5	5.93	1	Negative
13C3-HFPO-DA	Yes	287	Unit/Enh (6490)	185	Unit/Enh (6490)	166	19	5	5.929	1	Negative
13C3-HFPO-DA	Yes	287	Unit/Enh (6490)	169	Unit/Enh (6490)	166	3	5	5.929	1	Negative
NFDHA	No	295	Unit/Enh (6490)	201	Unit/Enh (6490)	166	4	5	5.572	1	Negative
NFDHA	No	295	Unit/Enh (6490)	85	Unit/Enh (6490)	166	24	5	5.572	1	Negative
PFBS	No	298.9	Unit/Enh (6490)	99	Unit/Enh (6490)	166	36	2	5.71	1	Negative
PFBS	No	298.9	Unit/Enh (6490)	80	Unit/Enh (6490)	166	43	2	5.71	1	Negative
13C3-PFBS	Yes	302	Unit/Enh (6490)	99	Unit/Enh (6490)	166	36	2	5.71	1	Negative
13C3-PFBS	Yes	302	Unit/Enh (6490)	80	Unit/Enh (6490)	166	43	2	5.71	1	Negative
PFHxA	No	313	Unit/Enh (6490)	269	Unit/Enh (6490)	166	7	2	5.664	1	Negative
PFHxA	No	313	Unit/Enh (6490)	119	Unit/Enh (6490)	166	23	2	5.664	1	Negative
PFEESA	No	314.9	Unit/Enh (6490)	135	Unit/Enh (6490)	166	23	5	6.089	1	Negative
PFEESA	No	314.9	Unit/Enh (6490)	83	Unit/Enh (6490)	166	19	5	6.089	1	Negative
13C2-PFHxA	Yes	315	Unit/Enh (6490)	270	Unit/Enh (6490)	166	7	2	5.663	1	Negative
13C2-PFHxA	Yes	315	Unit/Enh (6490)	119	Unit/Enh (6490)	166	23	2	5.663	1	Negative
13C5-PFHxA	Yes	318	Unit/Enh (6490)	273	Unit/Enh (6490)	166	7	2	5.663	1	Negative
13C5-PFHxA	Yes	318	Unit/Enh (6490)	120	Unit/Enh (6490)	166	23	2	5.663	1	Negative
4-2 FTSA	No	327	Unit/Enh (6490)	307	Unit/Enh (6490)	166	19	2	5.408	1	Negative
4-2 FTSA	No	327	Unit/Enh (6490)	81	Unit/Enh (6490)	166	39	2	5.408	1	Negative
13C2-4-2 FTSA	Yes	329	Unit/Enh (6490)	309	Unit/Enh (6490)	166	19	2	5.408	1	Negative
13C2-4-2 FTSA	Yes	329	Unit/Enh (6490)	81	Unit/Enh (6490)	166	39	2	5.408	1	Negative
5-3 FTCA	No	341	Unit/Enh (6490)	237	Unit/Enh (6490)	166	12	3	6.202	1	Negative
5-3 FTCA	No	341	Unit/Enh (6490)	217	Unit/Enh (6490)	166	28	3	6.202	1	Negative
PFPeS	No	348.9	Unit/Enh (6490)	99	Unit/Enh (6490)	166	36	2	6.465	1	Negative
PFPeS	No	348.9	Unit/Enh (6490)	80	Unit/Enh (6490)	166	40	2	6.465	1	Negative
PFHpA	No	363	Unit/Enh (6490)	319	Unit/Enh (6490)	166	7	2	6.327	1	Negative
PFHpA	No	363	Unit/Enh (6490)	169	Unit/Enh (6490)	166	19	2	6.327	1	Negative
13C4-PFHpA	Yes	367	Unit/Enh (6490)	322	Unit/Enh (6490)	166	7	2	6.327	1	Negative

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DONA	No	377	Unit/Enh (6490)	251	Unit/Enh (6490)	166	11	5	6.533	1	Negative
DONA	No	377	Unit/Enh (6490)	85	Unit/Enh (6490)	166	35	5	6.533	1	Negative
PFHxS	No	398.9	Unit/Enh (6490)	99	Unit/Enh (6490)	166	43	3	7.05	1	Negative
PFHxS	No	398.9	Unit/Enh (6490)	80	Unit/Enh (6490)	166	48	3	7.05	1	Negative
13C3-PFHxS	Yes	402	Unit/Enh (6490)	99	Unit/Enh (6490)	166	43	3	7.057	1	Negative
13C3-PFHxS	Yes	402	Unit/Enh (6490)	80	Unit/Enh (6490)	166	48	3	7.057	1	Negative
18O2-PFHxS	Yes	403	Unit/Enh (6490)	84	Unit/Enh (6490)	166	48	3	7.057	1	Negative
PFOA	No	413	Unit/Enh (6490)	369	Unit/Enh (6490)	166	7	2	6.878	1	Negative
PFOA	No	413	Unit/Enh (6490)	169	Unit/Enh (6490)	166	19	2	6.878	1	Negative
13C4-PFOA	Yes	417	Unit/Enh (6490)	172	Unit/Enh (6490)	166	19	2	6.874	1	Negative
13C8-PFOA	Yes	421	Unit/Enh (6490)	376	Unit/Enh (6490)	166	7	2	6.874	1	Negative
6-2 FTSA	No	427	Unit/Enh (6490)	407	Unit/Enh (6490)	166	27	2	6.646	1	Negative
6-2 FTSA	No	427	Unit/Enh (6490)	81	Unit/Enh (6490)	166	40	2	6.646	1	Negative
13C2-6-2 FTSA	Yes	429	Unit/Enh (6490)	409	Unit/Enh (6490)	166	27	2	6.646	1	Negative
13C2-6-2 FTSA	Yes	429	Unit/Enh (6490)	81	Unit/Enh (6490)	166	40	2	6.646	1	Negative
7-3 FTCA	No	441	Unit/Enh (6490)	337	Unit/Enh (6490)	166	11	4	7.477	1	Negative
7-3 FTCA	No	441	Unit/Enh (6490)	317	Unit/Enh (6490)	166	23	4	7.477	1	Negative
PFHpS	No	448.9	Unit/Enh (6490)	99	Unit/Enh (6490)	166	44	3	7.567	1	Negative
PFHpS	No	448.9	Unit/Enh (6490)	80	Unit/Enh (6490)	166	48	3	7.567	1	Negative
PFNA	No	463	Unit/Enh (6490)	419	Unit/Enh (6490)	166	8	2	7.362	1	Negative
PFNA	No	463	Unit/Enh (6490)	219	Unit/Enh (6490)	166	16	2	7.362	1	Negative
13C5-PFNA	Yes	468	Unit/Enh (6490)	423	Unit/Enh (6490)	166	8	2	7.362	1	Negative
13C9-PFNA	Yes	472	Unit/Enh (6490)	427	Unit/Enh (6490)	166	8	2	7.351	1	Negative
PFOSA	No	497.9	Unit/Enh (6490)	78	Unit/Enh (6490)	166	36	3	9.653	1	Negative
PFOSA	No	498.1	Unit/Enh (6490)	478	Unit/Enh (6490)	166	24	3	9.653	1	Negative
PFOS	No	498.9	Unit/Enh (6490)	99	Unit/Enh (6490)	166	48	4	8.044	2	Negative
PFOS	No	498.9	Unit/Enh (6490)	80	Unit/Enh (6490)	166	52	4	8.044	2	Negative
13C4-PFOS	Yes	503	Unit/Enh (6490)	99	Unit/Enh (6490)	166	48	4	8.044	1	Negative
13C4-PFOS	Yes	503	Unit/Enh (6490)	80	Unit/Enh (6490)	166	52	4	8.044	1	Negative

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13C8-PFOSA	Yes	506	Unit/Enh (6490)	78	Unit/Enh (6490)	166	36	3	9.652	1	Negative
13C8-PFOS	Yes	507	Unit/Enh (6490)	99	Unit/Enh (6490)	166	48	4	8.043	1	Negative
13C8-PFOS	Yes	507	Unit/Enh (6490)	80	Unit/Enh (6490)	166	52	4	8.043	1	Negative
N-MeFOSA	No	512	Unit/Enh (6490)	219	Unit/Enh (6490)	166	28	4	10.998	1	Negative
N-MeFOSA	No	512	Unit/Enh (6490)	169	Unit/Enh (6490)	166	28	4	10.998	1	Negative
PFDA	No	513	Unit/Enh (6490)	469	Unit/Enh (6490)	166	8	2	7.816	1	Negative
PFDA	No	513	Unit/Enh (6490)	219	Unit/Enh (6490)	166	16	2	7.816	1	Negative
13C2-PFDA	Yes	515	Unit/Enh (6490)	470	Unit/Enh (6490)	166	8	2	7.816	1	Negative
2H3-N-MeFOSA	Yes	515	Unit/Enh (6490)	219	Unit/Enh (6490)	166	28	4	10.997	1	Negative
13C6-PFDA	Yes	519	Unit/Enh (6490)	474	Unit/Enh (6490)	166	8	2	7.816	1	Negative
N-EtFOSA	No	526	Unit/Enh (6490)	219	Unit/Enh (6490)	166	28	4	11.386	1	Negative
N-EtFOSA	No	526	Unit/Enh (6490)	169	Unit/Enh (6490)	166	32	4	11.386	1	Negative
8-2 FTSA	No	527	Unit/Enh (6490)	507	Unit/Enh (6490)	166	31	2	7.588	1	Negative
8-2 FTSA	No	527	Unit/Enh (6490)	81	Unit/Enh (6490)	166	43	2	7.588	1	Negative
13C2-8-2 FTSA	Yes	529	Unit/Enh (6490)	509	Unit/Enh (6490)	166	31	2	7.588	1	Negative
13C2-8-2 FTSA	Yes	529	Unit/Enh (6490)	81	Unit/Enh (6490)	166	43	2	7.588	1	Negative
9Cl-PF3ONS	No	530.9	Unit/Enh (6490)	350.9	Unit/Enh (6490)	166	27	3	8.383	1	Negative
2H5-N-EtFOSA	Yes	531	Unit/Enh (6490)	219	Unit/Enh (6490)	166	28	4	11.374	1	Negative
9Cl-PF3ONS	No	532.8	Unit/Enh (6490)	353	Unit/Enh (6490)	166	28	3	8.383	1	Negative
PFNS	No	548.9	Unit/Enh (6490)	99	Unit/Enh (6490)	166	51	4	8.497	1	Negative
PFNS	No	548.9	Unit/Enh (6490)	80	Unit/Enh (6490)	166	59	4	8.497	1	Negative
PFUnDA	No	563	Unit/Enh (6490)	519	Unit/Enh (6490)	166	11	2	8.257	1	Negative
PFUnDA	No	563	Unit/Enh (6490)	269	Unit/Enh (6490)	166	19	2	8.257	1	Negative
13C7-PFUnDA	Yes	570	Unit/Enh (6490)	525	Unit/Enh (6490)	166	11	2	8.257	1	Negative
N-MeFOSAA	No	570	Unit/Enh (6490)	482.9	Unit/Enh (6490)	166	12	2	7.894	1	Negative
N-MeFOSAA	No	570	Unit/Enh (6490)	419	Unit/Enh (6490)	166	20	2	7.894	1	Negative
2H3-N-MeFOSAA	Yes	573	Unit/Enh (6490)	419	Unit/Enh (6490)	166	20	2	7.882	1	Negative
N-EtFOSAA	No	584	Unit/Enh (6490)	526	Unit/Enh (6490)	166	20	2	8.098	1	Negative
N-EtFOSAA	No	584	Unit/Enh (6490)	419	Unit/Enh (6490)	166	20	2	8.098	1	Negative

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2H5-N-EtFOSAA	Yes	589	Unit/Enh (6490)	419	Unit/Enh (6490)	166	20	2	8.097	1	Negative
PFDS	No	598.9	Unit/Enh (6490)	99	Unit/Enh (6490)	166	55	4	8.92	1	Negative
PFDS	No	598.9	Unit/Enh (6490)	80	Unit/Enh (6490)	166	63	4	8.92	1	Negative
PFDoDA	No	613	Unit/Enh (6490)	569	Unit/Enh (6490)	166	11	4	8.69	1	Negative
PFDoDA	No	613	Unit/Enh (6490)	319	Unit/Enh (6490)	166	20	4	8.69	1	Negative
13C2-PFDoDA	Yes	615	Unit/Enh (6490)	570	Unit/Enh (6490)	166	11	4	8.69	1	Negative
MeFOSE	No	616	Unit/Enh (6490)	59	Unit/Enh (6490)	166	11	5	10.874	1	Negative
2H7-MeFOSE	Yes	623.1	Unit/Enh (6490)	59	Unit/Enh (6490)	166	11	5	10.85	1	Negative
EtFOSE	No	630	Unit/Enh (6490)	59	Unit/Enh (6490)	166	44	5	11.252	1	Negative
11Cl-PF3OUdS	No	630.9	Unit/Enh (6490)	450.9	Unit/Enh (6490)	166	35	3	9.218	1	Negative
11Cl-PF3OUdS	No	632.9	Unit/Enh (6490)	452.9	Unit/Enh (6490)	166	32	3	9.218	1	Negative
2H9-EtFOSE	Yes	639.1	Unit/Enh (6490)	59	Unit/Enh (6490)	166	44	5	11.227	1	Negative
PFTrDA	No	663	Unit/Enh (6490)	619	Unit/Enh (6490)	166	11	4	9.091	1	Negative
PFTrDA	No	663	Unit/Enh (6490)	169	Unit/Enh (6490)	166	32	4	9.091	1	Negative
PFDoS	No	698.9	Unit/Enh (6490)	99	Unit/Enh (6490)	166	63	4	9.668	1	Negative
PFDoS	No	698.9	Unit/Enh (6490)	80	Unit/Enh (6490)	166	67	4	9.668	1	Negative
PFTDA	No	712.9	Unit/Enh (6490)	669	Unit/Enh (6490)	166	12	4	9.459	1	Negative
PFTDA	No	712.9	Unit/Enh (6490)	169	Unit/Enh (6490)	166	36	4	9.459	1	Negative
13C2-PFTDA	Yes	715	Unit/Enh (6490)	670	Unit/Enh (6490)	166	12	4	9.459	1	Negative

Figure 1: Final Bile salt spectra after modifications to mobile phase and LC conditions:

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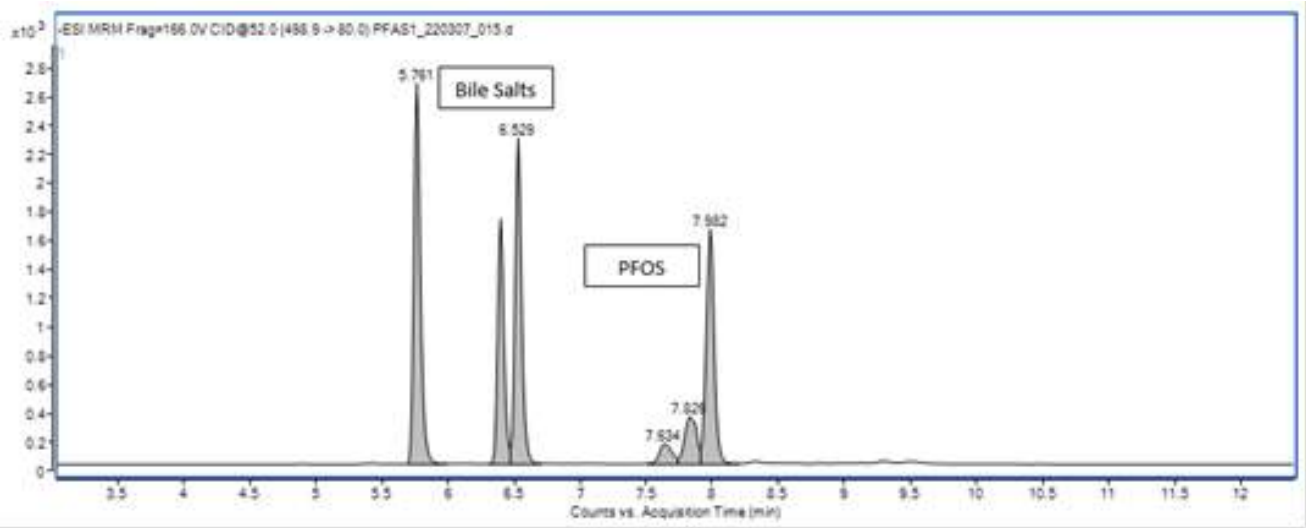

Table 10: Draft Method 1633 Table 2 to show reference compounds used as well as the ions- does not include errata sheet updates to draft method.

Target analyte	Example RT	Parent Ion	Quant Ion	Confirmation Ion	Typical Ion Ratio	Reference Compound
PFBA	1.96	212.8	168.9	NA	NA	$^{13}C_4$-PFBA
PFPeA	4.18	263.0	219.0	68.9	NA	$^{13}C_5$-PFPeA
PFHxA	4.81	313.0	269.0	118.9	13	$^{13}C_5$-PFHxA
PFHpA	5.32	363.1	319.0	169.0	3.5	$^{13}C_4$-PFHpA
PFOA	6.16	413.0	369.0	169.0	3.0	$^{13}C_8$-PFOA
PFNA	6.99	463.0	419.0	219.0	4.9	$^{13}C_9$-PFNA
PFDA	7.47	512.9	469.0	219.0	5.5	$^{13}C_6$-PFDA
PFUnA	7.81	563.1	519.0	269.1	6.9	$^{13}C_7$-PFUnA
PFDoA	8.13	613.1	569.0	319.0	10	$^{13}C_2$-PFDoA
PFTrDA[2]	8.53	663.0	619.0	168.9	6.7	avg. $^{13}C_2$-PFTeDA and $^{13}C_2$-PFDoA

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PFTeDA	8.96	713.1	669.0	168.9	6.0	$^{13}C_2$-PFTeDA
PFBS	4.79	298.7	79.9	98.8	2.1	$^{13}C_3$-PFBS
PFPeS	5.38	349.1	79.9	98.9	1.8	$^{13}C_3$-PFHxS
PFHxS	6.31	398.7	98.9	79.9	1.9	$^{13}C_3$-PFHxS
PFHpS	7.11	449.0	79.9	98.8	1.7	$^{13}C_8$-PFOS
PFOS	7.59	498.9	79.9	98.8	2.3	$^{13}C_8$-PFOS
PFNS	7.92	548.8	79.9	98.8	1.9	$^{13}C_8$-PFOS
PFDS	8.28	599.0	79.9	98.8	1.9	$^{13}C_8$-PFOS
PFDoS	9.14	699.1	79.9	98.8	1.9	$^{13}C_8$-PFOS
4:2FTS	4.67	327.1	307.0	80.9	1.7	$^{13}C_2$-4:2FTS
6:2FTS	5.81	427.1	407.0	80.9	1.9	$^{13}C_2$-6:2FTS
8:2FTS	7.28	527.1	507.0	80.8	3.0	$^{13}C_2$-8:2FTS
PFOSA	8.41	498.1	77.9	478.0	47	$^{13}C_8$-PFOSA
NMeFOSA	9.70	511.9	219.0	169.0	0.66	D_3-NMeFOSA
NEtFOSA	9.94	526.0	219.0	169.0	0.63	D_5-NEtFOSA
NMeFOSAA	7.51	570.1	419.0	483.0	2.0	D_3-NMeFOSAA
NEtFOSAA	7.65	584.2	419.1	526.0	1.2	D_5-N-EtFOSAA
NMeFOSE	9.57	616.1	58.9	NA	NA	D_7-NMeFOSE
NEtFOSE	9.85	630.0	58.9	NA	NA	D_9-NEtFOSE
HFPO-DA	4.97	284.9	168.9	184.9	1.95	$^{13}C_3$-HFPO-DA
ADONA	5.79	376.9	250.9	84.8	2.8	$^{13}C_3$-HFPO-DA
9Cl-PF3ONS	7.82	530.8	351.0	532.8→353.0	3.2	$^{13}C_3$-HFPO-DA
11Cl-PF3OUdS	8.62	630.9	450.9	632.9→452.9	3.0	$^{13}C_3$-HFPO-DA
3:3FTCA	3.89	241.0	177.0	117.0	1.70	$^{13}C_5$-PFPeA
5:3FTCA	5.14	341.0	237.1	217.0	1.16	$^{13}C_5$-PFHxA
7:3FTCA	6.76	441.0	316.9	336.9	0.69	$^{13}C_5$-PFHxA
PFEESA	5.08	314.8	134.9	82.9	9.22	$^{13}C_5$-PFHxA
PFMPA	3.21	229.0	84.9	NA	NA	$^{13}C_5$-PFPeA

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PFMBA	4.53	279.0	85.1	NA	NA	$^{13}C_5$-PFPeA
NFDHA	4.84	295.0	201.0	84.9	1.46	$^{13}C_5$-PFHxA
Extracted Internal Standards (EIS):						
$^{13}C_4$-PFBA	1.95	216.8	171.9	NA		$^{13}C_3$-PFBA
$^{13}C_5$-PFPeA	4.18	268.3	223.0	NA		$^{13}C_2$-PFHxA
$^{13}C_5$-PFHxA	4.80	318.0	273.0	120.3		$^{13}C_2$-PFHxA
$^{13}C_4$-PFHpA	5.32	367.1	322.0	NA		$^{13}C_2$-PFHxA
$^{13}C_8$-PFOA	6.16	421.1	376.0	NA		$^{13}C_4$-PFOA
$^{13}C_9$-PFNA	6.99	472.1	427.0	NA		$^{13}C_5$-PFNA
$^{13}C_6$-PFDA	7.47	519.1	474.1	NA		$^{13}C_2$-PFDA
$^{13}C_7$-PFUnA	7.81	570.0	525.1	NA		$^{13}C_2$-PFDA
$^{13}C_2$-PFDoA	8.13	615.1	570.0	NA		$^{13}C_2$-PFDA
$^{13}C_2$-PFTeDA	8.96	715.2	670.0	NA		$^{13}C_2$-PFDA
$^{13}C_3$-PFBS	4.78	302.1	79.9	98.9		$^{18}O_2$-PFHxS
$^{13}C_3$-PFHxS	6.30	402.1	79.9	98.8		$^{18}O_2$-PFHxS
$^{13}C_8$-PFOS	7.59	507.1	98.9	79.9		$^{13}C_4$-PFOS
$^{13}C_2$-4:2FTS	4.67	329.1	80.9	309.0		$^{18}O_2$-PFHxS
$^{13}C_2$-6:2FTS	5.82	429.1	80.9	409.0		$^{18}O_2$-PFHxS
$^{13}C_2$-8:2FTS	7.28	529.1	80.9	509.0		$^{18}O_2$-PFHxS
$^{13}C_8$-PFOSA	8.41	506.1	77.8	NA		$^{13}C_4$-PFOS
D_3-NMeFOSA	9.70	515.0	219.0	NA		$^{13}C_4$-PFOS
D_5-NEtFOSA	9.94	531.1	219.0	NA		$^{13}C_4$-PFOS
D_3-NMeFOSAA	7.51	573.2	419.0	NA		$^{13}C_4$-PFOS
D_5-NEtFOSAA	7.65	589.2	419.0	NA		$^{13}C_4$-PFOS
D_7-NMeFOSE	9.56	623.2	58.9	NA		$^{13}C_4$-PFOS
D_9-NEtFOSE	9.83	639.2	58.9	NA		$^{13}C_4$-PFOS
$^{13}C_3$-HFPO-DA	4.97	284.9	168.9	184.9		$^{13}C_2$-PFHxA
Non-Extracted Internal Standards						

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$^{13}C_3$-PFBA	1.95	216.0	172.0	NA
$^{13}C_2$-PFHxA	4.80	315.1	270.0	119.4
$^{13}C_4$-PFOA	6.16	417.1	172.0	NA
$^{13}C_5$-PFNA	6.99	468.0	423.0	NA
$^{13}C_2$-PFDA	7.47	515.1	470.1	NA
$^{18}O_2$-PFHxS	6.30	403.0	83.9	NA
$^{13}C_4$-PFOS	7.59	502.8	79.9	98.9

18. REFERENCES

16.1 EPA Draft Method 1633: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS. August 2021. EPA document 821-D-21-001.

16.2 EMT Quality Assurance Manual, Environmental Monitoring and Technologies, Inc., 509 N 3rd Ave, Des Plaines, IL 60016

16.3 Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories, version 5.4.

16.4 Agilent Application notes for PFAS analysis, Methods 537.1, and 533 as well as the PFAS MRM database software package.

16.5 Strategic Environmental Research and Development Program (SERDP) project ER19-1409, Single- Laboratory Validation Study of PFAS by Isotopic Dilution LC-MS-MS. January 2022.

16.6 The most current versions of EMT SOP's on TSS and PMoist (% TS) analysis: EMT-SOP-I-047 for TSS based on SM 2540 D and EMT-SOP-I-049 for PMoist/ % TS based on SM 2540 G.

19. REVISION HISTORY

19.1 This is the first revision of this SOP (Revision 0 for EMT SOP-O-1633).

19.2 *EPA-SOP-0-1633 Revision 1: Sections 16.7, 11.7.1, 17.1, and 19.2 were added, clarifications or additions made to sections 3.8, 6.2, 6.22.1, 6.22.4, 8.3.1, 11.3.8 (revised for new procedure),*

and 11.4.7.2 (evaporator tube to sample bottle), section 11.3.7 last sentence removed and sections 11.3.9 and 11.3.10 removed (soil evaporative steps). Note after 8.4 added for solids analysis storage and hold times with Section 16.6 for solids EMT SOP guidance on performing analysis. Notes added to 6.22.3 for 6:2 FTS contamination and 11.1.1 to refer to EMT SOP for full solids procedures and changed drying time and temperatures to match current practices. Deviation 16.8 added to reflect EMT solids procedures from 1633 draft for through-put and match current methods. Section 6.24 oven temperatures edited to reflect EMT procedures.

Appendix A - Sample Pre-screening Instructions

All samples that are known or suspected to contain high levels of PFAS or have no historical data should be pre-screened using the following procedure to avoid system contamination. As EMT starts out analyzing samples, there will not be any historical data to rely upon, so all samples must be pre-screened to protect contaminating the instrument. These are example procedures using smaller sample aliquots spiked with EIS and NIS and no clean up procedure. Other pre-screening procedures may be used to safely estimate levels while minimizing risk of instrument contamination.

Aqueous Samples

1. Weight out 10 (±0.1) g of sample into a 50-mL centrifuge tube.
2. Add 50 uL of EIS and NIS to the sample and vortex to mix.
3. Filter 1 mL of the sample through 0.2 um membrane filter into a micro vial. Sample is ready for instrumental analysis; simulates a 50 time “dilution” of a 500 ml sample.

Solid Samples

1. Weigh 1.0 (±0.1) g sample into 50-mL polypropylene centrifuge tubes.
2. Add 20 mL of 0.3% methanolic ammonium hydroxide. Vortex and mix on a shaker table (or equivalent) for 10 minutes. Allow to settle and/or centrifuge to produce a clear extract.
3. Filter using a Single Step® filter vial:
    a. Add 20 uL of EIS to a clean Single Step® filter vial (chamber) or equivalent.

b. Add 400 uL of clear extract from step 2 (e.g., by adding extract until it reaches the fill line), carefully vortex to mix.
c. Use filter/plunger part and filter.

4. Transfer 30 uL of filtrate to a ~300 uL polypropylene micro-vial and dilute to 300 uL with 0.3% methanolic ammonium hydroxide. Add NIS to the filtrate.
5. The extract is now a 10x dilution.
6. Sample is ready for instrumental analysis.

Calculate results using the equivalent sample weight computed as follows:

$$\text{Equivalent Weight} = \text{Sample weight (g)} \times \frac{0.4 \text{ ml}}{20 \text{ ml}}$$

Note that the EIS concentration in the diluted portion is 0.5x the level in the regular analysis for solid samples.

EMT may make modifications on screening depending on sample levels received to avoid instrument contamination and to add the EIS at a later point to save on the isotopic standards and help reduce costs and PFAS wastes. This would not have any effect on the actual sample analysis or reported data.

Appendix B - Aqueous Sample Subsampling Instructions

Warning: Because some target analytes may be stratified within the sample or adhere to the walls of the sample container, subsampling may only be done on a project-specific basis. Subsampling has been shown to increase uncertainty in PFAS analysis, especially on foaming samples.

If a reduced sample size is required, transfer a weighed subsample using the following subsampling procedure to a 60 mL HDPE bottle (or appropriately sized HDPE bottle) and dilute to approximately 60

509 N. 3rd Ave. Des Plaines, IL 60016

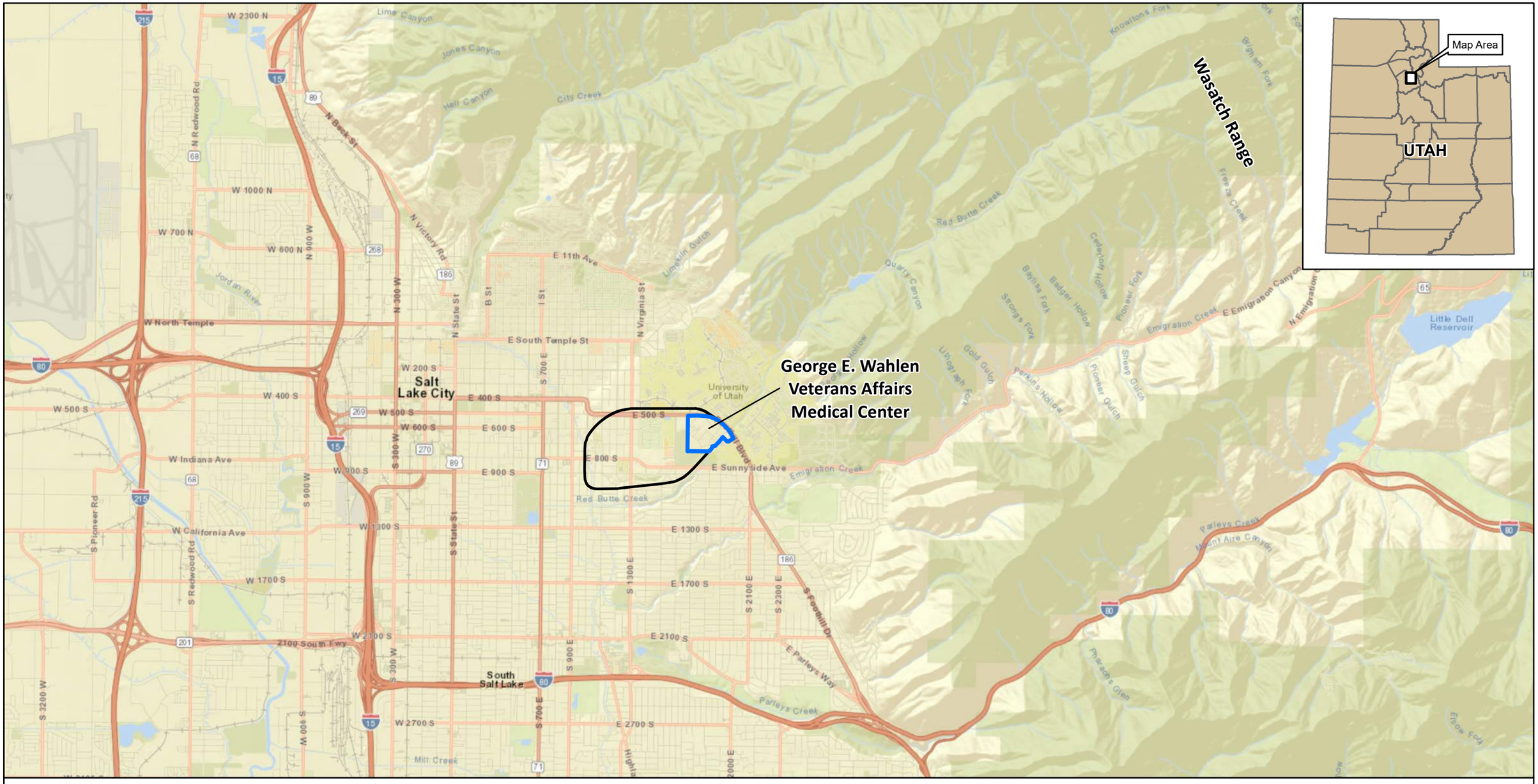
Reviewed Date: 10/5/2023 1:28:19 PM10/5/2023 1:28:19 PM10/5/2023 1:28:19 PM

Date Published: 10/5/2023 1:30:18 PM

mL using reagent water. This container is now considered the “sample bottle” and will need entry to LIMS for Batch selection.

1. Gently invert sample 3 to 4 times being careful to avoid foam formation and subsample Immediately - do not let stand.
2. If foam forms and more than 5 mL required – pour sample, avoiding any foam.
3. If foaming forms and a volume less than 5 mL is required – pipette from ½ cm below the foam.
4. If no foam forms – pour or pipette based on volume required.

Appendix C



Legend

George E. Wahlen Veterans Affairs Medical Center Boundary

Study Area Boundary

Notes:
OU = operable unit
PCE = tetrachloroethene

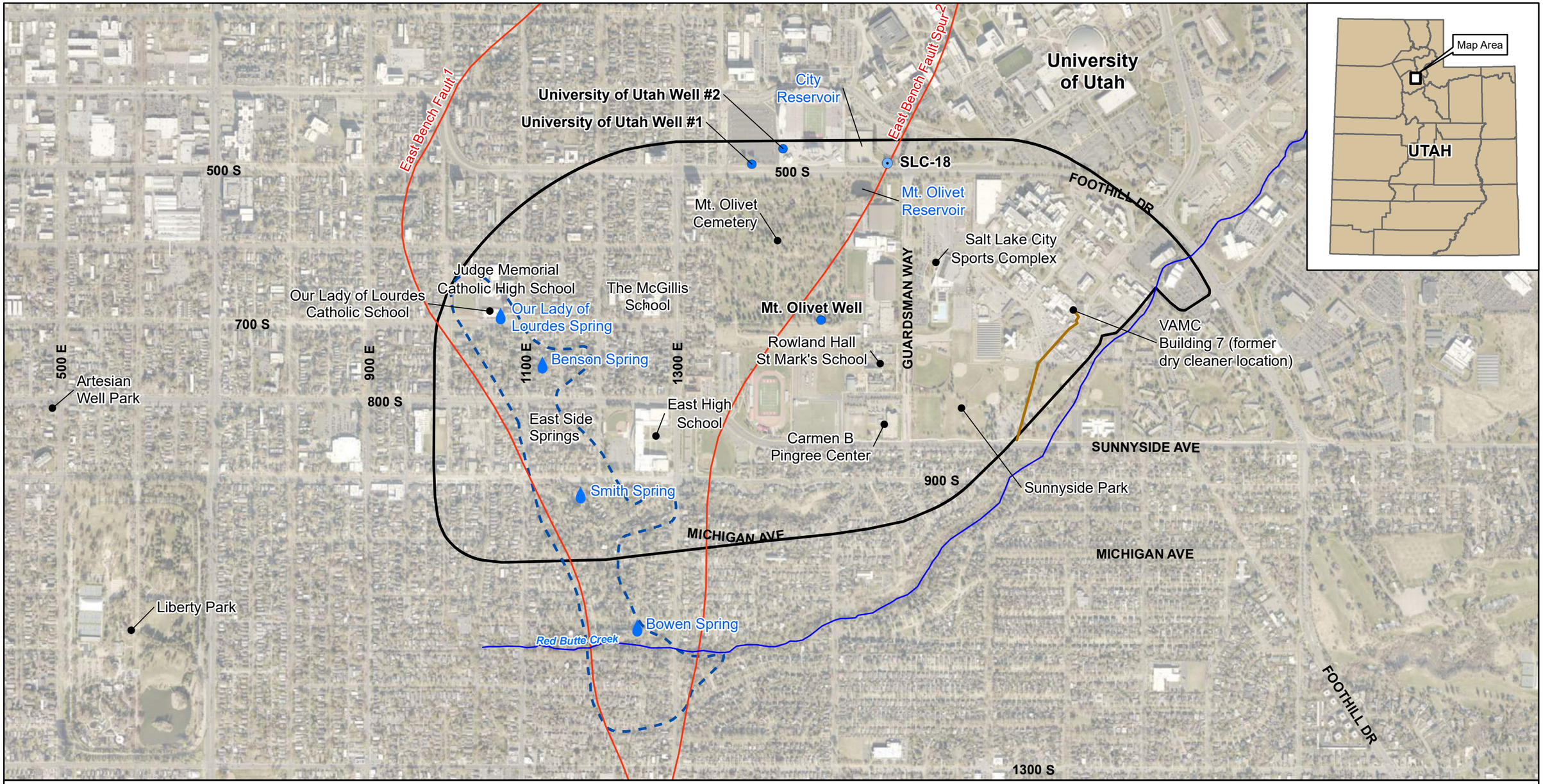
Figure 1-1
Site Location Map

N

0 0.5 1 Miles

CDM Smith

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah



Legend

- Drinking Water Supply Well
- Irrigation Well
- Spring Location
- Red Butte Creek
- Sewer Line
- Fault Line
- Study Area Boundary
- Springs Area

Notes:
(1) Location of University of Utah Well #1 is approximate; well is located less than 100 feet east of Fountain of Ute.

OU = operable unit
PCE = tetrachloroethene
VAMC = George E. Wahlen Veterans Affairs Medical Center

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N

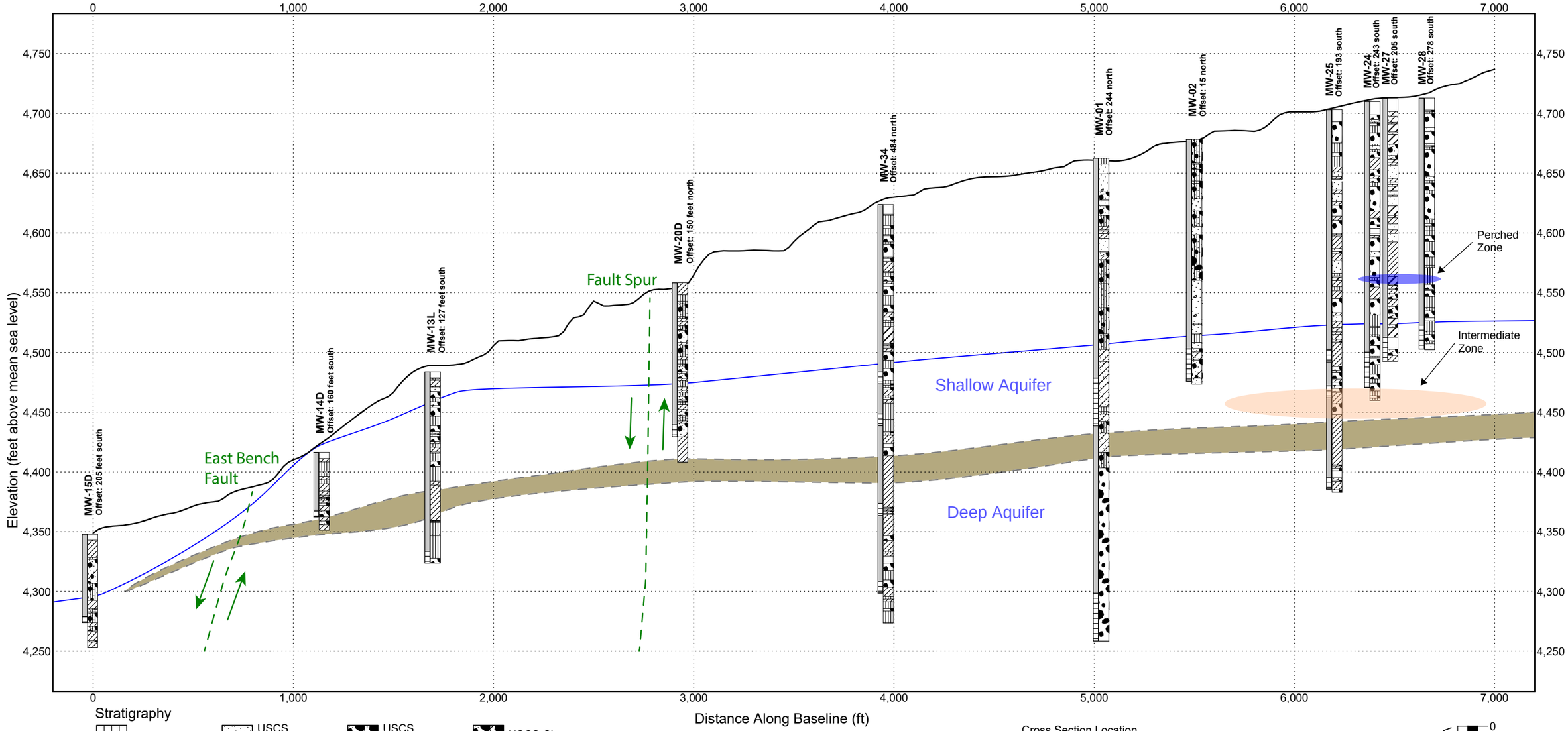
0 500 1,000 Feet

Figure 1-2
Site Features

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2021\RI_2021\Fig1-2_SiteFeatures.mxd WAGNERA 10/15/2021

Southwest A — **Northeast** A'



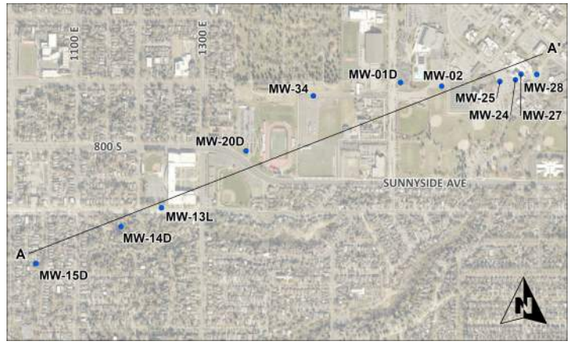
Stratigraphy

- USCS Silt
- USCS Well-graded Sand
- USCS Well-graded Gravel
- USCS Clayey Gravel
- USCS Silty Gravel
- USCS Low Plasticity Clay
- USCS Poorly-graded Sand
- USCS Silty Sand
- USCS Clayey Sand
- USCS Poorly-graded Gravel
- USCS Well-graded Sand with Silt
- USCS High Plasticity Clay

Well Construction Schematic

- Casing
- Screened Interval
- Semi-Confining Unit
- Fault
- Groundwater Elevation (3/15/21)
- Perched Zone
- Indicates direction of movement
- Intermediate Zone

Cross Section Location



0 — 502 Horizontal Scale (feet)

Vertical Scale (feet) 0 — 84

Vertical Exaggeration: 6x

Figure 4-2
Geologic Cross Section

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah

CDM Smith

CAYUGA CROSS SECTION 1-1 SLC VA PLUME SCTN_061021_JCM.GPJ SLC VA PLUME DRAFT_031121.GPJ 6/10/21 REV.

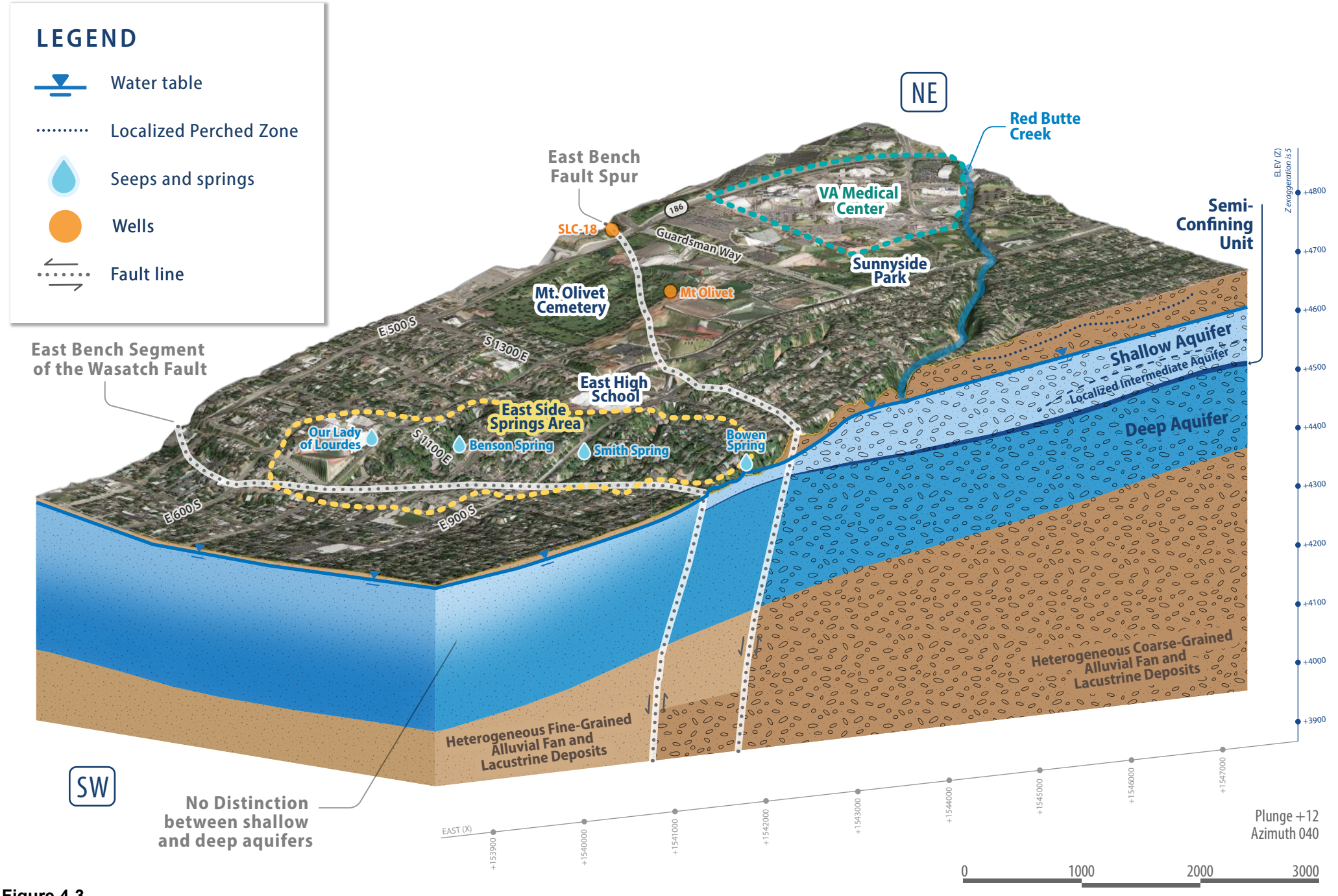
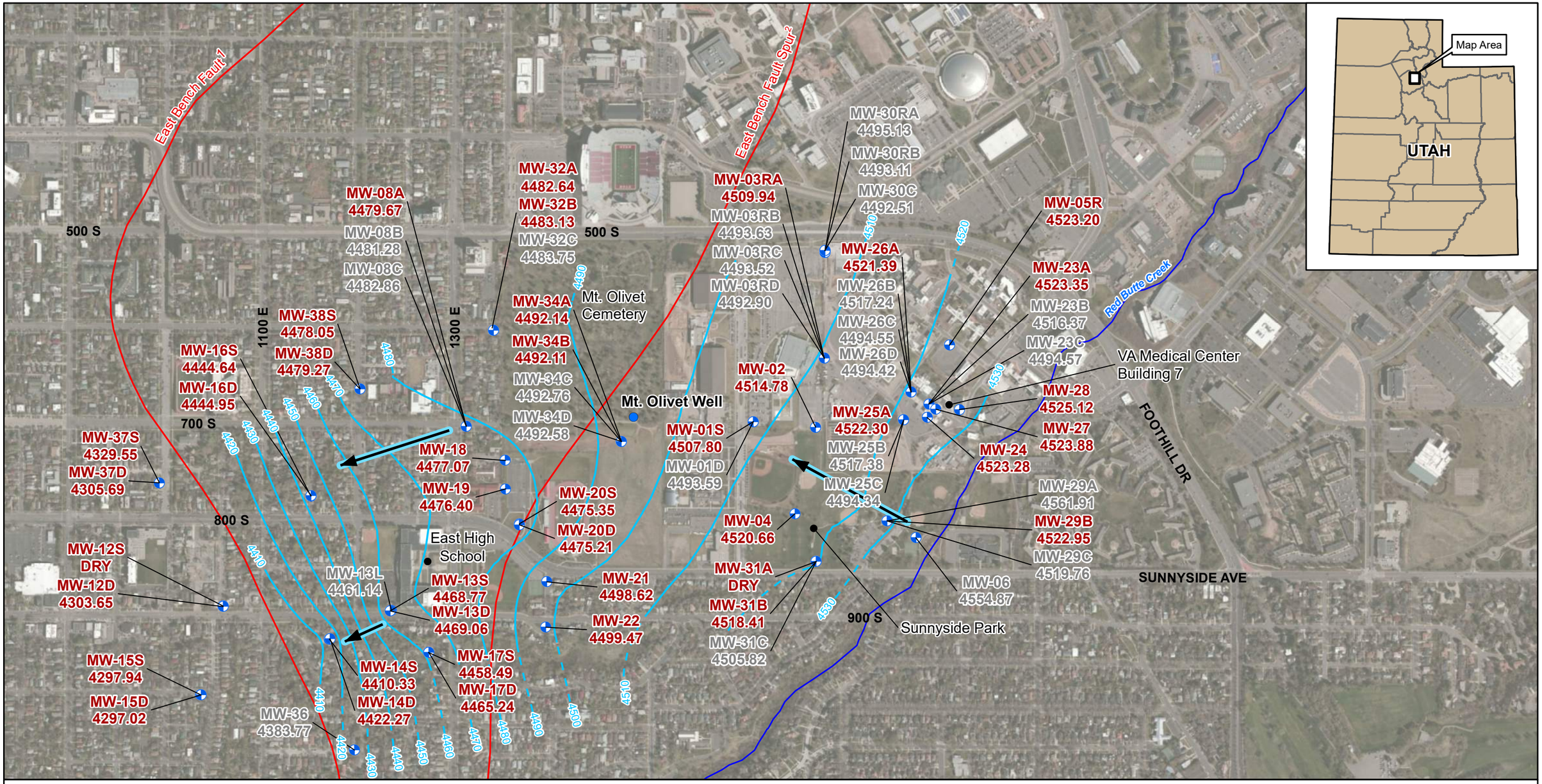


Figure 4-3
Conceptual Diagram of Topography, Surface Features, Geology, and Hydrogeology



Legend

- Monitoring Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Groundwater Contour
- Dashed Line - Inferred Extent
- Groundwater Flow Direction

Notes:
1. All ground surface elevations in feet amsl
2. Measurements taken December 6th through 8th 2020.
3. Water levels shown in grey were not used for the generation of the potentiometric contours and are shown for information only
4. Water level values for MW-14S/D and MW-17S/D were averaged during contouring.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

amsl = above mean sea level
OU = operable unit
VAMC = George E. Wahlen Veterans Affairs Medical Center

N W E S

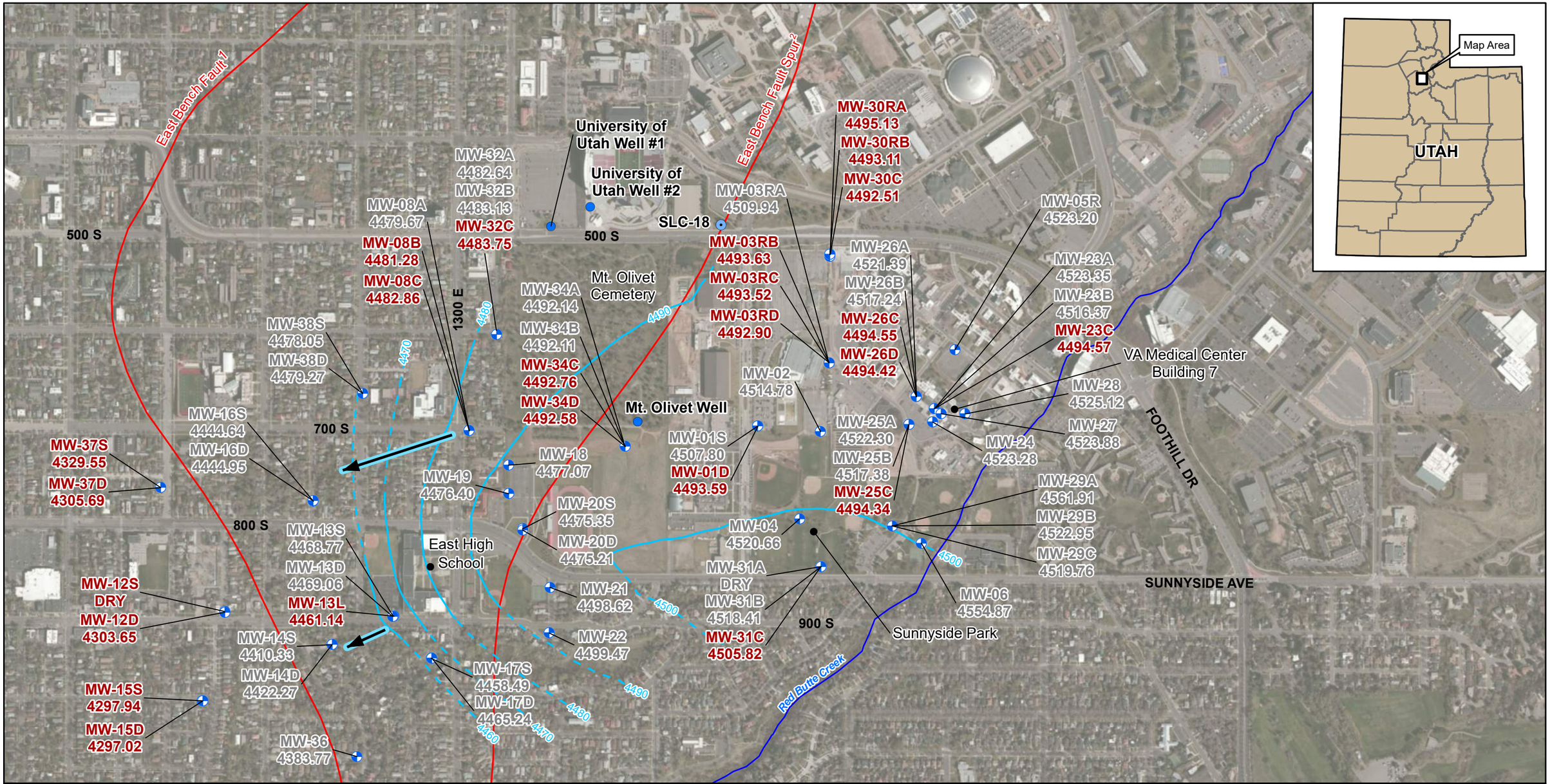
0 500 1,000 Feet

CDM Smith

Figure 4-4
Potentiometric Groundwater Surface Map - Shallow Aquifer

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2021\RI_2021\Fig4-4_GW_Shallow_Aquifer.mxd WAGNERA 9/24/2021 8:41:23 AM



Legend

- Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Groundwater Contour
- Dashed Line - Inferred Extent
- Groundwater Flow Direction

Notes:
1. All ground surface elevations in feet amsl
2. Measurements taken December 6th through 8th 2020.
3. Water levels shown in grey were not used for the generation of the potentiometric contours and are shown for information only

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

amsl = above mean sea level
OU = operable unit
VAMC = George E. Wahlen Veterans Affairs Medical Center

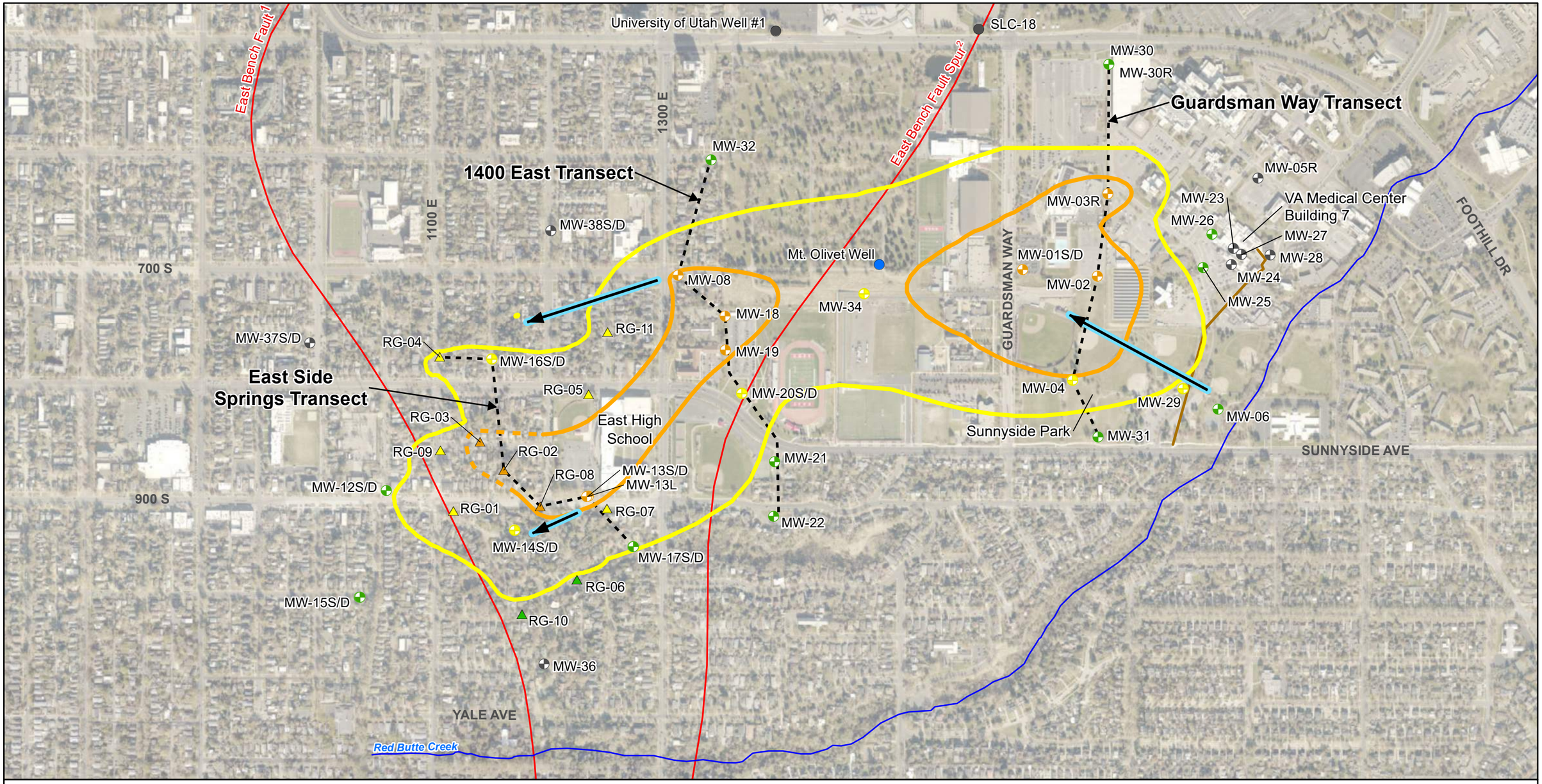
N W E S

0 500 1,000 Feet

Figure 4-5
Potentiometric Groundwater Surface Map - Deep Aquifer

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2021\RI_2021\Fig4-5_GW_Deep_Aquifer.mxd WAGNERA 9/24/2021 8:51:43 AM



Legend

- Monitoring Well
- Production/Irrigation Well
- Residential Groundwater Well
- Red Butte Creek
- Monitoring Well Transect Line
- Sewer Line
- Fault Line
- Groundwater Flow Direction

PCE Concentration

- = Non-detect
- = < 5 µg/L
- = 5 - 50 µg/L
- = > 50 µg/L

PCE Isoconcentration Contours

- 5 µg/L
- 50 µg/L

Dashed Line - Inferred Extent

Notes:

1. Plume contours were developed using Leapfrog 3-dimensional visualization software to interpolate the most recent data from each sampling location. The contours represent a top-down view of the 3-dimensional extent of the plume as interpreted in the Leapfrog software.
2. The color coded PCE concentration at each location is based on the most recent result.

OU = operable unit
PCE = tetrachloroethene
µg/L = micrograms per liter

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N W E S

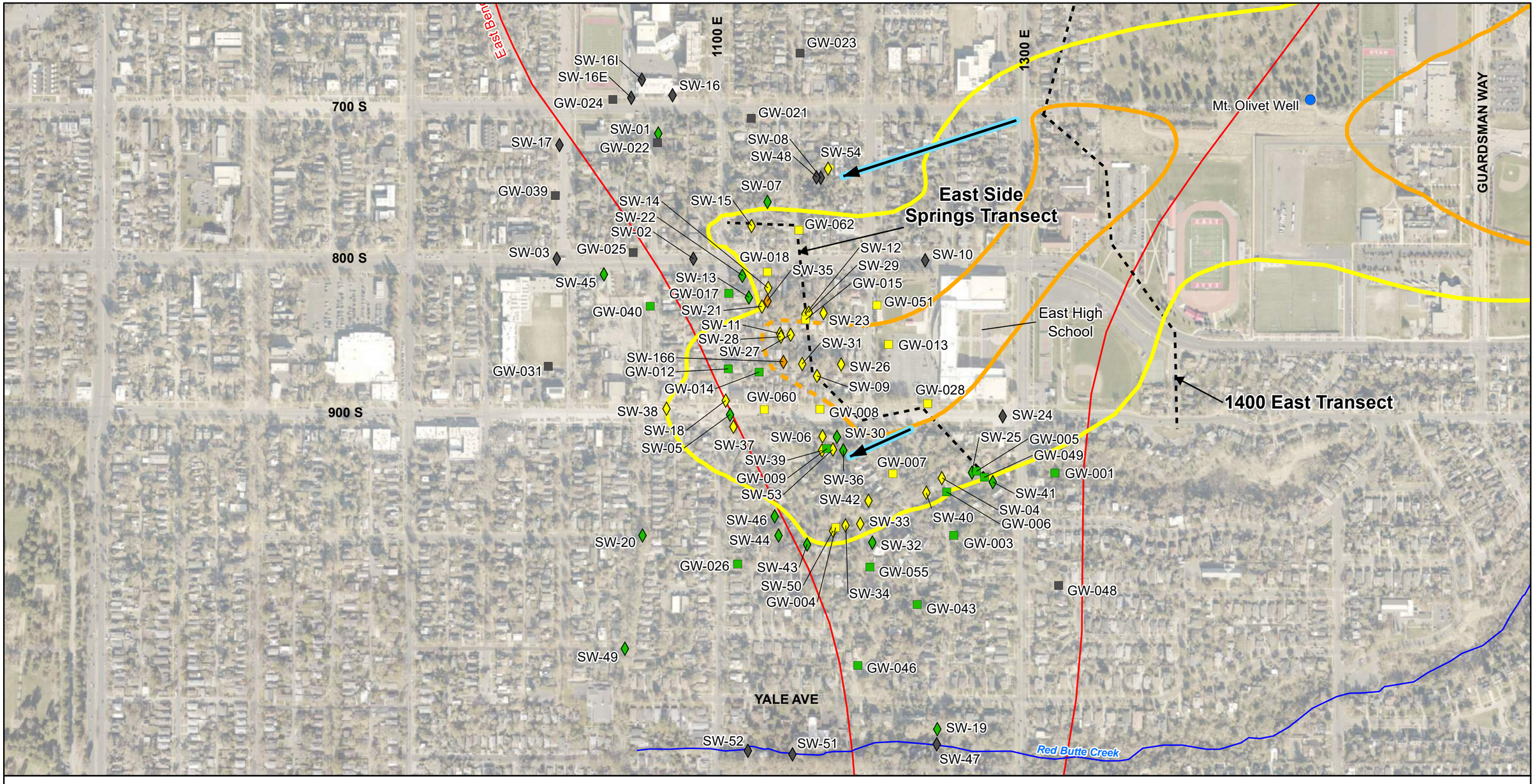
0 250 500 Feet

Figure 5-4A
Tetrachloroethene in Groundwater
Monitoring Wells

CDM Smith

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2021\RI_2021\Fig5-4A_PCE_in_Groundwater-MW.mxd WAGNERA 9/24/2021 9:19:59 AM



Legend

- Groundwater Location
- Surface Water Location
- Irrigation Well
- Red Butte Creek
- Monitoring Well Transect Line
- Sewer Line
- Fault Line
- Groundwater Flow Direction

PCE Concentration

- = Non-detect
- = < 5 µg/L
- = 5 - 50 µg/L
- = > 50 µg/L

PCE Isoconcentration Contours

- 5 µg/L
- 50 µg/L

Dashed Line - Inferred Extent

Notes:

1. Plume contours were developed using Leapfrog 3-dimensional visualization software to interpolate the most recent data from each sampling location. The contours represent a top-down view of the 3-dimensional extent of the plume as interpreted in the Leapfrog software.
2. The color coded PCE concentration at each location is based on the most recent result.

OU = operable unit
PCE = tetrachloroethene
µg/L = micrograms per liter

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N W E S

0 250 500 Feet

CDM Smith

Figure 5-4B
Tetrachloroethene in Groundwater
Shallow Groundwater and Surface Water

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2021\RI_2021\Fig5-4B_PCE_in_GW_ShallowGW_SW.mxd WAGNERA 8/6/2021 9:17:47 AM

Southwest **B** — **Northeast** **B'**

Elevation (feet above mean sea level)

Distance Along Baseline (ft)

Groundwater contamination surfaces in the ESS area

Groundwater contamination migrates to the southwest

Groundwater to vapor contaminant migration

Potential for vapor intrusion

Potential for vapor intrusion

Potential for vapor intrusion

Soil contamination leaches into groundwater

Soil to vapor migration

Possible surface releases on VAMC Campus

Source material infiltration

Releases along sanitary sewer

Lateral migration along boundaries

Perched zone

East Bench Fault

Fault Spur

MW-15 MW-14 RG-08 MW-13 MW-08 MW-34 MW-01 MW-02 MW-03R MW-25 MW-26

0.34J 0.16J 33 6 58 25 55 51 58 43 1U 1U 1U 36 16 1U 170 1U 230 25 220 6.1 1U 1.6 1U 1U 1.1 0.79J 1U 50 5

Stratigraphy

- USCS Silt
- USCS Well-graded Sand
- USCS Well-graded Gravel
- USCS Clayey Gravel
- USCS Silty Gravel
- USCS Low Plasticity Clay
- USCS Poorly-graded Sand
- USCS Silty Sand
- USCS Clayey Sand
- USCS Poorly-graded Gravel
- USCS Well-graded Sand with Silt
- USCS High Plasticity Clay

Well Construction Schematic

- Casing
- Screened Interval

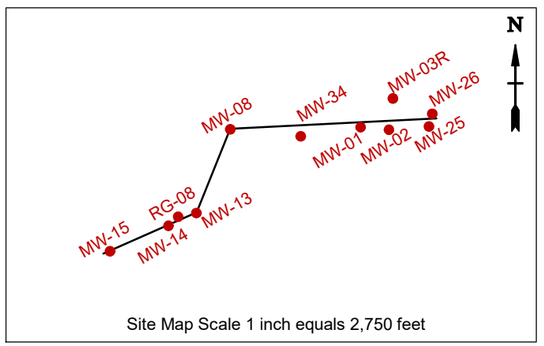
- Semi-Confining Unit
- Fault
- Groundwater Elevation (3/15/21) (RG Wells measured on 4/15/21)
- Perched Zone

51 Tetrachloroethene in Groundwater (µg/L)
Monitoring Well Data - Q1-2021
RG Well Data - April 2021
* - Collected June 19, 2020
J - Result is estimated
U - Not detected at associated value

- Tetrachloroethene Isoconcentration Contour (µg/L) >5µg/L
- Tetrachloroethene Isoconcentration Contour (µg/L) >50µg/L

MW-13, MW-14, and MW-15 are well clusters with each well installed in its own borehole

Cross Section Location



Site Map Scale 1 inch equals 2,750 feet

0 538 Horizontal Scale (feet)

Vertical Scale (feet) 0 109

Vertical Exaggeration: 5x

Figure 6-1
Conceptual Site Model

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, UT

CDM Smith

CAYUGA CROSS SECTION 1-1 SLC VA PLUME SCTN_062421.GPJ SLC VA PLUME DRAFT_031121.GPJ 7/6/21 REV.

PCE Statistical Trends

- Increasing
- Probably Increasing, >50% ND
- Stable
- Stable, >50% ND
- Decreasing
- Probably Decreasing, >50% ND
- No Trend
- No Trend, >50% ND
- Insufficient Detections for Statistical Analysis
- Multiple Screen Intervals
- Monitoring Well
- Residential Groundwater Well
- Irrigation Well
- Monitoring Well Transect Line
- Red Butte Creek

Notes:
1. Plume contours were developed using Leapfrog 3-dimensional visualization software to interpolate the most recent data from each sampling location. The contours represent a top-down view of the 3-dimensional extent of the plume as interpreted in the Leapfrog software.
2. For wells with multiple screening intervals, see well ID label for statistical trend.

PCE Isoconcentration Contours

- 5 µg/L
- 50 µg/L
- Dashed Line - Inferred Extent

OU = operable unit
RI = remedial investigation
PCE = tetrachloroethene
MW = monitoring well

N W E S

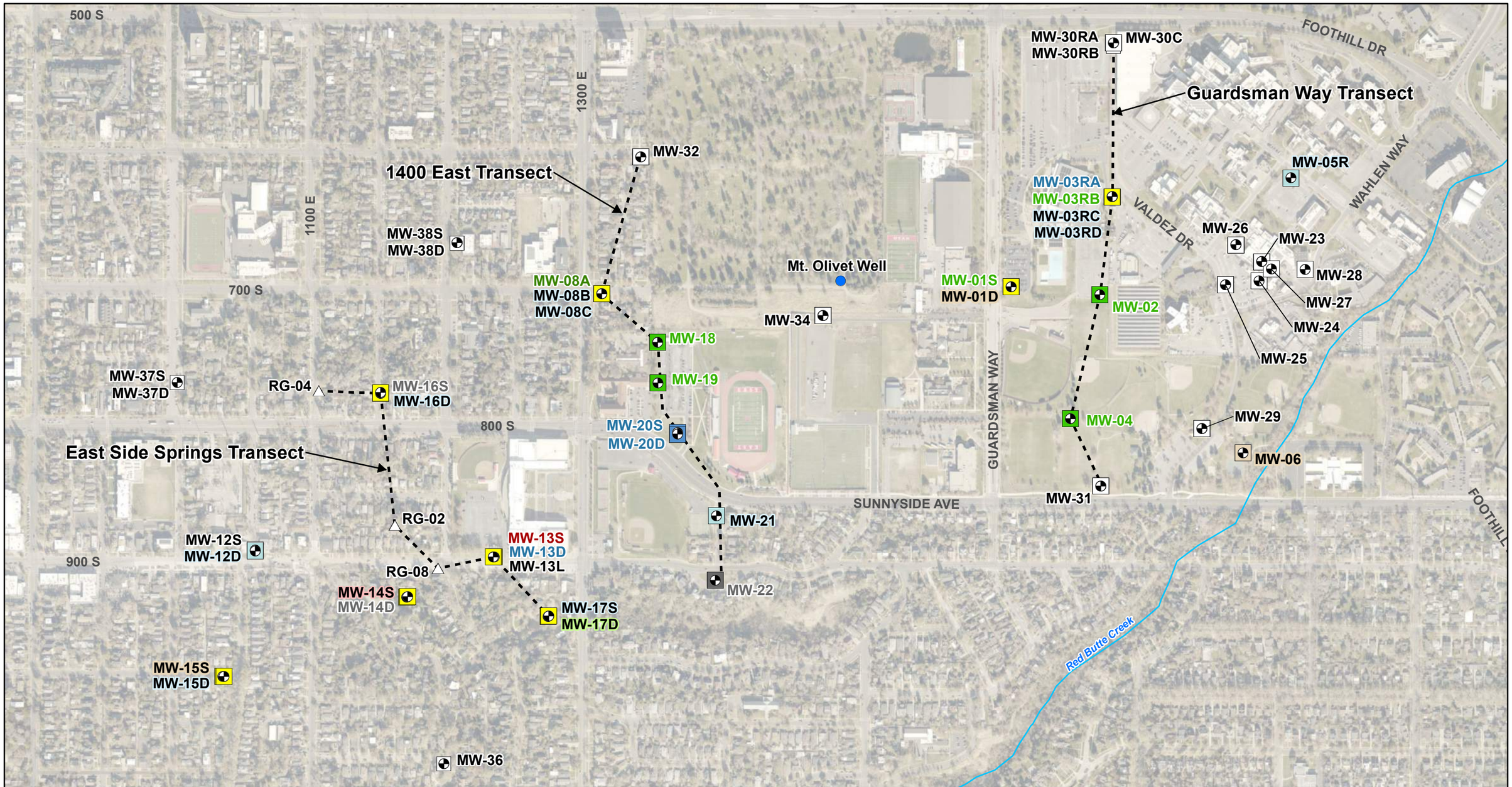
0 250 500 Feet

CDM Smith

Figure 6-30
Summary of Tetrachloroethene Concentration Trends Analysis

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2021\RI_2021\Fig6-30_PCE_Trend_Analysis.mxd WAGNERA 10/20/2021



TCE Statistical Trends

- Increasing
- Probably Increasing, >50% ND
- Stable
- Stable, >50% ND
- Decreasing
- Probably Decreasing, >50% ND
- No Trend
- No Trend, >50% ND
- Insufficient Detections for Statistical Analysis
- Multiple Screen Intervals
- Monitoring Well
- Residential Groundwater Well
- Irrigation Well
- Monitoring Well Transect
- Red Butte Creek

Notes:
1. For wells with multiple screening intervals, see well ID label for statistical trend.

OU = operable unit
RI = remedial investigation
PCE = tetrachloroethene
MW = monitoring well

N W E S

0 250 500 Feet

CDM Smith

Figure 6-31
Summary of Trichloroethene Concentration Trends Analysis

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2021\RI_2021\Fig6-31_TCE_Trend_Analysis.mxd WAGNERA 10/20/2021

Appendix D

FINAL Investigation-Derived Waste Management Plan

CONTRACT NO.: W912DQ-18-D-3008
DELIVERY ORDER: W912DQ19F3048

Phase 2 Remedial Investigation Work Plan
Operable Unit 1
700 South 1600 East PCE Plume site
Salt Lake City, Utah

U.S. Army Corps of Engineers
Kansas City District

Department of Veterans Affairs
Veterans Health Administration Salt Lake City Health Care System

December 2020

CDM Smith

Table of Contents

Acronyms and Abbreviations

APP	accident prevention plan
CDM Smith	CDM Smith, Inc.
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	code of federal regulations
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
GEMS	Green Environmental Management System
IDW	investigation-derived waste
POTW	publicly-owned treatment works
PPE	personal protective equipment
QAPP	quality assurance project plan
RCRA	Resource Conservation and Recovery Act
site	700 South 1600 East PCE Plume site
SOP	standard operating procedure
SPCC	spill prevention control and countermeasure
TSDF	treatment, storage and disposal facility
UAC	Utah Administrative Code
VA	U.S. Department of Veterans Affairs
VAMC	U.S. Department of Veterans Affairs Medical Center

1.0 Objectives

The objective of this investigation-derived waste (IDW) Management Plan is to establish consistent methods to handle and manage all IDW generated from investigation of the 700 South 1600 East PCE Plume, including:

- Solid waste, both hazardous and non-hazardous (e.g., soil cuttings, contaminated debris or equipment)
- Liquid waste both hazardous and non-hazardous (e.g., purge water, rinse water from decontamination, product removal)
- Personal protective equipment (PPE) (e.g., gloves, spent respirator cartridges, spent granulated carbon filters (from air purifiers), chemical resistant coveralls)

This plan provides procedures and standards that are in addition to applicable regulatory requirements and industry standards.

2.0 Applicability

Investigation sampling activities may generate solid, liquid, and PPE waste. This IDW Management Plan, in conjunction with SOP 2-2, *Guide to Handling Investigation-Derived Waste* (see Appendix A, QAPP), will be implemented in the field and on-site at the U.S. Department of Veterans Affairs Medical Center (VAMC).

3.0 Responsibility

The CERCLA Program Manager, or designee, will have the responsibility to oversee and ensure that IDW is properly handled and managed in accordance with this plan and any site-specific or project-specific planning documents. Contractor field personnel will be accountable for the comprehension and implementation of this plan during all field activities, as well as obtaining the appropriate field logbooks, forms, labels records and equipment needed to complete the field activities.

4.0 Definitions

Designated Waste: A solid or liquid waste that is not defined as hazardous, but which still may present a threat to groundwater, and which requires handling differently than a non-hazardous inert waste.

Department of Transportation (DOT). Typically referred to when specifying a type of container that is approved for transporting hazardous substances, either materials or waste, on streets.

Hazardous Waste: Soil, liquid or other wastes generated from site investigations that exhibit toxic (human or ecological effects), ignitable, corrosive, or reactive characteristics as defined by applicable state or federal regulation or which is otherwise classified as hazardous. Such waste requires special handling and documentation of disposal.

IDW: Investigation-Derived Waste. Solid (e.g., soil) or liquid (e.g., groundwater, decontamination fluids) wastes generated from field investigation activities.

Non-Hazardous Waste: A waste that does not exhibit characteristics of a hazardous waste and that is not otherwise classified as hazardous. Nonhazardous waste can be designated as inert waste.

PPE: Equipment worn by workers when potential for exposure to hazardous materials exists, including respirator cartridges.

5.0 Required Materials

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

- Containers for waste (e.g., 55-gallon open and closed top drums) and material to cover waste to protect from weather (e.g., plastic covering)
- Equipment (i.e., pumps, generators, water/interface level indicators, safety monitoring equipment)
- 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
- Steel-toed boots, chemical resistant gloves, coveralls, safety glasses, and any other PPE required in the Accident Prevention Plan (APP) (see Appendix C).

6.0 Methods

The following methods are used to handle the IDW.

6.1 Labeling

Containers used to store IDW must be properly labeled. Waste containers will be packaged and labeled in accordance with RCRA regulations as delegated to the State of Utah by U.S. Environmental Protection Agency (EPA) Region 8 (Utah Administrative Code [UAC] R315). All hazardous wastes will be labeled with a hazardous waste label that addresses the R315 requirements.

When generating IDW, two general conditions exist:

- waste characteristics are known from previous studies or on-site data; or
- waste characteristics are unknown until additional data are obtained.

The following information shall be placed on the containers for all non-hazardous waste and wastes where the waste characteristics are unknown:

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

Containers of IDW awaiting analysis will be labeled "IDW awaiting analysis" or similar words. Once the waste has been characterized, the label should be changed as appropriate for a non-hazardous or hazardous waste.

All non-hazardous waste shall keep the labels which include description of waste, contact information, and date when the waste was first accumulated. Nonhazardous waste containers will also be labeled as non-hazardous waste.

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. 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, labels will also be placed on the top of the containers to facilitate organization and disposal.

Each container of waste generated shall be recorded in the field notebook used by the person responsible for labeling the waste. After the waste is disposed of, an appropriate record shall be made in the same field notebook to document proper disposition of IDW.

It should be noted that, based on available existing data and site history information in the Conceptual Model Update for the 700 South 1600 East PCE Plume site (EA Engineering, Science, and Technology, Inc. 2017), IDW generated from this site are not expected to be characterized as hazardous waste.

6.2 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 below.

6.2.1 Solid Waste

Soil cuttings from boreholes will typically be shoveled back into the borehole after drilling is complete and do not require special handling. Drilling mud generated during investigation activities shall be collected in containers. Covers will be included on the containers and must be secured at all times and only open during filling activities. The containers shall be labeled in accordance with this plan. 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.

If hazardous wastes are generated, they will be disposed off-site at an approved Treatment, Storage and Disposal Facility (TSDF); solid wastes generated during this investigation are expected to be non-hazardous.

It is expected that soil cuttings will be accumulated in a roll-off box for disposal. Roll-off boxes will not be filled more than ½ full in order to meet the DOT weight requirements and can be transported for disposal. Drums may be needed to collect excess cuttings at each borehole. Drums will be transported to and emptied into the roll-off box.

6.2.2 Liquid Waste

Groundwater and decontamination water generated during monitoring well development, purging, and sampling will 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. Liquids generated during this investigation are expected to be non-hazardous and may be discharged to the local Salt Lake City publicly-owned treatment works (POTW) facility. Liquids will be discharged to the sanitary sewer and POTW as soon as possible, pending waste characterization and POTW discharge requirements.

If necessary, liquid waste drums or portable tanks will be held on the VA campus in a fenced, secure location, pending POTW approval for discharge. If hazardous waste liquids are generated, hazardous wastes will be handled separately and disposed off-site at an approved hazardous waste facility.

6.2.3 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 State landfill. The PPE from this site is expected to be non-hazardous.

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. The media at this site are expected to be non-hazardous.

6.3 Waste Accumulation On-Site

Solid, liquid, or PPE waste generated during investigation activities that are classified as non-hazardous or “characterization pending analysis” should be disposed of as soon as possible. Until disposal, such containers should be inventoried, stored securely, and inspected regularly, as a general good practice.

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 govern the labeling of waste;

- Secondary containment to contain spills;
- Spill containment equipment must be available;
- Fire extinguisher;
- Adequate aisle space for unobstructed movement of personnel.

Weekly storage area inspections shall be performed and documented to ensure compliance with these requirements. Throughout the project, an inventory shall be maintained to itemize the type and quantity of the waste generated.

6.4 Waste Disposal

Solid, liquid, and PPE waste will be characterized for disposal using generator knowledge, laboratory analytical data created from soil or groundwater samples gathered during field activities, and/or composite samples from individual containers.

All waste generated during field activities will be stored, transported, and disposed of according to applicable state, federal, and local regulations. If hazardous wastes are generated, all wastes classified as hazardous will be disposed of at a licensed TSDF. Waste disposal will be coordinated with the facility receiving the waste.

Facilities receiving waste have specific requirements that vary even for nonhazardous waste. Characterization will be conducted to support both applicable regulations and facility requirements.

CDM Smith, Inc. (CDM Smith) will contract with a local landfill and will dispose of non-hazardous soils, PPE, and trash in the local landfill. CDM Smith will also contact the local POTW to determine liquids discharge requirements.

If hazardous wastes are generated, the scope of work will for this project will need to be modified, although disposal will still need to occur within 90 days of waste generation.

6.5 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;
- UAC R315;
- CFR, Title 49, Parts 172, 173, 178, and 179.

6.6 Waste Transport

A state-certified DOT approved hazardous waste hauler shall transport all wastes classified as hazardous. Typically, the facility receiving waste can coordinate a hauler to transport the waste. Shipped hazardous waste shall be disposed of in accordance with all RCRA/EPA requirements.

All waste manifests or bills of lading will be prepared in accordance with DOT regulations and signed by the VA CERCLA Program Manager or designee. The CERCLA EPA ID number

UTD981548985 will be used for shipment of all CERCLA wastes. Utilization of the CERCLA EPA ID number for transportation and disposal tracking of the wastes was approved by the State of Utah Department of Environmental Quality on July 22, 2016 for both hazardous and non-hazardous IDW so as not to impact the VAMC Small Quantity Generator status.

Wastes generated by this investigation are expected to be characterized as nonhazardous waste. All non-hazardous wastes will be transported under a non-hazardous waste manifest or bill-of-lading to document disposal of IDW.

7.0 Spill Containment and Source Elimination

If there is no hazard to the safety of personnel, the first spill responder(s) should attempt to contain the spill only if there is no threat to their safety, to prevent its entry into a storm drain, a ditch, or leaving VAMC property. The person first observing the spill alarm or evidence of the spill will implement emergency spill response procedures in accordance with the VAMC Spill Prevention Control and Countermeasure plan (SPCC) and notify the following personnel as soon as practical.

- The facility Green Environmental Management System (GEMS) Coordinator Richard Hofman at (202) 632-7890
- The Boiler Plant Operator at 801-582-1565 x 1043
- The CERCLA Program Manager Shannon Smith at (801) 582-1565 x 2021, or designee

Materials used for spill response include shovels, absorbent materials and pads, drain covers, and dikes. Non-sparking tools, such as plastic shovels, if needed, will be used to clean up any spill that may be flammable. If spill clean-up is beyond the capability of appropriate VAMC staff, the GEMS Coordinator will arrange for a spill response contractor.

CDM Smith will also follow the incident procedures in the Accident Prevention Plan regarding spill response and notification.

7.1 Spill Cleanup and Mitigation

After the appropriate notifications have been made and spill response guidance received from the GEMS Coordinator, the staff responsible for cleanup or the spill response contractor will collect the spilled material in the appropriate manner and place the material into containers appropriate for the spilled material (determined by the GEMS Coordinator).

1. The GEMS Coordinator will select the appropriate cleanup and decontamination method and provide this information to the appropriate VAMC staff.

2. Spill material and debris will be managed in a manner that is compliant with applicable local, state, and federal laws regarding recycling or disposal of regulated waste materials.

The nearest spill response and containment materials are available at VAMC Building 38.

8.0 References

U.S. EPA Guide to Management of Investigative-Derived Waste, Publication: 9345.3-03FS, April 1992.

Code of Federal Regulations, Title 40, Section 262.32, Standards Applicable to Generators of Hazardous Wastes, Subpart C – Pre-transport Requirements, Marking, (periodically updated – use most current version).

EA Engineering, Science, and Technology, Inc. 2017. Conceptual Model Update for the 700 South 1600 East Street PCE Plume. February.

9.0 Attachments

IDW Container Management Log

IDW Container Management Log

From Month/Year:					To Month/Year:				
Location: Building 38					Point of Contact: Shannon Smith (801) 582-1565 x 2021				
Date in Storage	Inspector (Printed Name AND Initials)	Container							
		Good Condition		Closed		Labeled "IDW Awaiting Analysis"		Accumulation Logged	
		Yes	No	Yes	No	Yes	No	Yes	No

Appendix E

Data Management Plan

CONTRACT NO.: W912DQ-18-D-3008
DELIVERY ORDER NO.:
W912DQ19F3048

700 South 1600 East PCE Plume Site
Salt Lake City, Utah

U.S. Army Corps of Engineers
Kansas City District

Department of Veterans Affairs
Veterans Health Administration Salt Lake City Health Care System

August 2020

CDM Smith

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Appendices

Acronyms and Abbreviations

ASC	analytical services coordinator
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	chain of custody
DBA	database administrator
DC	data coordinator
DM	data manager
DMP	data management plan
DMS	data management system
DS	data specialist
DU	data user
DV	data validator
EDD	electronic data deliverable
EDMS	environmental data management system
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
FTL	field team leader
GS	geographic information system specialist
GIS	geographic information system
ID	identifier
PC	project chemist
PII	personally identifiable information
PM	project manager
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RI	remedial investigation
RIWP	remedial investigation work plan
SQL	structured query language
USACE-KC	U.S. Army Corps of Engineers, Kansas City District
VHA	Veterans Healthcare Administration

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Section 1
Introduction

This data management plan (DMP) outlines the systems and processes that will support data management during the remedial investigation (RI) being conducted at the 700 South 1600 East PCE Plume Site located near the George E. Wahlen Veterans Affairs Medical Center in Salt Lake City, Utah. This DMP was prepared to support the data collection activities described in the Phase 2 Remedial Investigation Work Plan (RIWP) (CDM Federal Programs Corporation [CDM Smith] 2020a). This document includes the data management standards and guidelines for data generation, validation, and distribution during the project.

This DMP will be used by project team members and subcontractors involved in generating, managing, and reporting data. This DMP describes quality assurance (QA) and quality control procedures (QC) specific to managing project data. QA/QC procedures for data generation are described in the Phase 2 Quality Assurance Project Plan (QAPP) (CDM Smith 2020b), a component of the RIWP. This plan may be revised or amended to accommodate changes in site conditions or data management requirements to better achieve project objectives.

1.1 Remedial Investigation Scope

The RI field activities associated with Phase 2 may include the following activities:

- Collection and off-site analysis of subsurface soil samples
- Installation of shallow and deep groundwater wells and soil vapor probes
- Push-ahead groundwater sampling during monitoring well drilling
- Collection of soil samples during well installation for geotechnical testing at an off-site laboratory
- Aquifer slug testing and aquifer pumping tests on monitoring wells
- Geophysical and groundwater flow logging within borings or wells
- Synoptic water level measurements and hydraulic gradient calculations at monitoring wells
- Transducers for continuous water level measurement at select locations
- Groundwater monitoring of new and existing monitoring wells, with collection of field parameters and analysis at off-site laboratories
- Surface water sampling, with collection of field parameters and analysis at off-site laboratories
- Vapor intrusion assessments at structures within the groundwater plume boundary

- Ecological site reconnaissance
- Surveying of sample locations and wells
- Well maintenance as necessary

The data management system (DMS) will support efficient and accurate information storage and access, with traceable documentation from the point of data generation through final data storage.

1.2 Data Management Objectives

The overall goal of the DMS is to provide the Veterans Healthcare Administration (VHA) project team members ready access to consistent and accurate data. This involves developing a DMS that will integrate multiple types of data, including geographic, tabular, text, image, and written documentation data from a variety of sources. The following are the objectives of the VHA project-specific DMS:

- Standardize data management methods
- Support efficient delivery of high-quality data to project team members, including minimizing time between data collection, entry, and analysis
- Standardize data management QA/QC procedures, consistent with the Phase 2 QAPP (CDM Smith 2020b)
- Maintain adequate data backup
- Support long-term integrity of digital data and associated metadata through archival storage standards and practices
- Provide for storage and archiving of nondigital information, such as log sheets, inspection forms, documents, published and unpublished reports, and maps

Subsequent sections of this plan summarize roles and responsibilities of project team members, describe the types of information inputs required to the DMS, and provide guidelines for data management operations.

1.3 Roles and Responsibilities

Figure 1-1 shows the CDM Smith project team organizational chart. The overall responsibility for implementing the DMP is assigned to the data manager (DM). Designated qualified individuals will assume execution responsibility of this plan as described in this section. The roles and responsibilities, pertaining specifically to this DMP, are summarized as follows:

- The project manager (PM) is responsible for project planning and execution, which includes ensuring development of the project DMP, conducting a review of the DMP, and supporting the data management team.
- The DM is responsible for:

  - Working with PMs to determine project data needs
  - Training, qualifying, and mentoring data coordinators (DCs) and data specialists (DSs)
  - Interfacing with the database administrator (DBA)
  - Developing and implementing the project DMP and ensuring data quality and management objectives and requirements specified in the DMP are met
  - Monitoring the activities of the data management team members to ensure quality objectives, budget, and schedule are met
  - Verifying the data management tasks, in conjunction with sampling analysis and validation/qualification, data entry, and data analysis reporting, are completed
  - Ensuring updates generated during the project are incorporated into the DMP and applicable databases
  - Authorizing the release of data from a hold point
  - Performing self-assessments, evaluating the data management process, and issuing corrective actions, as necessary
- The DC is the primary interface between all responsible parties involved in the data management process to ensure all data activities are conducted in accordance with the project DMP.
- The field team leader (FTL) is responsible for the field investigation planning and data collection while ensuring the accuracy of field data.
- The DS is responsible for entering environmental project data into the database, ensuring all information is entered accurately, the data uploads are completed, and generating reports from the database.
- The analytical services coordinator (ASC) may serve as the liaison between CDM Smith, clients, and/or subcontract laboratories, and is responsible for reviewing laboratory invoices to ensure correct billing.
- The data validator (DV) ensures analytical data are accurate, according to the project-specific set of criteria. The DV is responsible for performing any required data validation.
- Data users (DUs) define, review, and verify output reports generated by the DS for preparing reports (e.g., investigation, risk assessments, feasibility study, data usability, design, long-term monitoring, or operations and maintenance documents).
- The project chemist (PC) is responsible for training and mentoring ASCs and DVs. The PC conducts independent reviews of DV work.

- The DBA is responsible for creating the environmental database, assigning user permissions, and configuring the backup schedule.
- The geographic information system (GIS) specialist (GS) is responsible for the project's spatial data. The GS is responsible for the development and maintenance of the project geodatabase. The GS will produce project maps and figures.
- The stakeholders, VHA and U.S. Army Corps of Engineers, Kansas City District (USACE-KC) staff, will have access to project documents through the project SharePoint site and will have access to the project database through EQuIS Enterprise.

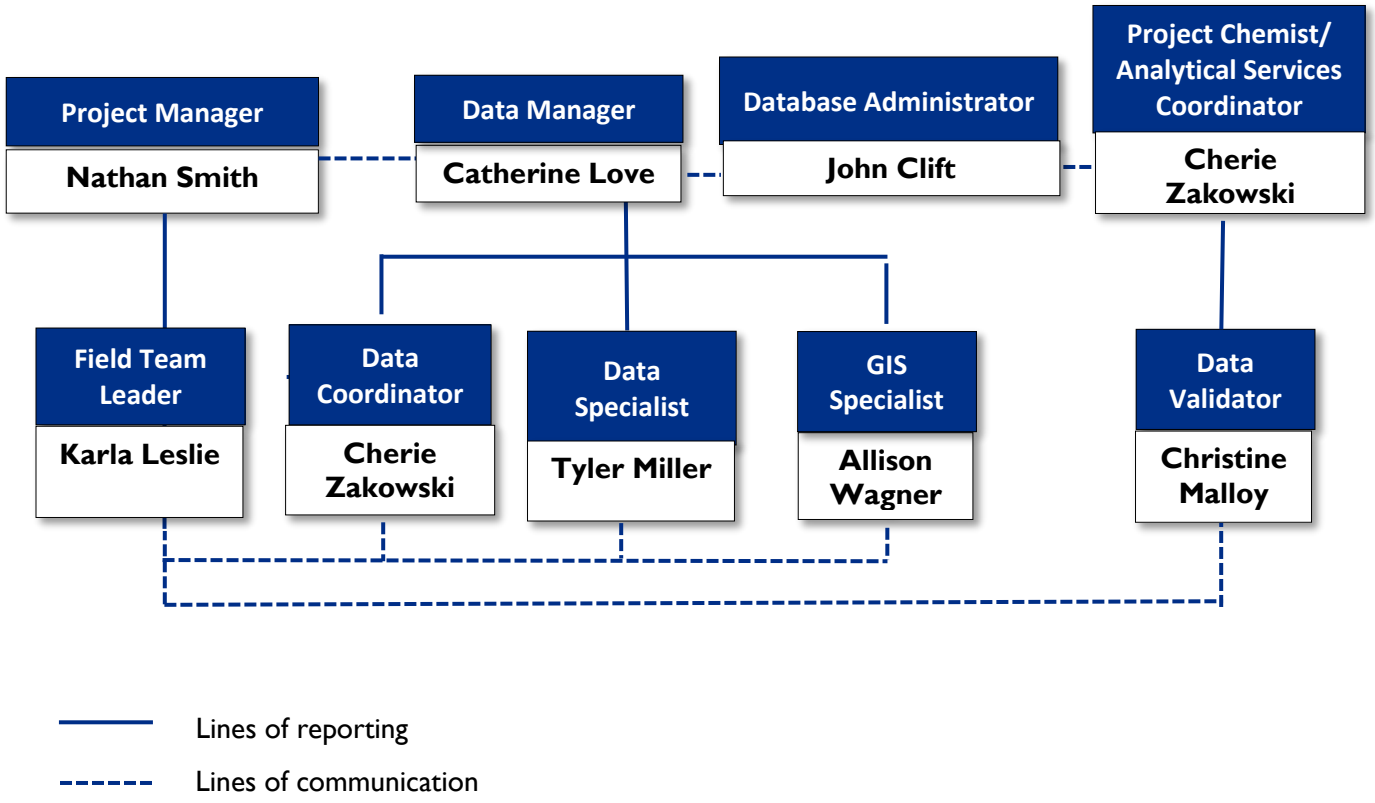

Figure 1-1
CDM Smith Data Management Organization

Section 2

Data Management System and Processes

This section describes the DMS and related processes that will be used during Comprehensive Environmental Response, Compensation, and Liability Act of 1980 activities at the Site.

2.1 Data Management System

The data management system will be set up to manage chemical, geological, hydrogeological, and geospatial data; well construction data; and project documents. The system is comprised of the major elements discussed in subsequent sections and shown on Figure 2-1.

2.2 EQuIS Database

An environmental data management system (EDMS) will be developed using the EarthSoft EQuIS system. This is a third-party, commercial, off-the-shelf, packaged EDMS software system that uses a SQL Server database. The EDMS will house the following data:

- Location information for wells and other sampling points
- Well construction information
- Simplified lithological information for boring logs
- Water level data
- Field parameters (for example, pH and specific conductivity)
- Sample information including location, date and time, sampling method, and matrix
- Analytical chemistry data

2.3 EQuIS Enterprise

A secure, password-protected EQuiS Enterprise website will be developed to give USACE-KC and VHA personnel access to the analytical chemistry and other project data stored in the EDMS. The EQuIS Enterprise web interface connects to the EQuIS database and provides query, view, and sort capabilities without any special hardware or software requirements for users.

2.4 Geodatabase

Spatial data will be managed using the ArcGIS Environmental Systems Research Institute suite of products. The GIS will be used to house and visualize geospatial data, including project-specific location information (such as wells and sample points) and reference entities (such as roads, buildings, and water bodies). Spatial data will be managed in a project geodatabase. Spatial data for the project will be referenced to State Plane Utah Central, North American Datum of 1983 feet.

2.5 ProjectWise

CDM Smith will internally use ProjectWise for managing documents such as field forms, chain-of-custody records (COCs), laboratory packages, electronic data deliverable (EDD) tabular data, final report files, and other project documents and records. Items stored in ProjectWise are traceable and controlled.

2.6 SharePoint

A Microsoft SharePoint site containing draft and final deliverable documents, including native files, will be developed to promote document version control and sharing of documents between project members. SharePoint features, such as document check-in/check-out and site permissions, will be implemented.

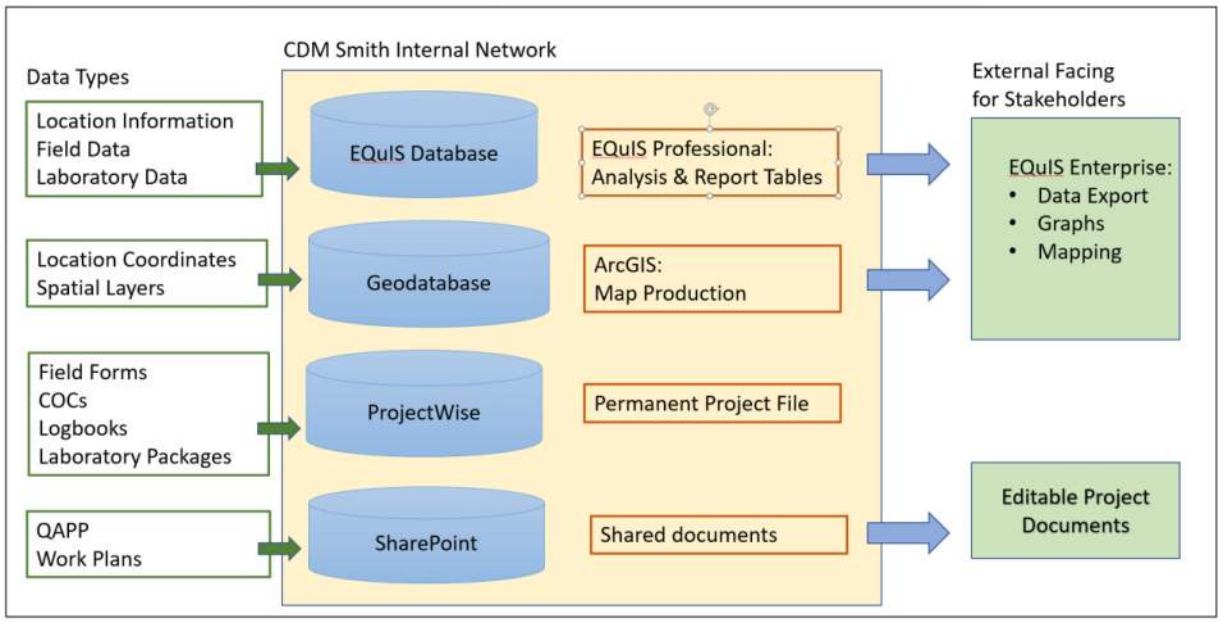

Figure 2-1
Data Management System

2.7 Data Management Processes

Data management tasks will follow a definitive flow, starting with project and sample planning and ending with the release of final data to team members for use in reports, maps, and other project deliverables.

The project's QA/QC requirements will be specified in the Phase 2 QAPP (CDM Smith 2020b). Specific data collection activities will be described in the Phase 2 RIWP (CDM Smith 2020a). An auditable trail of the information workflow will be implemented.

The workflow process of data management planning and implementation for the VHA project is composed of the following elements:

- **Project and Sample Planning:** The DM participates in the project planning meetings to discuss scope, schedule, and budgets. Based on this information, the DM develops a DMP to

support the QAPP and RIWP. Laboratory procurement needs are identified with the ASC so that EDDs and other data products match project requirements. See Appendix A for information on EDD format and field definitions.

- **Field Investigation and Data Collection:** The DM attends field planning meetings to ensure that field templates are correctly set up for the field event. During the field event, the FTL performs checks on field forms and COCs. Any data entry into field data loading templates will receive a 100 percent QC review. Locational data that are collected will be plotted by the GS and its accuracy verified by the FTL.

- **Sample Analysis and Validation:** As laboratory data arrives, a tracking sheet will be created by the DC to ensure that each sample delivery group (SDG) has been reviewed and loaded into the database. Each package will be reviewed for completeness and quality by the DV. Field sample information will be compared against the EDDs to ensure all the laboratory results expected are in the EDDs. Ten percent of the EDDs will be checked against the hard copy packages results. Data will be validated based on the standards set in the Phase 2 QAPP (CDM Smith 2020b). A technical review of the validation will be conducted by the PC.

- **Database Management**: The DS specialist loads the validated data into the EDMS using the EQuIS Data Processor (EDP). When data have met valid values and format business rules, the EDP will show a clean error log. At this time, the DS will commit the data to the EQuIS database. After the data are loaded, a table from the database will be produced and reviewed by the DV. An independent review of the database will be conducted by the DM to confirm that database queries will produce the correct results. Once the review steps are complete, the DM will sign the Hold Point Release Form (see Appendix B) to certify that the data are ready for use.

- **Data Analysis and Output**: The DM will meet with project staff needing tables or other data products to verify requirements. All data products will be reviewed by the DM or designee.

Table 2-1 lists each QC step and the owner responsible for completing the step.

Table 2-1 Data Management Workflow QC Steps

QC Steps	QC Process Description	Owner
	Project and Sample Planning	
QC 0	Conduct project kickoff meeting, to include DM	PM
QC 1	Ensure DMP preparation	PM
QC 2	Review project EDD requirements	DM
	Field Investigation and Data Collection	
QC 3	Conduct field planning meeting, to include DM or DC	FTL
QC 4	Review 100% of initial field data spreadsheet template	FTL
QC 5	Review 100% of labels, COCs, and data added to field database	FTL
QC 6	Confirm sample receipt at laboratory and review receipt form for errors	FTL
QC 7	Review field data spreadsheet for correct sample identifiers (IDs), collection date and time, sample description and field measurements.	FTL
QC 8	Review sample summary report (trip report)	DC
QC 9	Review 100% of location information from Global Positioning System or survey data	FTL
	Sample Analysis and Validation	
QC 10	Receive data packages and EDDs; initiate tracking sheet	ACS
QC 11	10% check of data packages and EDDs received from laboratory for completeness	DV
QC 12	Validate data from subcontract laboratories	DV
QC 13	Perform 100% data validation technical review (90% stage 3 and 10% stage 4)	PC
	Database Management	
QC 14	Review EDDs via EDP prior to loading	DS
QC 15	Generate error summary log; resolve any issues	DS
QC 16	Ensure field samples and laboratory samples are all accounted for	DC
QC 17	Review 100% of manually entered qualifiers from validation	DV
QC 18	Review EDD tracking sheet for completeness	DC
QC 19	Perform QC check on database	DM
QC 20	Hold point/DM review	DM
QC 21	Release point; database is ready	DM
	Data Analysis and Output	
QC 22	Report production planning meeting, to include DM or DC	PM
QC 23	Review reports generated by DS and inform DS of any changes or updates that need to be captured in the database	DU

Section 3
Data Products and Documentation

This section describes the types of data products and documentation that will be created, managed, and archived during the project. To meet the needs of the project and subsequent work, data will be presented in tables, charts, graphs, forms, and maps for evaluation and reporting. Once data have been entered into the EDMS and the Hold Point Review Form has been signed, then tables, figures, and diagrams can be created from the EDMS. Standalone data tools should interact with the DMS through data exports from the DMS report library to avoid omissions of data or incorrect data resulting from errors in exporting. For example, software such as the U.S. Environmental Protection Agency (EPA) ProUCL may be used to analyze data during the RI. In such cases, exports directly from the EDMS should be used as input files rather than compiling input files from other data sources, such as printed tables.

3.1 Field and Laboratory Chemistry Data

Data collected during this project will consist of field observations and measurements and analytical laboratory data. Field observations and measurements will be documented in field logbooks and on hard copy field forms. Standard field forms will be the primary data source documents. Field data will be recorded and field quality will be maintained following the procedures outlined in the Contractor Quality Control Plan (CDM Smith 2019). Monitoring data sheets will be developed for recording data. Data sheets, field forms, field notebooks, and other standard forms (field sampling logs and COC forms) will be stored in ProjectWise.

Analytical laboratory data, in the format of hard copy laboratory packages or EDDs, will be stored with the project files in electronic format on ProjectWise. Any hard copy package or EDD that has been resubmitted will be uploaded to ProjectWise and both the resubmitted and original files will be stored and clearly documented as to which is the correct dataset. As noted in Section 2, analytical data will be compiled and stored in the EQuIS database and exported for use in presentation applications, such as LeapFrog, ArcGIS, Microsoft Excel, and other geospatial modeling environments. Figure 3-1 describes the data flow of analytical laboratory data. See Appendix A for information on EDD format and field definitions.

The EDMS database standard reporting library will be used to generate reports. Custom code, queries, and reports for producing tabulated data may be written and saved in the reporting library so they can easily be rerun to recreate a tabulated data set. These tabulated data sets will

be downloaded and saved for use in applications for formatting, graphical presentation, and publication.

Figure 3-1
Analytical Laboratory Data Flow

3.2 Document Data

Information generated from field activities will be documented on appropriate forms and will be maintained in the project file. These include COCs, field logbooks, well construction forms, well development logs, boring logs, field parameters, sample logs, location sketches, and site photographs.

Both hard copy deliverables and EDDs will be managed and stored. Hard copy data packages will be filed by year, month, and SDG or laboratory batch, as appropriate. Hard copy data packages will be handled by team staff during the data loading and validation phase and will be sent to the hard copy project files for storage. Upon project closeout, data packages will be archived with the project files.

The raw laboratory EDD files will be stored in the data validation project folder on the CDM Smith network and loaded and processed data will be managed in the EDMS database. File names for the EDDs will include the SDG or laboratory batch to facilitate document control and retrieval. The original laboratory EDD will be archived in ProjectWise.

Secondary data is data collected by non-project entities. Examples may include data such as non-VA wells, climate data, weather data or surface water flow data. This data will be stored on Project Wise. Any data that needs to be compiled in the EDMS will follow the same quality procedures for loading as describe in Table 2-1.

3.3 Geographic Information System Data

The primary types of geospatial information that will be stored or dynamically linked to the DMS include cartographic spatial data, georeferenced spatial data and images, and point spatial data. The geospatial information will be stored in a project geodatabase on a CDM Smith network server. See Section 4.4 for information on the backup of CDM Smith's network server. Map generation activities will be performed using ArcGIS.

Section 4

Database Administration and Security

4.1 Database Administration

The DBA will oversee the administration of the EDMS and will manage the setup, configuration, operation, and maintenance of the project database and data management processes. Database maintenance will consist of the following:

- Allocating sufficient system storage for the project database
- Adding, altering, and deleting users, roles, and privileges
- Upgrading database software and applications as necessary
- Providing routine backup of the database

4.1.1 Valid Values and Reference Values

Valid values are critical to large relational databases. Inconsistencies in naming conventions, subtle differences in analyte names, differences in analytical method spelling, and the use of nonstandard abbreviations can result in irretrievable data and incorrect conclusions. EDDs, tables, and forms in the project database use reference tables for acceptable valid values and will not allow the entry of data that do not conform. Valid value lookup tables are incorporated into the project database. Reference tables will use the reference values for the EQuIS version 7 EPA Region 2 format. The most current version of the format reference values can be downloaded from the EarthSoft website at https://www.epa.gov/superfund/region-2-superfund-electronic-data-submission-documents.

4.1.2 Data Integrity Control

Database schema updates and modifications will be managed only through vendor database upgrades. Data management operations will be performed using the EQuIS standard interfaces. Users will not be allowed to modify database data and reference tables directly. Open Database Connectivity access to the database is not allowed to avoid compromising data integrity and to avoid degrading database performance. Updates to valid values in the reference tables will be controlled to conform to EPA Region 2 reference value specifications.

4.2 Document Management and Archiving Procedures

Project-related information will be managed and stored by CDM Smith. Record storage will be performed using the following two methods:

- Back-up storage during the project (See Section 4.4)
- Permanent storage of project records

CDM Smith will store files in ProjectWise throughout project closeout and the contract-mandated project files retention period. Final primary documents will also be stored in the Site's administrative record at https://pceplume.org/.

4.3 Change Management

This DMP is a "living" document and content may be revised or amended to accommodate changes in the scope of the VHA project activities or data management requirements that affect successful completion of the project. In addition, the DMP appendices will be subject to modification as new or improved methods of data management are developed and implemented.

Any modifications made to the tools will be communicated to the project team via email. As revisions are finalized, they will be distributed electronically to all users. After revision, it is the user's responsibility to conform to revised portions of the DMP.

4.4 Data Backup and Recovery

The EQuIS project database in the hosted environment includes the following important data protection features:

- Servers in the virtual private cloud with Amazon Web Services
- 99. 99 percent uptime with 24/7/365 network and server monitoring
- Daily incremental backups, with full weekly backups saved to disk for 30 days

The project data management files (such as the GIS geodatabase) on CDM Smith network servers, will be managed as part of the CDM Smith network server management policy. Backup and recovery procedures will include daily incremental backups and full backups twice a week that are saved on CDM Smith's private cloud. Data can be restored up to 30 days.

4.5 Personally Identifiable Information

Personally identifiable information (PPI), such as names or addresses of residents participating in indoor air sampling, will be managed such that no PPI is stored on any outward-facing servers. This means that no PPI will be stored in the EQuIS database, where it could become discovered via the EQuIS Enterprise site. Instead data will be stored by its location number.

Section 5
References

CDM Smith. 2020a. *Draft Phase 2 Remedial Investigation Work Plan*. In preparation by CDM Smith for the U.S. Corps of Engineers, Kansas City District and the Department of Veterans Affairs, Veterans Health Administration. Denver, CO.

CDM Smith. 2020b. *Draft Phase 2 Quality Assurance Project Plan*. In preparation by CDM Smith for the U.S. Corps of Engineers, Kansas City District and the Department of Veterans Affairs, Veterans Health Administration. Denver, CO.

CDM Smith. 2019. *Contractor Quality Control Plan*. Prepared by CDM Smith for the U.S. Corps of Engineers, Kansas City District and the Department of Veterans Affairs, Veterans Health Administration. Denver, CO.

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Appendix A

Laboratory Electronic Data Deliverable, EQuIS Definition

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Laboratory Electronic Data Deliverable

A.1 Introduction

Analytical data generated by the laboratory will undergo quality control (QC) reviews by laboratory staff to ensure that the electronic data match those on the hard copy reports. Additionally, the laboratory will use the laboratory electronic data deliverable (EDD) format specified in this appendix. This data structure will allow the laboratory to use electronic data processors to verify that the EDD is in the correct format and uses correct, valid values established by the project.

A.2 Electronic Data Deliverable Format

The main EDD file for laboratory use will be the CDM EZEDD validated file. This format will be used in conjunction with the EQuIS Data Processor tool. Reference values can be downloaded from the EarthSoft website at https://www.epa.gov/superfund/region-2-superfund-electronic-data-submission-documents. The analytical laboratory will provide EDDs in the CDM EZEDD validated file format. CDM Smith will use the EDD format to validate the data, and then will apply the validation qualifier information to the EDD for upload to the Site database.

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Field Name	Data Type	Key	Required	Default	Parent	Lookup	Database Mapping(s)	Comment
project_code	Text(20)							Unique identifier assigned to a project site or delivery order.
Sys_Sample_Code	Text(40)	PK	Y				dt_sample. Sys_Sample_Code dt_field_sample. Sys_Sample_Code dt_test. Sys_Sample_Code dt_sample. Sys_Sample_Code	Uniquely identifies a field or laboratory sample. For field samples, use the Field Sample ID. For laboratory blanks or samples, the laboratory may use Lab Sample ID only if the Lab Sample ID is unique. Otherwise, the laboratory must come up with a way to generate a unique lab sample ID to be entered in this field.
Sample_Name	Text(50)						dt_sample. Sample_Name dt_sample. Sample_Name	This field contains the sample number as written in the Analysis Request and Chain of Custody (AR/COC) form sent to the laboratory with the field samples for analysis. This is a unique number assigned to each sample by sampling personnel.
Sample_Type_Code	Text(20)	PK	Y			rt_sample_type. sample_type_code	rt_sample_type. sample_type_desc dt_sample. Sample_Type_Code dt_sample. Sample_Type_Code	Specifies sample type. For field samples, enter N (regular environmental sample). Normal field samples must be distinguished from laboratory method blank samples, etc.. Field sample types (e. g. , field duplicates, field blanks, etc.) might be submitted blind to the laboratory; in such cases the laboratory may report all field samples as if they were all normal field samples. The laboratory is not required to export data for a spike if a spike duplicate is exported (unless the PC requests spikes).
Sample_Date	Date						dt_field_sample. Sample_Date	mm/dd/yyyy. Date sample was collected in the field. Date information must be identical with the date from the AR/COC form. Leave blank for laboratory samples. Year may be entered as yy.
Sample_Time	Time						dt_field_sample. Sample_Time	hh:mm (24-hour clock, e. g. 3:40 pm is 15:40). Time sample was collected in the field. Time information must be identical with the time from the AR/COC form. Leave blank for laboratory samples.
Sys_loc_Code	Text(20)						dt_sample. Sys_Loc_Code	Uniquely identifies a location in the field where sample was collected. Not required for laboratory samples.
Start_Depth	Numeric						dt_sample. Start_Depth	Must only be a numeric value.
End_Depth	Numeric						dt_sample. End_Depth	Must only be a numeric value.
Depth_Unit	Text(15)						dt_sample. Depth_Unit	Unit for start and end depth.
Analysis_Location	Text(2)					(Enumeration:…)	dt_test. Analysis_Location dt_test. Analysis_Location	Must be either FI for field instrument or probe, FL for mobile field laboratory analysis, or LB for fixed-based laboratory analysis.
Lab_Name_Code	Text(20)		Y			rt_company. company_code	rt_subcontractor. subcontractor_name dt_test. Lab_Name_Code dt_test. Lab_Name_Code	Laboratory that performed the analysis.
Lab_Sample_Id	Text(20)		Y				dt_test. Lab_Sample_Id dt_test. Lab_Sample_Id	Unique sample ID internally assigned by the laboratory.
percent_moisture	Text(5)						dt_test. percent_moisture	Percent moisture of the sample portion used in this test; this value may vary from test to test for any sample. Report 70.1% as 70.1 not as 70.1%.
Lab_Del_Group	Text(20)						dt_sdg. sdg_name dt_sdg. sdg_desc dt_field_sample. field_sdg dt_test. lab_sdg	Tracking code used by the laboratory. Most commonly called SDG.
Lab_Batch_Number	Text(20)							Tracking number used by the laboratory to identify a group of samples analyzed in the same batch. This field, in conjunction with laboratory blank ID, is used to link the relationship between field samples and laboratory blank and other QC samples. Note: This field does not populate in the EQuIS database.
Lab_Anl_Method_Name	Text(20)	PK	Y			rt_analytic_method. analytic_method	rt_std_analytic_method. analytic_method rt_std_analytic_method. preferred_name dt_test. lab_anl_method_name dt_test. analytic_method	Test method used in the analysis of the analyte.
Cas_Rn	Text(15)	PK	Y			rt_analyte. cas_rn	dt_result. Cas_Rn dt_result. Cas_Rn	Unique analyte identifier. Use assigned Chemical Abstracts Service (CAS) number when one is identified for an analyte. Tentatively identified compounds (TICs) are not assigned a standard CAS number. The laboratory is required to assign a unique identifier for each TIC. The unique identifier must be placed in this field. Since retention time for TICs are unique per sample and sample analysis method, this information is the recommended value to use as the unique identifier.
Chemical_Name	Text(60)		Y				rt_analyte. chemical_name	Name of analyte or parameter analyzed.

Field Name	Data Type	Key	Required	Default	Parent	Lookup	Database Mapping(s)	Comment
Result_Value	Numeric						dt_result. result_text dt_result. result_numeric dt_result. Result_Value	Must only be a numeric value. It is stored as a string of characters so that significant digits can be retained. Must be identical with values presented in the hard copy. It may be blank for nondetects.
Result_Unit	Text(15)		Y			rt_unit. unit_code	dt_result. Result_Unit dt_result. Result_Unit	This format assumes that the result value and detection limit have the same units.
Lab_Qualifiers	Text(7)						dt_result. Lab_Qualifiers dt_result. Lab_Qualifiers	Qualifier flags assigned by the laboratory. This is an optional field for the laboratory EDD unless otherwise specified by the PC. EQuIS does not enforce a controlled vocabulary on the values of this field, although a list of valid values may optionally be provided by the EQuIS project manager.
Validator_Qualifiers	Text(7)						dt_result. Validator_Qualifiers	Qualifier flags assigned by the DV.
Interpreted_Qualifiers	Text(7)						dt_result. Interpreted_Qualifiers	Qualifier used in reporting.
Validated_YN	Text(2)		Y			(Enumeration: . . .)	dt_result. validated_yn	Enter Y for validated results or N for unvalidated data.
Validation_Level	Text(20)						dt_result. custom_field_2	If Validation_YN is Y (yes) then enter the level of validation performed. For example, Level 1–Level 4, Tier 1–Tier 4, etc.
Test_Type	Text(10)	PK	Y				dt_test. Test_Type dt_test. test_type	Type of test. Valid values include Initial, Reextract1, Reextract2, Reextract3, Dilution1, Dilution2, Dilution3, Reanalysis
Reportable_Result	Text(3)		Y			(Enumeration: . . .)	dt_result. Reportable_Result	Must be either Yes or No
Detect_Flag	Text(2)		Y			(Enumeration: . . .)	dt_result. Detect_Flag dt_result. Detect_Flag	Enter Y for detected analytes or N for nondetected analytes.
Result_Type_Code	Text(10)		Y			rt_result_type. result_type_code	dt_result. Result_Type_Code dt_result. Result_Type_Code	Type of result (TIC, target analyte, etc.).
Reporting_Detection_Limit	Numeric						dt_result. Reporting_Detection_Limit dt_result. Reporting_Detection_Limit	Must only be a numeric value. Use the value of the reported detection limit, project quantitation limit, or contract-required quantitation limit. Value is stored as a string to retain significant figures. Unit of measure must be identical with the Result Unit field.
Detection_Limit_Unit	Text(15)		Y				dt_result. Detection_Limit_Unit	This format assumes that the result value and detection limit have the same units.
Dilution_Factor	Numeric		Y	1			dt_test. Dilution_Factor dt_test. Dilution_Factor	Must be a numeric entry. The factor by which the sample was diluted as part of the preparation process. If no dilution was done, enter the value 1.
Sample_Matrix_Code	Text(10)		Y			rt_matrix. matrix_code	rt_matrix. matrix_desc dt_sample. sample_matrix_code dt_sample. Matrix_Code	Code that distinguishes between the different type of sample matrix. For example, soil samples must be distinguished from groundwater samples. ERPIMS-style sample matrix codes are understood by EQuIS, and other valid sample types can be added by the DM. The matrix of the sample as analyzed may be different from the matrix of the sample as retrieved (e.g., toxicity characteristic leaching procedure) but this EDD asks only for the matrix as sampled.
Total_or_Dissolved	Text(1)	PK				rt_fraction. fraction	dt_test. Total_or_Dissolved dt_test. fraction	Must be T for total metal concentration, D for dissolved or filtered metal concentration, R for total recoverable, or N for organic (or other) parameters for which neither Total nor Dissolved is applicable.
column_number	Text(2)	PK	Y	NA		(Enumeration: . . .)	dt_test. column_number	Must be either 1C for first column analyses, 2C for second column analyses, or NA for analyses for which neither 1C nor 2C is applicable. Second column data may not be required, depending on the needs identified by the PM, in which case all results may be reported as NA. However, if any 2C tests are reported, then there must be corresponding 1C tests present also. Also, laboratories typically can report which of the two columns is to be considered primary. This distinction is handled by the reportable result field in the result table.
Basis	Text(10)					(Enumeration: . . .)	dt_test. Basis dt_test. Basis	Enter Wet for wet-weight-basis reporting, Dry for dry-weight-basis reporting, or NA for tests for which this distinction is not applicable.
Analysis_Date	Date	PK					dt_test. Analysis_Date	mm/dd/yy. Date sample was analyzed.
Analysis_Time	Time	PK					dt_test. Analysis_Time	hh:mm (24-hour clock or military time; e.g., 3:40 p.m. is 15:40). Time sample was analyzed.
Method_Detection_Limit	Text(20)						dt_result. Method_Detection_Limit dt_result. Method_Detection_Limit	Must be a numeric value. Use the method detection limit for organic compounds, or the instrument detection limit for inorganic compounds. The value is stored as a string of characters in order to retain significant digits. Unit of measure must be identical with the Result Unit field.
quantitation_limit	Text(20)						dt_result. quantitation_limit dt_result. quantitation_limit	Concentration level above which results can be quantified with a 95% confidence limit. Must reflect conditions such as dilution factors and moisture content. Report as the sample-specific quantitation limit.

Field Name	Data Type	Key	Required	Default	Parent	Lookup	Database Mapping(s)	Comment
Lab_Prep_Method_Name	Text(20)					rt_prep_method. prep_method	dt_test. Lab_Prep_Method_Name dt_test. prep_method	Description of sample preparation or extraction method.
Prep_Date	Date						dt_test. Prep_Date	mm/dd/yy. This field, in conjunction with extraction time, is used to determine whether holding times for field samples have been exceeded.
Prep_Time	Time						dt_test. Prep_Time	hh:mm. This field, in conjunction with extraction date, is used to determine whether holding times for field samples have been exceeded.
Test_Batch_ID	Text(20)						dt_test_batch. test_batch_id at_test_batch_assign. Test_Batch_ID dt_test_batch_assign. Test_Batch_ID	Sample preparation batch number assigned by the laboratory.
Result_Error	Text(20)						dt_result. Result_Error_Delta dt_result. Result_Error_Delta	Applicable only when reporting radiological sample results.
TIC_Retention_Time	Text(8)						dt_result. TIC_Retention_Time dt_result. TIC_Retention_Time	Retention time (HH:MM:SS) for tentatively identified compounds. May be used in the CAS number field to identify individual TICs as long as each retention time per sample per method of analysis is unique.
QC_Level	Text(10)						dt_test. QC_Level dt_test. QC_Level	Laboratory QC level associated with the analysis.
Comment	Text(255)						dt_result. remark dt_result. Result_Comment	Comments related to the analysis.
parent_sample_code	Text(40)						dt_sample. parent_Sample_Code dt_sample. parent_Sample_Code	Parent sample code.
task_code	Text(40)						dt_task. task_code dt_sample. task_code	Task code.
Default Mappings								
				LAB			rt_subcontractor. subcontractor_type	
				NA			dt_test. column_number	
				INITIAL			dt_test. test_type	
				PREP			dt_test_batch. test_batch_type	
				PREP			at_test_batch_assign. test_batch_type	
				PREP			dt_test_batch_assign. test_batch_type	
				Y			dt_result. reportable_result	
				Y			dt_result. organic_yn	
				Yes			dt_result. reportable_result	
Method Mappings								
				CompanyType_LAB			rt_company. company_type	
				CreateTestSurrogateKey			dt_test. test_surrogate_key	
				GetSampleDate			dt_sample. sample_date	
				GetSampleId			dt_field_sample. sample_id	
				GetSampleId			dt_test. sample_id	
				GetAnalysisDate			dt_test. Analysis_Date	
				GetPrepDate			dt_test. Prep_Date	
				GetTestID			at_test_batch_assign. test_id	
				CreateTestSurrogateKey			dt_test_batch_assign. test_surrogate_key	
				GetTestID			dt_result. test_id	
				CreateTestSurrogateKey			dt_result. test_surrogate_key	

Appendix B

Hold Point Release Form

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ENVIRONMENTAL DATA MANAGEMENT HOLD POINT RELEASE FORM

Contract/Project: _____

Charge Number: _____

Project Manager: _____

Data Coordinator: _____ Data Specialist: _____

Evidence was provided to the data manager for the following required database quality control checks. Data reviews require a 10% check at a minimum. Check the boxes to verify reviews were completed:

1. Database Quality Control Review ☐
2. Sample Summary Data Review (Field and Analytical Grid Report) ☐
3. EDDs Against Form Is Data Review ☐
4. Exported Result Table Data Review ☐
5. Statistical Tables Data Review ☐
6. EDD Tracking Sheet Completed ☐

Comments on the database including any limitations the project manager needs to be aware of:

Database Manager Signature _____ Date: _____

Note: ***By signing this you are authorizing that the data can be released by evidence of the required quality control checks in accordance with Quality Procedure 5.6, Environmental Data Management.***

Return for Follow-up Database review?* ☐ **Yes** ☐ **No**

Concurrence with Comment Resolution – When follow-up review is required

Database Manager's Signature: _____ Date: _____

*Only required if the evidence of quality control checks have been determined to be incomplete or unacceptable. Rev.0 – 4/23/2014

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Appendix C

VHA Privacy Program Policy

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Appendix F

Comment and Response Worksheet

Review Due Date		Report Date		DOCUMENT TITLE			Contract/TO Number	
10/25/2024		8/23/2024		Draft QAPP - PFAS Site Inspection 700 South 1600 East PCE Plume Site			Contract No. W912DQ-21-D-3004/Delivery Order No. W912DQ22F3063	
Item	**Source**	**Commentor**	**Line**	**Section**	**Page**	**Class**	**Comment**	**Response**
				General Comments				
1	EPA	NS					EPA Regional Screening Levels (RSLs) continue to be updated every six months as the state of the science surrounding per- and polyfluoroalkyl substances (PFAS) evolves. Federal facilities and contractors relevant to these projects should be aware of the expectation to incorporate the most recent EPA RSLs in any data analysis moving forward to ensure that human health and the environment continue to remain a priority in any delineation or remediation efforts as per the most recent EPA RSL tables.	VA recognizes that RSLs for PFAS are updated every six months. The text in Worksheet #11 (Project/Data Quality Objectives) will be revised to clarify that data will be compared to the most current version of the RSLs.
2	EPA	CL					It is the position of EPA Region 8 that regulator comments be included as an appendix to the QAPP as part of the administrative record for future project planning needs and assessments to document both EPA and Utah Department of Environmental Quality (UDEQ) involvement. Please include an additional appendix to the Draft QAPP for regulator comments.	VA will attach the EPA and UDEQ comments and responses as an appendix to the QAPP.
				Specific Comments				
1	EPA	CL/NS		WS 1 & 2	1		Please include either signature lines for both USEPA Region 8 RPM Shaun Cwick and UDEQ RPM Maureen Petit or include a statement within the worksheet that a letter of regulatory concurrence will be included as an appendix within the QAPP.	Text will be added to Worksheet # 1 & 2 to indicate that a letter of regulatory concurrence will be provided from EPA and UDEQ and included as an appendix in the QAPP.
2	EPA	CL		WS 3 & 5	4		Remove USEPA Region 8 QA Branch Manager Mary Goldade from the distribution list, as RPM Shaun Cwick is a Delegated QA Approved Officer.	Mary Goldade has been removed from the distribution list and the organization chart.
3	EPA	CL		WS 3 & 5	4		Please specify the analytical laboratory to be used in the sampling effort as EPA will need to review analytical procedures and certifications, and identify all field team leaders for this project within the distribution chart.	The analytical laboratory, Sterling Labs, has been added to the QAPP. Field team leaders have been added to the organization chart
4	EPA	CL		WS 4, 7, 8	7		Please specify the analytical laboratory to be used in the sampling effort as the QAPP will require a signature from the analytical laboratory prior to approval. Additionally please add the Site Safety and Health Officer, the lead organization contact, and the regulatory agencies to the sign-off sheet.	The appropriate signature lines for the analytical laboratory, site safery and health officer, and lead agency representatives have been added to Worksheet #4, 7, 8. The regulatory agencies (EPA and UDEQ) are not typically signatories to the QAPP and are not responsible for implementation of the QAPP; therefore have not been added to Worksheet #4, 7, and 8.
5	EPA	NS		WS 6	9		For major deviations from the QAPP, EPA and UDEQ should also be informed and concurrence obtained.	Worksheet #6 has been revised to indicate that notification and concurrence from EPA and UDEQ will be obtained for major deviations.
6	EPA	CL		WS 6	13		Please include following communication drivers within WS 6: Regulatory agency interface, Field progress reports, and Stop work due to safety issues as outlined within the UFP-QAPP Guidance.	These communication drivers have been added to Worksheet #6
7	EPA	NS		WS 10	15		Recommend adding a brief summary to the third paragraph of the "Site Overview" of potential PFAS sources associated with medical equipment/supplies/wastewater. The "Site Overview" should provide a more brief discussion of what is presented in the following "Historical PFAS Usage" section.	The third paragraph of the site overview section has been updated to include a brief summary of potential historical uses of PFAS at the facility.
8	EPA	CL		WS 10	18		Please describe the site hydrology, climate, land use considerations, and identify any data gaps and uncertainties associated with the CSM.	The section has been revised to provide more information related to hydrologic setting, climate, and land use. A brief section on data gaps and uncertainties in the CSM has been added; however, note that the CSM for PFAS at the site is in the initial development stage and is primarily focused on identification of potential sources, receptors, and pathways between the two.
9	EPA	CL		WS 10	19		Have there been any reported material spills at the site that may contain PFAS?	The text has been revised to state that the VA does not have records of spills of PFAS-containing materials at the site.
10	EPA	NS		WS 11	20		Step 2. Should soil also be considered as a potential source to groundwater? If so, please include a discussion that areas near sewer pipes/discharge points will be targeted in the future if groundwater detections are present?	The study questions and potential outcomes in Step 2 have been revised to indicate that if PFAS are detected in groundwater, additional investigation, including potential investigation of soil near potential or suspected release points, may be considered.
11	EPA	NS		WS 11	21		Step 2. Question 2, how will the groundwater detections (if present) be attributed to specific sources given the data collection that is planned? Given the long distance between likely sources and groundwater detections for PCE, if the same occurs for PFAS, how will the likely sources be determined? Should samples from near potential discharge points be collected to aid source composition evaluation?	The text has been revised to clarify that types of PFAS compounds detected in groundwater would be evaluated against known historical uses at the VAMC campus as described in the PA. If PFAS compounds cannot be tied to identified historical uses, then additional investigation may be warranted to attempt to identify sources, including potential investigation of soils near potential/suspected release locations at the VAMC campus.
12	EPA	CL		WS 11	21		Step 2. The last sentence states that if PFAS are not detected at concentrations above applicable RSLs then no further action is required. Please include that "no further investigation of PFAS is necessary in groundwater at this time."	The text has been revised accordingly.
13	EPA	NS		WS 11	21		Step 4. Need to include a reference to the target analytes for the study and temporal information per UFP-QAPP guidance.	The text in Step 4 has been revised to describe the target analytes and the temporal boundaries of the study
14	EPA	NS		WS 11	21		Step 5. Recommend also comparing PFAS concentrations in downgradient wells to upgradient/background wells.	The text has been revised to indicate that PFAS concentrations will be compared between upgradient and downgradient wells within the study area.
15	EPA	NS		WS 11	21		Step 5. PFAS detections should be compared to the most recent RSLs/MCLs.	The text has been revised to indicate that PFAS detections will be compared to the most recent RSLs/MCLs.
16	EPA	NS/CL		WS 11	22		Step 6. If significant issues with the data are found, regulatory input on any decisions for data usage would be required.	The text has been revised to state that if significant issues are encountered with the analytical data, the VA and USACE, in consultation with EPA and UDEQ, will discuss the usability of the data for decision making.
17	EPA	CL		WS 12	23		Please modify table to outline specific contract laboratory requirements. Industry standard for field duplicates of aqueous PFAS samples is ≤ 30% please modify accordingly. Additionally, please explain why the completeness DQI is less than 100%, and include analytical methods as an appendix to this document.	The text has been revised to include laboratory-specific information to Worksheet #12. The field duplicate RPD criterion was revised to 30%. It is likely that the objectives of the study (evaluating whether PFAS compounds are present in groundwater) will still be met even if data completeness is slightly less than 100 percent; however, any data which are rejected, or samples which are unable to be collected, will be evaluated to determine whether the data are adequate to meet the objectives of the study.

Comment and Response Worksheet

Review Due Date			Report Date				DOCUMENT TITLE	Contract/TO Number
10/25/2024			8/23/2024				Draft QAPP - PFAS Site Inspection 700 South 1600 East PCE Plume Site	Contract No. W912DQ-21-D-3004/Delivery Order No. W912DQ22F3063
Item	**Source**	**Commentor**	**Line**	**Section**	**Page**	**Class**	**Comment**	**Response**
18	EPA	NS		WS 13	25		What types of historical data will be used as secondary data? Please list specific sources and any applicable limitations.	Secondary data applicable to the PFAS SI consist predominantly of geological/hydrogeological data and analytical data collected during the remedial investigation for PCE at the site. These data are all presented in the RI report. The text has been revised to indicate these specific data types, as well as to indicate that the data collected during the RI were collected under approved Quality Assurance Project Plans, and that no limitations on use of the data were presented in the RI.
19	EPA	CL		WS 14 & 16	26		Please include additional detail within the project timeline including tasks such as additional scoping meetings if applicable, finalization of the QAPP, sample analysis, IDW management and disposal, data validation, Draft Supplemental RI Report, and Final Supplemental RI Report.	The approximate schedule for these tasks has been added to Worksheet #14 & 16.
20	EPA	CL		WS 15	27		Please include laboratory specific LOQs and LODs.	The laboratory LOQs and LODs have been added to the text.
21	EPA	NS		WS 17	31		None of the proposed monitoring well locations are upgradient, as discussed in DQO Step 4. Please review and clarify within the document. Please confirm within the table whether the selected wells exhibit elevated PCE associated with the known source areas for the PCE plume. Please confirm within the table what the screened intervals are, and typical water level elevation/depth to water.	The description of monitoring well MW-05 has been revised to describe it as upgradient of the PCE plume and cross-gradient of Building 2 where PFAS were present but no known releases occurred. A table has been added to Worksheet #17 with well construction information, screen intervals, depth to water measurements, and recent PCE concentrations for the wells to be sampled during the SI.
22	EPA	CL		WS 17	34		Pump intake should vary if well screen interval is not fully saturated. Please modify language accordingly.	A table has been added to Worksheet #17 with well construction information, screen intervals, and depth to water measurements. All wells proposed for sampling have fully submerged screen intervals; therefore pumps will be placed in the center of the screen intervals except for ZIST pumps as described, which seat to a receiver at the top of the screen interval.
23	EPA	NS		WS 17	34		Groundwater Sampling section, ZIST wells. Do these well types use any PTFE components that may bias results?	According to the pump manufacturer, the ZIST pumps (model Panacea P100) do not use PTFE components; the pumps are constructed of stainless steel, nitrile seals, and HDPE filters. Existing Teflon-lined tubing for these pumps will be removed from the wells and replaced with HDPE tubing prior to collection of PFAS samples. The text has been updated accordingly.
24	EPA	CL/NS		WS 17	34		EPA is concerned regarding the discussion of pump placement within an apparent large number of wells to be sampled for this effort. For existing wells MW-03R and MW-29, will the samples be collected using ZIST pumps, or a different approach? If ZIST pumps are unable to be used, are there replacement wells or nearby wells that could be utilized to get representative samples within the well screen or perhaps a smaller pump or sampling methodology that might be able to be employed to compare the samples at the top of the screened interval to concentrations from within the screened interval?	As described in response to Comment #23, the ZIST pumps are constructed of PFAS-free materials and can be used as intended for collection of PFAS samples. Existing Teflon-lined tubing for these pumps will be removed and replaced with HDPE tubing prior to collection of PFAS samples. The text in Worksheet #17 has been modified to clarify this. Use of ZIST pumps as designed at MW-03R, MW-30C, and MW-29 should alleviate concerns about pump placement in the well screens at ZIST wells.
25	EPA	CL		WS 17	34		Note that samples with a turbidity higher than or equal to 10 NTUs have been shown to potentially bias PFAS concentration results. Recommend making every effort to reduce turbidity during sample collection or initiation of additional evaluation of the potential need for monitoring well redevelopment should turbidity levels come back higher than anticipated.	The text has been revised to reiterate the importance of low turbidity readings during sampling (less than 10 NTU) and that efforts will be undertaken to reduce turbidity during sample collection. If turbidity remains elevated during sampling at specific wells, VA will consult with EPA and UDEQ regarding the usability or potential bias in data from samples with turbidity greater than 10 NTU. Additional sampling approaches may also be considered, such as passive diffusion bag samplers, in the event that turbidity cannot be reduced during low-flow sampling.
26	EPA	CL		WS 17	34		Request synoptic water levels throughout the monitoring network be taken prior to beginning sampling efforts. Additionally consider pairing sampling with ongoing sampling efforts and collection of a round of synoptic water levels throughout the existing monitoring well network to produce a more comprehensive snapshot of local water variations and flow paths.	The text has been revised to indicate that synoptic water levels will be measured at the monitoring wells within the study area for PFAS sampling, which will consist of all site monitoring wells located east of Guardsman Way.
27	EPA	CL		WS 17	35		Additional precautions for decontamination during PFAS sampling should be included within the section on decontamination including the use of only Alconox® and Liquinox® detergents and consider an additional rinse with PFAS-free lab grade water for all reusable sampling equipment including not only any pump(s) used for low-flow sampling, but the water level meter as well. Note that the SOP outlines some practices that may not be appropriate for PFAS sampling. Please include language to that effect within the QAPP and specify which components are not applicable or add a PFAS-specific SOP for decontamination purposes.	The text in QAPP Worksheet #17 has been revised to provide more clear procedures for decontamination of materials to be used for PFAS sampling (sampling pumps and water level meters). Decontamination for items used during sampling and other activities at the site will consist of a wash with Alconox or Liquinox and then triple rinse with PFAS free water that has been supplied by the laboratory. The decontamination SOP (SOP 4-5) is a general decontamination SOP and includes many methods and approaches for decontamination of field equipment and is not intended to be prescriptive (i.e. that all methods described must be followed). The procedures described in the QAPP Worksheet #17 take precedence.
28	EPA	CL		WS 17	36		Please indicate sampling locations on a figure/location map within the QAPP main document.	A figure with sample locations has been added to the QAPP.
29	EPA	CL		WS 18	37		Please include QA/QC samples in the WS 18 chart as well as a reference to figures identifying sample locations.	Worksheet #18 has been updated to include QA/QC samples (field duplicate, field blank, and equipment rinsate blank samples) as well as a reference to Figure 1 showing the sample locations.
30	EPA	CL		WS 22	41		Note that groundwater samples with a turbidity ≥10NTUs have been proven to cause interference and bias in laboratory results. Should a sample be taken with higher than or equal to 10 NTUs turbidity, EPA will expect either resampling and/or redevelopment of the existing well to ensure data sufficient for decision-making purposes.	Please see response to Comment 25 and the applicable revisions to Worksheet #17 to address turbidity during sampling being less than 10 NTU. No updates were made to Worksheet #22, which describes field equipment calibration, maintenance, testing, and inspection.
31	EPA	CL		WS 28	48		The QC field duplicates should be 1 per sample batch not >10 samples as per prior QAPP specifications. Additionally, please include specifications for the method blank.	The field duplicate collection frequency in Worksheet #28 was revised to be one per batch of not more than 10 samples, consistent with other worksheets in the QAPP. A row was added to Worksheet #28 to describe the laboratory method blank specifications.
32	EPA	CL		WS 36	61		Clarify how this incorporates an independent third party review for data validation. Please edit according to the UFP-QAPP guidance, adding the appropriate categories listed within.	The text has been modified to indicate that the staff conducting data validation will be independent of the field sampling team and of the analytical laboratory.
33	EPA	NS		SOP 2-2			There is no discussion of IDW sampling methods within the QAPP. Please incorporate as appropriate.	Text was added to Worksheet #17 to describe collection of IDW samples. Liquid IDW generated during sampling is stored in polyethylene tanks on site, and a representative sample of the tank is collected using a disposable bailer or peristaltic pump to characterize the IDW for profiling and disposal.

Comment and Response Worksheet

Review Due Date			Report Date				DOCUMENT TITLE	Contract/TO Number
10/25/2024			8/23/2024				Draft QAPP - PFAS Site Inspection 700 South 1600 East PCE Plume Site	Contract No. W912DQ-21-D-3004/Delivery Order No. W912DQ22F3063
Item	**Source**	**Commentor**	**Line**	**Section**	**Page**	**Class**	**Comment**	**Response**

End.

Column A:	Comment Identifier Number
Column B:	Source (Commenter/Authority)
Column C:	Line Number of Comment (first line associated
Column D:	Section Number of Comment
Column E:	Page Number of Comment (first page associated with comment)
Column F:	Comment Classification
Column G:	Comment
Column H:	Response
Column I:	Government Response to Contractor
	Comments must be actionable ("add the following text:…", "delete…", "change text to:")
Notes:	Place only one comment per row.
	Classify comment as C, S, or A.

Comment Classifications

(C) Technically Critical: Issues that affect the overall objective of the document with significant risk of unsuccessful performance and/or regulatory approval. Provide convincing support.

(S) Technically Substantive: Issues that affect the overall objective of the document with minimum or moderate risk of unsuccessful performance and/or regulatory approval.

(A) Administrative Error: Issues that should have been fixed using the "Hill AFB ORC General Document Checklist" or other editorial errors that are not explicitly found within the document checklist.

Comment and Response Worksheet

Review Due Date					DOCUMENT TITLE	
10/28/2024					Draft QAPP - PFAS Site Inspection 700 South 1600 East PCE Plume Site	
Item	**Source**	**Commentor**	**Section**	**Page**	**Comment**	**Response**
1	UDEQ/DERR	MP	WS 1 & 2	1	Please note, UDEQ RPM Maureen Petit will provide a letter of regulatory concurrence to be included as an appendix within the QAPP.	Text will be added to Worksheet # 1 & 2 to indicate that a letter of regulatory concurrence will be provided from EPA and UDEQ.
2	UDEQ/DERR	MP	WS 3 & 5	4	Please specify the analytical laboratory that will be used during the sampling effort.	The analytical laboratory, Sterling Labs has been added to the QAPP.
3	UDEQ/DERR	MP	WS 13	25	Please specify what historical data will utilized as secondary data.	Secondary data applicable to the PFAS SI consist predominantly of geological/hydrogeological data and analytical data collected during the remedial investigation for PCE at the site. These data are all presented in the RI report. The text has been revised to indicate these specific data types, as well as to indicate that the data collected during the RI were collected under approved Quality Assurance Project Plans, and that no limitations on use of the data were presented in the RI.
4	UDEQ/DERR	MP	WS 14 & 16	26	Please include the finalization of the QAPP in the project schedule.	The approximate schedule for this task has been added to Worksheet #14 & 16.
5	UDEQ/DERR	MP	WS 17	35	Please specify which detergents could be utilized during decontamination practices.	The text has been revised to clarify that either Alconox or Liquinox will be used for decontamination.
7	UDEQ/DERR	MP	WS 31, 32, & 33	56	Please note, major deviations from the QAPP must also be shared with EPA and UDEQ for approval. Additionally, the UDEQ and EPA RPMs hold stop work authority.	The text in Worksheet #31, 32, and 33 has been revised to indicate that major deviations from the QAPP will be communicated to EPA and UDEQ for review and concurrence. The text was also revised to indicate that EPA and UDEQ RPMs have stop work authority.
8	UDEQ/DERR	MP	Figures	N/A	Please include a second figure that delineates the PCE Plume boundaries in relation to the PFAS sampling locations.	A figure presenting the PCE plume boundaries related to the PFAS sampling locations has been added.

Appendix G

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
Denver, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

January 23, 2025

Sent by email

Ref: 8SEMD-RB

Ms. Shannon Smith
CERCLA Program Manager
Veterans Affairs Salt Lake City

Re: Draft Final Quality Assurance Project Plan PFAS Site Inspection, 700 South 1600 East PCE Plume Site, Operable Unit 1, Salt Lake City, Utah

Dear Ms. Smith:

The U.S. Environmental Protection Agency has reviewed the Draft Final Quality Assurance Project Plan PFAS Site Inspection, 700 South 1600 East PCE Plume Site, Operable Unit 1, Salt Lake City, Utah. The document was prepared by CDMSmith on behalf of the Department of Veterans Affairs Veterans Health Administration Salt Lake City Health Care System. Based on the review of the document, EPA has no additional comments.

If you have any questions, please contact me at cwick.shaun@epa.gov or (720) 843-6569.

Sincerely,

Shaun Cwick, P.G.
Remedial Project Manager
EPA – Superfund Remedial Branch

cc:
Maureen Petit, WDEQ, Remedial Project Manager mpetit@utah.gov

State of Utah

SPENCER J. COX
Governor

DEIDRE HENDERSON
Lieutenant Governor

Department of
Environmental Quality

Kimberly D. Shelley
Executive Director

DIVISION OF ENVIRONMENTAL
RESPONSE AND REMEDIATION

Brent H. Everett
Director

ERRS-014-25

February 3, 2025

George E. Whalen
Department of Veterans Affairs
ATTN: Shannon Smith
CERCLA Program Manager
500 Foothill Drive, Mail Stop #138
Salt Lake City, Utah 84113

RE: Draft Final Quality Assurance Project Plan, PFAS Site Inspection

Dear Ms. Smith:

The Division of Environmental Response and Remediation (DERR) reviewed the Draft Final Quality Assurance Project Plan, PFAS Site Inspection for the 700 S 1600 E PCE Plume Site received on December 19, 2024. The DERR has no additional comments and concurs with finalizing the document.

If you have any questions, please contact me at (385) 391-8127.

Sincerely,

Maureen Petit (Feb 3, 2025 15:50 MST)

Maureen Petit, Project Manager
Division of Environmental Response and Remediation

MP/lg

ecc: Shaun Cwick, U.S. Environmental Protection Agency, Region 8