Memo

SUBJECT
2026 Groundwater PFAS Sampling Plan
RACER Trust – Buick City, Flint, Michigan

TO
Evin Maguire – EGLE
Jeremy Pepin – EGLE
Shaun Shields – EGLE

DATE
May 20, 2026

OUR REF
30324893

COPIES TO
Brendan Mullen – RACER Trust
Dave Favero – RACER Trust

NAME
Patrick Curry – Arcadis
patrick.curry@arcadis.com

On behalf of Revitalizing Auto Communities Environmental Response (RACER) Trust, Arcadis of Michigan, LLC (Arcadis) has prepared this work plan for sampling groundwater at select monitoring wells for per- and polyfluoroalkyl substances (PFAS) analysis at RACER Buick City (Site) in Flint, Michigan. The purpose of the sampling is to assess trends in plume concentrations for Plumes 1, 2, 5, 6, and 7. The plumes are associated with a source area located north of Hamilton Ave in the Building 44 area (Plume 1), the north end of Building 40 (Plume 2), the vicinity of Building 86 (Plume 5), former Wastewater Aeration Lagoons (Plume 6), and former Foam Generation Building (Plume 7). Plume extents were interpreted based on available groundwater data. The plumes are depicted on **Figure 1**, along with the most recent PFAS groundwater analytical results compared to Michigan Part 201 Groundwater-Surface Water Interface Criteria.

Groundwater sampling is proposed for 118 monitoring wells, as listed in **Tables 1** through **4**. Sampling of up to 56 wells within Plumes 1 and 2 is proposed to continue trend analysis at wells that were sampled in November 2025. Sampling of Plumes 5, 6, and 7 is proposed to assess current conditions within those plumes. Up to 9 wells are proposed for sampling within Plume 5, up to 34 wells are proposed for sampling within Plume 6, and up to 19 wells are proposed for sampling within Plume 7. Plumes 3 and 4 are delineated within the current and former RACER-owned properties and are not prioritized for sampling at this time.

The wells are categorized as shallow and deep. In general, shallow wells are screened at the water table or within 5 feet of the water table and typically screened within 15 feet of the ground surface but may be deeper if the groundwater table is deeper. Deep wells are typically screened greater than 5 feet below the water table.

Well inspections were performed as part of the well selection process to confirm the accessibility and suitability of wells for sampling. The wells were selected for sampling within each area as follows:

- The proposed well network for Plumes 1 and 2 consists predominantly of the wells sampled in November 2025, plus two additional wells that were not sampled. One of the two wells, MW-84-73(7-12) was not sampled due to an observed non-aqueous phase liquid (NAPL) sheen. If observed again, the well will be sampled by either decanting the NAPL prior to filling the sample vial or collecting the sample from the bottom of a bailer to avoid the NAPL. The other well, MW-84-77(6-16), could not be found. It is uncertain whether this well may have been hidden beneath a vehicle, so another attempt to find and sample the well will be performed. Additionally, the wells previously sampled within Hamilton Avenue have been damaged and are proposed for abandonment. Analytical results from these wells represent concentrations immediately downgradient of the proposed collection trench. A parallel transect of wells north of Hamilton Avenue, approximately coincident with the proposed trench alignment, are proposed to be sampled as replacements.

- Available wells within and near Plume 5 will be sampled. Many wells within the defined plume extent were abandoned in 2023 in association with property redevelopment activities. The wells that are available for sampling are located within the downgradient end of the defined plume area.
- Most wells within and immediately adjacent to Plume 6 have been selected for sampling. Wells not selected within the plume extents include those that could not be located during the inspection or were classified as being in poor condition. Additionally, select wells from the downgradient edge of the lagoon were excluded because they are largely redundant with other wells along James P. Cole Blvd.
- Available wells from within the Plume 7 extent were selected for sampling, and nearby wells were also included. Wells not selected from within the Plume 7 extent could not be located or are damaged and unavailable for sampling.

Sampling will be conducted in accordance with the Arcadis technical guidance instruction (TGI): *TGI – Per- and Polyfluoroalkyl Substances (PFAS) Field Sampling Guide,* and *TGI – Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells* included as **Attachment 1**. Sampling will be completed using low-flow groundwater purging and sampling procedures in accordance with the TGI guidance.

Equipment decontamination will be performed in accordance with *TGI – Groundwater and Soil Sampling Equipment Decontamination*, including a water level meter, multiparameter meter, and if needed a submersible pump. Note a submersible pump will only be used if the well is too deep for a peristaltic pump. Two equipment blanks will be collected with decontaminated sampling equipment in accordance with *TGI - Equipment and Reagent Blank Sample Collection for PFAS Analysis*. Duplicate samples will be collected at a frequency of 1 duplicate sample for every 10 samples (12 total) and matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of 1 MS/MSD sample for every 20 samples (5 total). The equipment decontamination and sample blank collection TGIs are included in **Attachment 1**.

Groundwater samples will be analyzed by Merit Laboratories, Inc. by modified method ASTM D7979 (**Attachment 2**). The reported analytes will include the 34 compounds listed in **Table 5**. Results of the sampling will be compared to the Michigan Environment, Great Lakes, and Energy (EGLE) Part 201 groundwater-surface water interface (GSI) criteria and provided to EGLE electronically within sixty (60) days of completion of the sampling event (R 299.9611 Environmental Monitoring, Rule 611(6)) and later as a summary report. Analytical results will be managed using the EQuIS database.

One use of the PFAS data will be to help develop an interim groundwater monitoring plan for PFAS and other compounds (e.g., VOCs associated with vapor intrusion monitoring) at the Site. The interim monitoring plan will be developed in the second half of 2026, targeting 4th quarter for the inaugural event.

Enc.

Figures

1 Area Wide PFAS Results

2 Plume 1 and 2 PFAS Monitoring Well Sampling Locations

3 Plume 5 PFAS Monitoring Well Sampling Locations

4 Plume 6 PFAS Monitoring Well Sampling Locations

5 Plume 7 PFAS Monitoring Well Sampling Locations

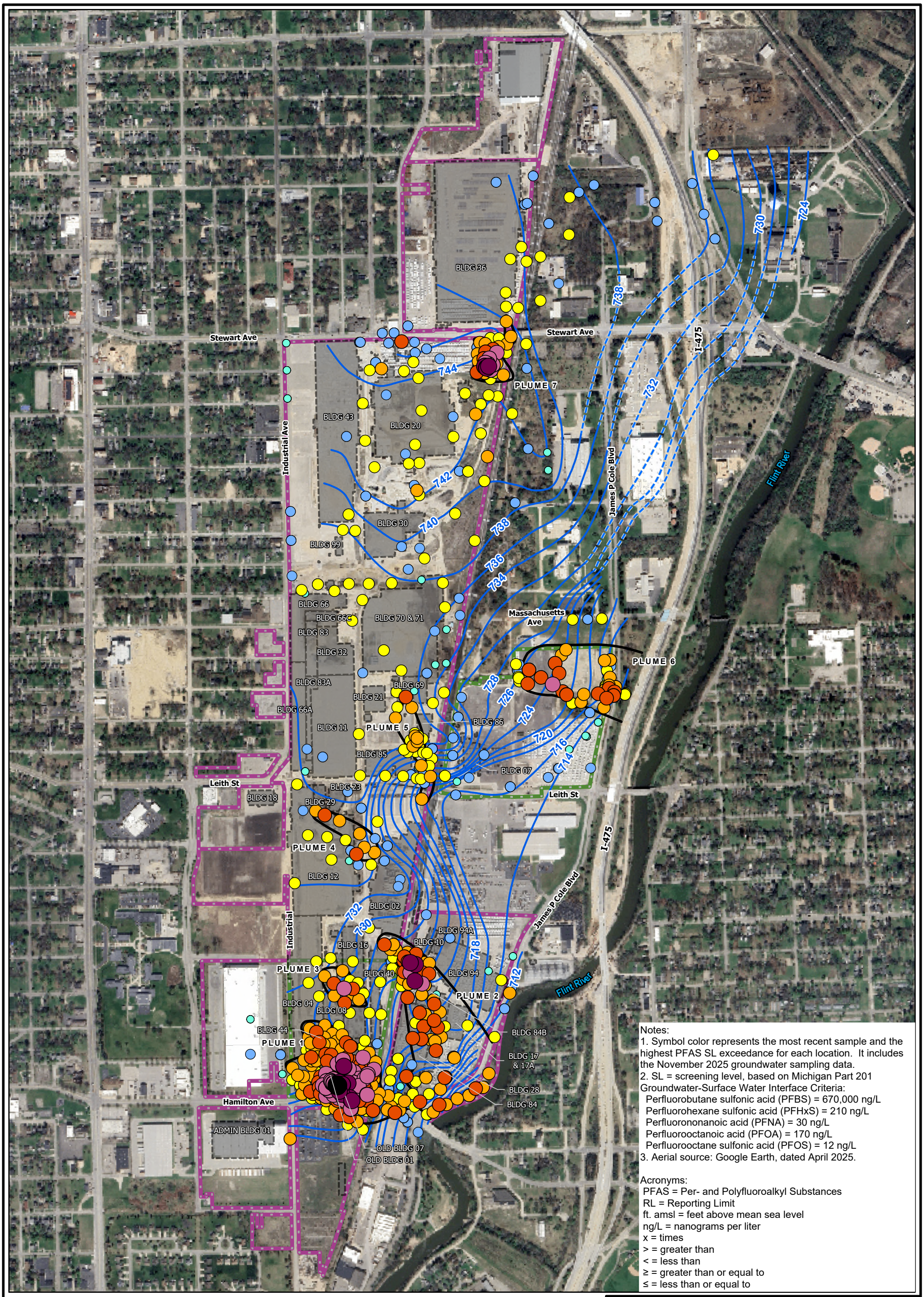
Tables

1. Plumes 1 and 2 Proposed PFAS Sampling List
2. Plume 5 Proposed PFAS Sampling List
3. Plume 6 Proposed PFAS Sampling List
4. Plume 7 Proposed PFAS Sampling List
5. PFAS Analyte List

Attachments

1. Technical Guidance Instructions
2. Laboratory Standard Operating Procedure for ASTM D7979

Figures



Notes:
1. Symbol color represents the most recent sample and the highest PFAS SL exceedance for each location. It includes the November 2025 groundwater sampling data.
2. SL = screening level, based on Michigan Part 201 Groundwater-Surface Water Interface Criteria:
   Perfluorobutane sulfonic acid (PFBS) = 670,000 ng/L
   Perfluorohexane sulfonic acid (PFHxS) = 210 ng/L
   Perfluorononanoic acid (PFNA) = 30 ng/L
   Perfluorooctanoic acid (PFOA) = 170 ng/L
   Perfluorooctane sulfonic acid (PFOS) = 12 ng/L
3. Aerial source: Google Earth, dated April 2025.

Acronyms:
PFAS = Per- and Polyfluoroalkyl Substances
RL = Reporting Limit
ft. amsl = feet above mean sea level
ng/L = nanograms per liter
x = times
> = greater than
< = less than
≥ = greater than or equal to
≤ = less than or equal to

LEGEND

Highest PFAS Exceedance in Groundwater Sample

- Greater than 100,000x SL
- >10,000x to 100,000x the SL
- >1,000x to 10,000x the SL
- >100x to 1,000x the SL
- >10x to 100x the SL
- ≥SL to 10x the SL
- Detection < SL
- Non-detect (RL > SL)
- Non-detect (RL ≤ SL)

- Potentiometric Surface Contour, October 2022 (ft. amsl)
- Interpreted PFAS Groundwater Plume > 10x SL
- Former Building Footprints
- Former Building Footprints (Older Buildings)
- Current RACER-owned Properties
- Former RACER-owned Properties

N

0 500 1,000
GRAPHIC SCALE IN FEET

RACER TRUST
BUICK CITY, FLINT, MI
2026 PFAS GROUNDWATER SAMPLING WORK PLAN

AREA-WIDE PFAS RESULTS

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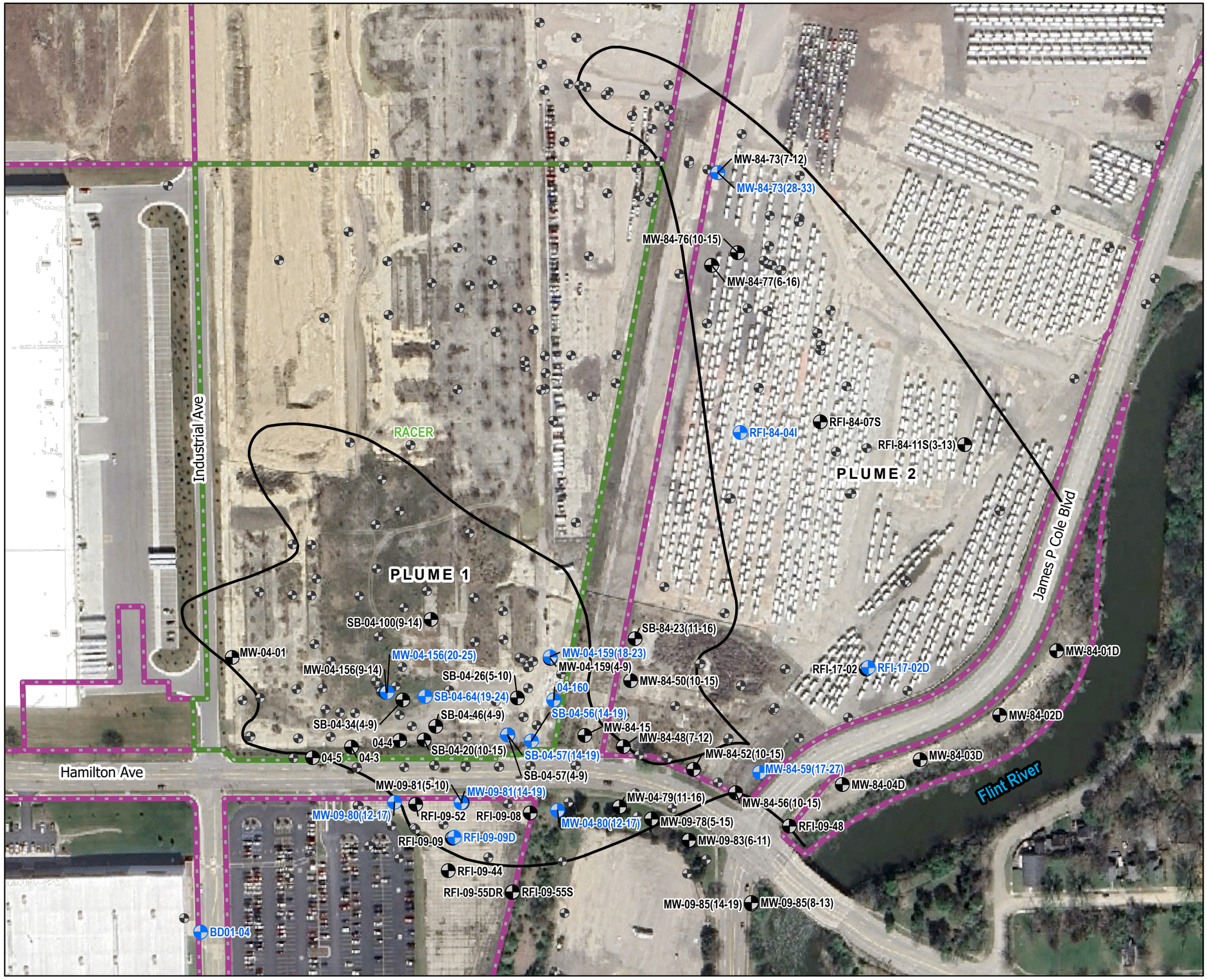
FIGURE
1



LEGEND

- PFAS Monitoring Well Sampling Location - Shallow
- PFAS Monitoring Well Sampling Location - Deep
- Other Existing Active Monitoring Well
- Interpreted PFAS Groundwater Plume > 10x SL
- Current RACER-owned Properties
- Former RACER-owned Properties

Note:
1. Aerial source: Google Earth, dated April 2025.

Acronyms:
PFAS = Per- and Polyfluoroalkyl Substances
SL = screening level, based on Michigan Part 201 Groundwater-Surface Water Interface Criteria
x = times
> = greater than

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GRAPHIC SCALE IN FEET

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RACER TRUST
BUICK CITY, FLINT, MI
2026 PFAS GROUNDWATER SAMPLING WORK PLAN

PLUME 1 AND 2 PFAS MONITORING WELL SAMPLING LOCATIONS

ARCADIS

FIGURE
2

Path: T:_ENV\RACER_BuickCity_Prof\Figures\PFAS groundwater sampling work plan 2026.aprx\Figure 2 - Plume 1 and 2 PFAS Monitoring Well Sampling Locations Last Saved By: mg01044 5/15/2026

LEGEND

- PFAS Monitoring Well Sampling Location - Shallow
- PFAS Monitoring Well Sampling Location - Deep
- Other Existing Active Monitoring Well
- Interpreted PFAS Groundwater Plume > 10x SL
- Current RACER-owned Properties
- Former RACER-owned Properties

Note:
1. Aerial source: Google Earth, dated April 2025.

Acronyms:
PFAS = Per- and Polyfluoroalkyl Substances
SL = screening level, based on Michigan Part 201 Groundwater-Surface Water Interface Criteria
x = times
> = greater than

0 150 300

GRAPHIC SCALE IN FEET

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RACER TRUST
BUICK CITY, FLINT, MI
2026 PFAS GROUNDWATER SAMPLING WORK PLAN

PLUME 5 PFAS MONITORING WELL SAMPLING LOCATIONS

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FIGURE
3

Path: T:_ENV\RACER_BuickCity_Prof\Figures\PFAS groundwater sampling work plan 2026.aprx\Figure 3 - Plume 5 PFAS Monitoring Well Sampling Locations Last Saved By: mgl01044 5/15/2026

LEGEND

- PFAS Monitoring Well Sampling Location - Shallow
- PFAS Monitoring Well Sampling Location - Deep
- Other Existing Active Monitoring Well
- Interpreted PFAS Groundwater Plume > 10x SL
- Current RACER-owned Properties

Note:
1. Aerial source: Google Earth, dated April 2025.

Acronyms:
PFAS = Per- and Polyfluoroalkyl Substances
SL = screening level, based on Michigan Part 201 Groundwater-Surface Water Interface Criteria
x = times
> = greater than

0 125 250

GRAPHIC SCALE IN FEET

N

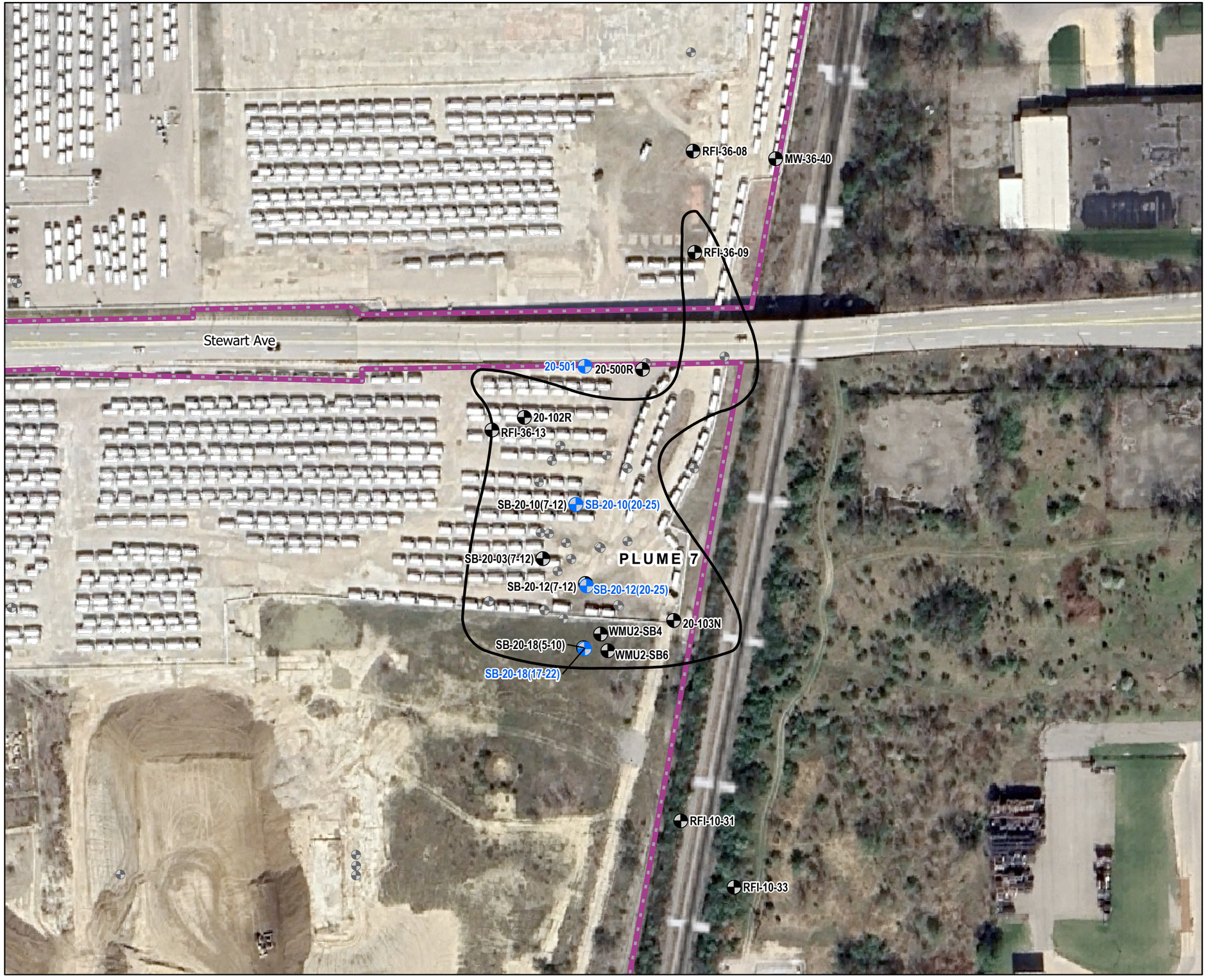
RACER TRUST
BUICK CITY, FLINT, MI
2026 PFAS GROUNDWATER SAMPLING WORK PLAN

PLUME 6 PFAS MONITORING WELL SAMPLING LOCATIONS

ARCADIS

FIGURE
4

Path: T:_ENV\RACER_BuickCity_Prof\Figures\PFAS groundwater sampling work plan 2026.aprx\Figure 4 – Plume 6 PFAS Monitoring Well Sampling Locations Last Saved By: mg010441 5/15/2026



LEGEND

- PFAS Monitoring Well Sampling Location - Shallow
- PFAS Monitoring Well Sampling Location - Deep
- Other Existing Active Monitoring Well
- Interpreted PFAS Groundwater Plume > 10x SL
- Former RACER-owned Properties

Note:
1. Aerial source: Google Earth, dated April 2025.

Acronyms:
PFAS = Per- and Polyfluoroalkyl Substances
SL = screening level, based on Michigan Part 201 Groundwater-Surface Water Interface Criteria
x = times
> = greater than

0 125 250
GRAPHIC SCALE IN FEET

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RACER TRUST
BUICK CITY, FLINT, MI
2026 PFAS GROUNDWATER SAMPLING WORK PLAN

PLUME 7 PFAS MONITORING WELL SAMPLING LOCATIONS

ARCADIS

FIGURE
5

Path: T:_ENVIRACER_BuickCity_Pro4\Figures\PFAS groundwater sampling work plan 2026.aprx\Figure 5 - Plume 7 PFAS Monitoring Well Sampling Locations Last Saved By: mg01044 5/15/2026

Tables

Table 1
Plumes 1 and 2 Proposed PFAS Sampling List
RACER Buick City
Flint, Michigan

Well ID	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Zone
Plume 1			
04-160	15	22	Deep
04-3	4	14	Shallow
04-4	2.5	12.5	Shallow
04-5	NM	NM	Shallow
BD01-04	11	21	Deep
MW-04-01	5	10	Shallow
MW-04-156(20-25)	20	25	Deep
MW-04-156(9-14)	9	14	Shallow
MW-04-159(18-23)	18	23	Deep
MW-04-159(4-9)	4	9	Shallow
MW-04-79(11-16)	11	16	Shallow
MW-04-80(12-17)	12	17	Deep
MW-09-78(5-15)	5	15	Shallow
MW-09-80(12-17)	12	17	Deep
MW-09-81(14-19)	14	19	Deep
MW-09-81(5-10)	5	10	Shallow
MW-09-83(6-11)	6	11	Shallow
MW-09-85(14-19)	14	19	Shallow
MW-09-85(8-13)	8	13	Shallow
MW-84-15	3	13	Shallow
MW-84-48(7-12)	7	12	Shallow
MW-84-50(10-15)	10	15	Shallow
MW-84-52(10-15)	10	15	Shallow
MW-84-56(10-15)	10	15	Shallow
RFI-09-08	3.8	13.8	Shallow
RFI-09-09	3.8	13.8	Shallow
RFI-09-09D	17	22	Deep
RFI-09-44	5	15	Shallow
RFI-09-52	5	15	Shallow
RFI-09-55DR	13	18	Shallow
RFI-09-55S	5	15	Shallow
SB-04-100(9-14)	9	14	Shallow
SB-04-20(10-15)	10	15	Shallow
SB-04-26(5-10)	5	10	Shallow
SB-04-34(4-9)	4	9	Shallow
SB-04-46(4-9)	4	9	Shallow
SB-04-56(14-19)	14	19	Deep
SB-04-57(14-19)	14	19	Deep
SB-04-57(4-9)	4	9	Shallow
SB-04-64(19-24)	19	24	Deep
SB-84-23(11-16)	11	16	Shallow
Plume 2			
MW-84-01D	10	20	Shallow
MW-84-02D	16	26	Shallow
MW-84-03D	17	22	Shallow
MW-84-04D	12	22	Shallow
MW-84-59(17-27)	17	27	Deep
MW-84-73(28-33)	28	33	Deep
MW-84-73(7-12)	7	12	Shallow
MW-84-76(10-15)	10	15	Shallow
MW-84-77(6-16)	6	16	Shallow
RFI-09-48	8	18	Shallow
RFI-17-02	4	14	Shallow
RFI-17-02D	14	24	Deep
RFI-84-04I	29	34	Deep
RFI-84-07S	11	21	Shallow
RFI-84-11S(3-13)	3	13	Shallow

Notes:
ft bgs = feet below ground surface
NM = Not Measured

Table 2
Plume 5 Proposed PFAS Sampling List
RACER Buick City
Flint, Michigan

Well ID	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Zone
RFI-SS-01	2.5	12.5	Shallow
RFI-SS-02	2.5	12.5	Shallow
RFI-86-01R	21	26	Shallow
RFI-86-15	10	20	Deep
RFI-86-06SR	10	15	Shallow
RFI-86-06DR	20	25	Shallow
RFI-86-16R	10	20	Deep
07-01	8	18	Deep
RFI-81-12R	8	18	Shallow

Notes:
ft bgs = feet below ground surface

Table 3
Plume 6 Proposed PFAS Sampling List
RACER Buick City
Flint, Michigan

Plume 6 Well ID	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Zone
MW-LAG-25(9-14)	9	14	Shallow
MW-LAG-40(15-20)	15	20	Deep
MW-LAG-40(6-11)	6	11	Deep
MW-LAG-44(4-9)	4	9	Shallow
MW-LAG-45(5-10)	5	10	Shallow
MW-LAG-46(10-15)	10	15	Shallow
MW-LAG-46(3-8)	3	8	Shallow
MW-LAG-46(15-20)	15	20	Deep
MW-LAG-47(5-10)	5	10	Shallow
MW-LAG-48(15-20)	15	20	Deep
MW-LAG-54(18-23)	18	23	Deep
MW-LAG-54(9-14)	9	14	Shallow
MW-LAG-57(14-19)	14	19	Deep
MW-LAG-58(14-19)	14	19	Deep
MW-LAG-58(6-11)	6	11	Shallow
MW-LAG-59(19-24)	19	24	Deep
MW-LAG-59(2-7)	2	7	Shallow
MW-LAG-61(15-20)	15	20	Deep
MW-LAG-62(15-20)	15	20	Deep
MW-LAG-62(6-11)	6	11	Shallow
MW-LAG-63(14-19)	14	19	Deep
MW-LAG-63(2-4)	2	4	Shallow
MW-LAG-63(8-10)	8	10	Shallow
SB-LAG-05(8-13)	8	13	Shallow
SB-LAG-08(17-20)	17	20	Deep
SB-LAG-08(8-13)	8	13	Shallow
SB-LAG-10(7-12)	7	12	Shallow
SB-LAG-27(2-7)	2	7	Shallow
SB-LAG-28(15-20)	15	20	Deep
SB-LAG-28(9.5-14.5)	9.5	14.5	Shallow
SB-LAG-30(3-8)	3	8	Shallow
SB-LAG-33(3-8)	3	8	Shallow
SB-LAG-35(15-20)	15	20	Deep
SB-LAG-35(3-8)	3	8	Shallow

Notes:
ft bgs = feet below ground surface

Table 4
Plume 7 Proposed PFAS Sampling List
RACER Buick City
Flint, Michigan

Plume 7 Well ID	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Zone
20-103N	10.5	15.5	Shallow
20-500R	6	16	Shallow
20-501	13	18	Deep
MW-36-40	2	12	Shallow
RFI-10-31	4	14	Shallow
RFI-10-33	7	17	Shallow
RFI-36-08	6	16	Shallow
RFI-36-09	6	16	Shallow
RFI-36-13	NM	NM	Shallow
SB-20-03(7-12)	7	12	Shallow
SB-20-10(20-25)	20	25	Deep
SB-20-10(7-12)	7	12	Shallow
SB-20-12(7-12)	7	12	Shallow
SB-20-12(20-25)	20	25	Deep
SB-20-18(17-22)	17	22	Deep
SB-20-18(5-10)	5	10	Shallow
20-102R	10	15	Shallow
WMU2-SB4	7	12	Shallow
WMU2-SB6	8	13	Shallow

Notes:
ft bgs = feet below ground surface
NM = Not Measured

Table 5
PFAS Analyte List
RACER Trust Buick City
Flint, Michigan

Analyte
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)
Fluorotelomer sulfonic acid 4:2 (4:2 FTS)
Fluorotelomer sulfonic acid 6:2 (6:2FTS)
Fluorotelomer sulfonic acid 8:2 (8:2FTS)
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)
4,8-dioxa-3H-perfluorononanoic acid (ADONA)
2H,2H,3H,3H-Perfluorodecanoic acid (FHpPA)(7:3 FTCA)
2H,2H,3H,3H-Perfluorooctanoic acid (FPePA) (5:3 FTCA)
2H,2H,3H,3H-Perfluorohexanoic acid (FPrPA) (3:3 FTCA)
Hexafluoropropylene oxide dimer acid (HFPO-DA)
N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)
N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)
Perfluorobutanesulfonic acid (PFBS)
Perfluorobutanoic acid (PFBA)
Perfluorodecanesulfonic acid (PFDS)
Perfluorodecanoic acid (PFDA)
Perfluorododecanoic acid (PFDoA)
Perfluoroheptanesulfonic Acid (PFHpS)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorohexanoic acid (PFHxA)
Perfluorononanesulfonic acid (PFNS)
Perfluorononanoic acid (PFNA)
Perfluorooctane Sulfonamide (FOSA)
Perfluorooctane sulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluoropentanesulfonic acid (PFPeS)
Perfluoropentanoic acid (PFPeA)
Perfluorotetradecanoic acid (PFTeA)
Perfluorotridecanoic Acid (PFTriA)
Perfluoroundecanoic acid (PFUnA)
Perfluorobutylsulfonamide (PFBSA)
Perfluoro-4-ethylcyclohexanesulfonic Acid (PFECHS)
Perfluorohexanesulfonamide (PFHxSA)

Attachment 1

Technical Guidance Instructions

TGI – Per- and Polyfluoroalkyl Substances (PFAS) Field Sampling Guide

Rev: 13

Rev Date: April 24, 2025

Version Control

Revision No.	Date Issued	Page No.	Description	Reviewed By
0	April 27, 2017	All	Initial Release	Erica Kalve Erika Houtz Sue Tauro
1	June 19, 2018	1 through 4 and 17	Updated Information on Sampling Materials	Erica Kalve Erika Houtz
2	October 15, 2018	6 to 16	Minor updates on laboratory elements, updates to decontamination procedures, and clarification on equipment and reagent blank collection	Erika Houtz Erica Kalve
3	December 17, 2018	4, 6, 17	Removed Sharpies from acceptable field writing implements; Changed language in Section 3.2 and Section 10.5 to provide stricter guidance for DoD projects.	Erika Houtz, Erica Kalve
4	March 26, 2019	4,5	Removed Citranox from acceptable Decon solutions in Table 1a, added all fluoropolymer containing materials to prohibited items in Table 1b. Made a correction that Liquinox contains trace levels of 1,4 Dioxane, not Alconox.	Erika Houtz
5	October 16, 2020	14	Added Air Force preference to sample surface water at surface for Air Force investigations.	Erika Houtz
6	March 23, 2021	4, 5, 7, 12, 13, 14, 15, 16, 17	Made clarifications that fine/ultra-fine point Sharpies are allowed. Referenced 2018 MDEQ sampling guidance. Made updates to ‘After Sample Collection’ in Section 7.	Kevin Engle

7	April 18, 2021	All	Changed title from Poly- and Perfluoroalkyl Substances to **"Per- and Polyfluoroalkyl Substances"** and changed PFASs to PFAS.	Rosario Varrella, Erika Houtz
8	May 4, 2021	12, 13, 15, 16	Clarified that sample containers should have an HDPE lined screw cap and that LDPE plastic sheeting should be used.	Kevin Engle, Erika Houtz
9	October 20, 2021	Note that numbers have shifted one page forward relative to prior versions. 5, 7, 9-12, 15, 16, 18-25.	Specific acceptable sunscreen and insect repellent brands were added to Table 1. Clarified language regarding footwear and H&S trainings. Laboratories section and Section 10.5 was updated to reflect new laboratory names and an updated version of the QSM. Sections 5 and 6 were updated to provide clearer language on health and safety protocols for sunscreen, insect repellent, and rain events. Added language to specify decontamination of reusable equipment prior to initial use in Section 7.1. Section 8 on Waste Management was updated to state that waste storage and disposal should be determined in the site specific workplan. Section 9 was updated to include Rite in the Rain® notebooks as approved for PFAS sampling. Changed the term "sample port" to "sample location" when describing where to place plastic sheeting. Section 10.1 was updated to indicate an equipment blank can be collected for unvetted hazard controls that contact a sample. References were updated to include the newer version of the DoD QSM, MDEQ Sampling Guidance, and	Kevin Engle, Erika Houtz

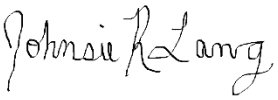
			California State Water Board PFAS Sampling Guidance.	
10	January 26, 2022	Various, Section 7	TGI formatted to comply with new QMS TGI template and Arcadis brand compliance. Indicated to avoid use of anti-fog spray on safety glasses due to possible presence of PFAS.	Rosario Varrella, Kevin Engle
11	January 13, 2023	Various	TGI updated to include specific information found in the June 2022 ITRC Guidance document. Updates reflecting current state of the practice analytical procedures. Table 1a and Table 1b updates	Kevin Engle, Joey Matzke, Lauren March
12	September 20, 2023	Various	Decontamination procedure in Section 8.1 has been updated to remove solvent rinse. Procedure is now: Scrub with alconox, rinse with DI/distilled water, rinse with “PFAS-free” water, repeat. Updated “Shipping” section 8.4, allowing for Saturday delivery with laboratory approval. Made various minor corrections and clarifications related to specific brand names	Alexander Hamilton, Johnsie Lang
13	April 24, 2025	Various	General template updates, insect repellant and watch band updates added by Dana Schmidt	Lydia Cox, Johnsie Lang

Approval Signatures

Prepared by: 4/24/2025

Lydia Cox, Staff Geologist — Date

Reviewed by: 4/24/2025



Johnsie Lang, PhD (Subject Matter Expert) — Date

1 Introduction

This document is intended to provide guidance to field staff sampling for Per- and Polyfluoroalkyl Substances (PFAS). The content in this document describes the intended use, scope and application, personnel qualifications, equipment, cautions, health and safety considerations, procedures, waste management, data recording and management, and quality assurance of PFAS sampling.

2 Intended Use and Responsibilities

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

3 Scope and Application

The purpose of this Technical Guidance Instructions (TGI) is to provide guidance on field sampling to be used for **Per- and Polyfluoroalkyl Substances** (PFAS). This protocol was adapted from various sources including Arcadis Australia, Transport Canada, and the U.S Army Corp of Engineers (USACE) Omaha. In general, sampling techniques used for PFAS site characterization are consistent with conventional sampling techniques used in the environmental industry, but special consideration is made regarding PFAS-containing materials and cross-contamination potential. **Table 1a** provides a summary of materials that have been approved for site investigation; this list is expected to grow longer as industry experience increases. **Table 1b** provides a summary of field equipment and materials that have available testing information and/or industry knowledge regarding

PFAS cross-contamination potential, and it is recommended that these materials be prohibited for sample collection; for materials that are suspected of containing PFAS and/or to retain PFAS, these recommendations are considered preliminary and subject to change. Further discussion of approved and prohibited materials is found throughout this document. In general, prohibited materials include but are not limited to peolytetrafluoroethylene (PFTE), waterproof coatings containing PFAS, fluorinated ethylene-propylene (FEP), ethylene tetrafluoroethylene (ETFE), low density polyethylene (LDPE), polyvinylidene fluoride (PVDF) [ITRC 2022].

Table 1a: Summary of Acceptable Sampling Equipment and Materials for PFAS Site Investigations

Sampling Materials	Additional Considerations	References
Water Sampling Materials		
High density polyethylene (HDPE) or silicone tubing materials	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
HDPE HydraSleeves™	LDPE HydraSleeves™ are not recommended	USACE 2016; MassDEP 2017
Drilling and Soil Sampling Materials		
PFAS-free drilling fluids	--	DER 2016
PFAS-free makeup water	Confirm PFAS-free water source via laboratory analysis prior to investigation	--
Acetate liners	For use in soil sampling	USACE 2016
Sample Containers and Storage		
HDPE sample containers with HDPE lined lids for soil and water samples	Laboratory should provide; whole bottle analysis of aqueous samples combined with a solvent rinse of bottle is recommended	DER 2016, MassDEP 2017
Ice contained in plastic (polyethylene) bags (double bagged)	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation		
Ball point pens	--	MassDEP 2017
Standard paper and paper labels	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Fine/Ultra-Fine point Sharpies®	Larger point Sharpies® should be avoided.	MDEQ 2018
Decontamination		

Sampling Materials	Additional Considerations	References
Water-only decontamination	Confirm PFAS-free water source via laboratory analysis prior to investigation	DER 2016
Alconox® or Liquinox® followed by deionized water or PFAS-free water rinse	Liquinox® known to contain trace levels of 1,4-dioxane	NHDES 2016; USACE 2016; MassDEP 2017
Sun and Biological Protection		
OFF® Deep Woods Insect Repellent	Apply >10 m away from sampling area. Topical spray. Generally observed to be more effective against mosquitos than permethrin. Topical spray. Replace nitriles following application.	MDEQ 2018
Sawyer® Do-It-Yourself Permethrin Treatment for Clothing; Insect Shield® Permethrin Spray	Apply >10 m away from sampling area, ideally, prior to conducting field activities. Do not allow contact with skin. Manufacturer application instructions may vary, including how to apply, how often reapplication should occur, how long to allow the clothing/fabric to dry prior to wearing/using the item, etc. Replace nitriles if they contact treated clothing/items during fieldwork. Generally observed to be more effective against ticks than OFF® Deep Woods (DEET).	Bartlett 2018; MDEQ 2018
Insect Shield® Permethrin-Treated Clothing	Generally observed to be more effective against ticks than OFF® Deep Woods (DEET). Replace nitriles if they contact treated clothing/items during fieldwork.	Bartlett 2018
Banana Boat, Coppertone, Neutrogena, Meijer, and L'Oreal Sunscreens	Apply >10 m away from sampling area	MDEQ 2018

Note: This list is considered preliminary and additional materials may be added as additional information becomes available. Project teams are expected to follow a methodical evaluation process of materials to be used and confirm acceptance prior to implementation of field activities.

Table 1b: Summary of Sampling Equipment and Materials Not Recommended for PFAS Site Investigations.

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFAS	References
Water Sampling Materials				

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFAS	References
Teflon®, PTFE-containing or other fluoropolymer coated or containing field equipment (e.g., tubing, bailers, liners, tape, plumbing paste, pump parts)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Passive diffusion bags			x	MassDEP 2017
LDPE HydraSleeves ™			x	USACE 2016; MassDEP 2017
Water particle filters			x	MassDEP 2017
Drilling and Soil Sampling Materials				
Aluminium foil			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Drilling fluid containing PFAS	x	x		DER 2016
Coated bentonite		x		Radford et al 2023
Pipe thread compounds and tape			x	ITRC 2022
Sample Containers and Storage				
Glass sample containers with lined lids			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
LDPE containers and lined lids			x	USACE 2016
Teflon® or PTFE- lined lids on containers (e.g., sample containers, rinsate water storage containers)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Reusable chemical or gel ice packs (e.g., BlueIce®)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation				
Self-sticking notes and similar office products (e.g., 3M Post-it-notes)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Waterproof paper, notebooks, and labels	x			DER 2016, MassDEP 2017
Markers		x		NHDES 2016

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFAS	References
Decontamination				
[Some] detergents and decontamination solutions (e.g., Decon 90® Decontamination Solution)	x	x		DER 2016; NHDES 2016; MassDEP 2017

Note: For materials that are suspected of containing PFAS, or have the potential to retain PFAS, project specific considerations may provide adequate justification for use during the field event. For example, further evaluation may be conducted in the form of pre-field equipment blank sample analysis.

Given the extremely low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFAS, field personnel are advised to err on the side of caution by strictly following these protocols, frequently replacing nitrile gloves, and rinsing field equipment to help mitigate the potential for false detections of PFAS. A summary of other specific items related to field sampling for PFAS are discussed in the sections below.

This TGI applies to all Arcadis and subcontractor personnel involved in field sampling for PFAS.

4 Personnel Qualifications

4.1 Sampling Personnel

Field personnel must have current health and safety training, including 40-hour HAZWOPER training, up to date 8-hour refresher, site supervisor training, and site-specific training, as needed. In addition, field personnel will be versed in the other relevant SOPs (e.g., low flow sampling) and will possess the skills and experience necessary to successfully complete the desired field work. The site Health and Safety Plan (HASP) and other documents will identify any other training requirements such as site-specific safety training or access control requirements.

4.2 Laboratories

These laboratories are example laboratories that could be used to analyze environmental media for PFAS, pending project approval:

- United States: Pace, SGS, Vista, ALS, and Eurofins
- Canada: AXYS-SGS and Bureau Veritas

Other laboratories may be used if they are appropriately accredited for PFAS analysis according to any project requirements. It is recommended that a laboratory is Environmental Laboratory Accreditation Program (ELAP)-accredited for PFAS analysis in accordance with the Department of Defense (DoD) Quality Systems Manual (QSM) 5.3 Table B-15 or any subsequent updates. **For all data collection efforts at DoD sites, PFAS data must be obtained using a method that is DoD ELAP-accredited under QSM 5.3 or later.**

5 Equipment List

The following equipment and materials must be available for sampling:

- Site plan of sampling locations, relevant work plan (or equivalent), and this TGI;
- Appropriate health and safety equipment, as specified in the site HASP;
- Dedicated plastic sheeting (preferably high-density polyethylene [HDPE]) or other clean surface to prevent sample contact with the ground;
- Conductivity/temperature/pH meter;
- Dissolved oxygen meter, oxidation reduction potential meter, and turbidity meter;
- Depth to water meter;
- If using low-flow groundwater sampling techniques, peristaltic pump (groundwater sampling)/bladder pump (with PFAS free bladder/ HDPE bladder), flow through cell, and accompanying HDPE and silicone tubing;
- Hydrasleeves™, if using Hydrasleeves™ for groundwater sampling;
- Metal trowel for soil samples; specialized soil/sediment sampling equipment as required;
- Brushes for scrubbing sampling equipment;
- Pens, pencils, and/or fine/ultra-fine point Sharpies® for writing;
- Clipboards, field binders, and field note pages that are not waterproof;
- Labeled sample bottles:
    - There are various laboratory and analytical methods in place at the time of this TGI revision (Revision 11). Only use certified PFAS free materials provided by the laboratory for sample collection.
- If high concentrations of PFAS related to class B firefighting foams are expected, bring additional small vials to conduct field-based shaker tests for foaming;
- Ziploc® bags to hold ice and samples;
- Bottles containing “PFAS-free” water used for reagent blanks;
- Labeled, thoroughly decontaminated coolers for samples with ice; Blue ice is not permitted;
- Deionized or distilled water for initial decontamination rinsing;
- “PFAS-free” water provided by the laboratory for final decontamination rinsing;
- Alconox or Liquinox®;
- Packing and shipping materials;
- Groundwater and/or Sampling Log; and
- Chain-of-Custody (COC) Forms.

6 Cautions

6.1 Food Packaging

Some food packaging may be treated with PFAS-containing chemicals to prevent permeation of oil and water in the food outside of the packaging. To avoid potential food packaging-related PFAS contact:

- Do not bring any food outside of the field vehicles onsite and eat snacks and meals offsite.
- Wash hands after eating.
- Remove any field garments or outer layers prior to eating. Do not put them back on until done eating and hands are washed.

6.2 Field Gear

6.2.1 Clothing

Many types of clothing are treated with PFAS for stain and water resistance, in particular outdoor performance wear. Certain clothing or accessories may be manufactured with PFAS for durability (e.g., certain “sport” smartwatch bands which are made of high-quality fluoroelastomers). To avoid potential clothing-related PFAS contact:

- Do not wear any outdoor performance wear that is water or stain resistant, or appears to be. Err on the side of caution.
- Wear pre-laundered (multiple washings, i.e., 6+) clothing that is not stain resistant or waterproof (unless made from the materials listed in Section 5.3.1).
- Natural fabrics such as cotton are preferred. Synthetic fabrics may also be acceptable if there is no indication on the label that the fabric is water and stain resistant.
- Remove smartwatches or watches that are made of high-quality elastomeric materials, or replace smartwatch bands with those made of metal or silicone.
- Change nitrile gloves frequently, as described in **Section 6.2.2**.
- Most importantly, avoid contacting your clothing with sampling equipment, bottles, and samples.
    - Consider specifying roles during field work; one field team member could document sampling (e.g., entering data into Fulcrum, taking photos, and timing groundwater sampling) while another contacts sampling materials more directly

6.2.2 Personal Protective Equipment

Safety Footwear

Some safety footwear has been treated to provide a degree of waterproofing and increased durability and may represent a source of trace PFAS. If at all possible, safety footwear without waterproofing should be worn;

footwear that provides adequate safety from physical hazards is required and takes precedence over potential PFAS concerns. To avoid any PFAS cross contamination to samples from footwear:

- Do not contact your footwear with equipment, bottles, or samples in any way.
- Do not allow gloves used for sampling to come in contact with safety footwear.

Nitrile Gloves

Wear disposable nitrile gloves at all times. Assume that everything you touch contains PFAS, and replace nitriles between subtasks. Don a new pair of nitrile gloves **before** the following activities at each sample location:

- Decontamination of re-usable sampling equipment;
- Contact with sample bottles or "PFAS-free" water bottles;
- Handling personal items (e.g., watches, phones, etc.);
- Recording notes or capturing photos;
- Insertion of anything into the sample ports (e.g., HDPE tubing); and
- Handling of any quality assurance/quality control (QA/QC) samples including field blanks and equipment blanks.

Don a new pair of nitrile gloves **after** the following activities:

- Handling of any non-dedicated sampling equipment;
- Contact with contaminated surfaces; or
- When judged necessary by field personnel.

6.3 Personal Hygiene

- Shower at night.
- Do not use personal care products after showering such as lotions, makeup, and perfumes, UNLESS medically necessary.
- Use sunscreen and insect repellent as necessary for health and safety, i.e., if sampling is to occur outdoors in direct sunlight and/or if insect hazards may be present. Specific products that are acceptable for PFAS sampling are listed in Table 1 and in Section 6.1. Apply sunscreen and insect repellant prior to initiating field sampling. If sunscreen and/or repellant need to be reapplied, ensure a safe distance away from the sampling locations and equipment (i.e., more than 10 meters (m) away). Wash hands after application and don new gloves following hand washing.

6.4 Visitors

Visitors to the site are asked to remain at least 10 meters from sampling areas.

7 Health and Safety Considerations

7.1 Biological and Environmental Hazard Controls

7.1.1 Sunscreens and Insect Repellents

When site conditions warrant, insect repellent and sunscreen should be applied. Some insect repellents and sunscreen have been approved for PFAS sampling by individual states. According to Michigan Department of Environmental Quality (MDEQ; now known as Michigan Department of Environment, Great Lakes, and Energy [EGLE]), the products below are allowable (MDEQ 2018). Note that California State Water Quality Control Board's PFAS sampling guidance refers to MDEQ/EGLE's allowable list of sunscreens and insect repellents (California State Water Quality Control Board 2020).

Insect Repellents

- Topical spray:
  - OFF® Deep Woods Insect Repellent (DEET)
- Treatment sprays for workwear:
  - Sawyer® Do-It-Yourself Permethrin Treatment for Clothing
  - Insect Shield® Permethrin Spray
- Treated workwear:
  - Insect Shield® brand

Sunscreen

- Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30
- Meijer Sunscreen Lotion Broad Spectrum SPF 30
- Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30
- Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30
- Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30
- Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30
- Banana Boat Sport Performance Sunscreen Stick SPF 50
- Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50
- Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30
- Coppertone Sunscreen Stick Kids SPF 55
- L'Oréal Silky Sheer Face Lotion 50+
- Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50
- Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70
- Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70
- Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30
- Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+

Please plan for sampling events and purchase these products ahead of time. For any sunscreens and bug sprays, including those listed above, always follow these instructions for application:

- Topical insect repellent and sunscreen should be applied away from the work area prior to initiating sampling.
- Workwear treated with insect repellent sprays should be treated according to manufacturers instructions and prior to conducting fieldwork.
- When re-applying, stay at least 10 m away from the sampling locations and equipment.
- Wash hands after application/contact with treated materials and don new nitrile gloves.

7.1.2 Rain Event

Special care should be taken when rain is falling at the project site:

- Field sampling during extreme rainfall should be avoided if possible. If sampling needs to take place during a rain event (or other extreme weather condition), ensure the rain gear or other safety clothing is appropriate. For example, rain gear made from the following materials is allowable: polyurethane, PVC, wax coated fabrics, rubber/neoprene, uncoated Tyvek® (MDEQ 2018).
- If project timelines are tight, consider the use of a gazebo tent that can be erected over the top of the monitoring well to provide shelter from the rain. The canopy material is possibly a PFAS-treated surface and should be managed as such; therefore, wear gloves when moving the tent, change them immediately after moving the tent, and avoid further contact with the tent until all sampling activities have been finished and the team is ready to move on to the next site.

7.1.3 Other H&S Considerations

- ***If an unapproved or potentially suspect hazard control is needed for health and safety, apply or keep that control away from the samples, document its use in field notes, and, if it does contact a sample, take an equipment blank with that material.***
- The ability to safely access the surface water sampling locations must be verified before sampling.
- Field activities must be performed in accordance with the site HASP, a copy of which will be present onsite during such activities.
- Safety hazards associated with sampling surface water include fast-moving water, deep water, and steep slopes close to sampling sites. Use extreme caution when approaching sampling sites
- If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.
- Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.
- Avoid the use of anti-fog sprays on glasses, which may contain PFAS. It's recommended to instead purchase pre-treated anti-fog safety glasses.

8 Procedure

8.1 Field Equipment Cleaning

Reusable field sampling equipment will require cleaning before initial use and between uses. For groundwater sampling, between uses, decontaminate the flow-through cell and any non-dedicated equipment (i.e., interface probe of depth to water meter) that comes into contact with well water. Trowels and other materials used to sample soil samples will also require decontamination, although dedicated, single use equipment such as liners should be used where possible.

After donning a new pair of nitrile gloves:

- Rinse sampling equipment with Alconox or Liquinox® cleaning solution; Scrub equipment with a plastic brush if needed;
- Rinse with distilled water or deionized water;
- Rinse with “PFAS-free” water
- Repeat this entire process, scrubbing equipment a second time, rinsing with distilled or deionized water, then rinsing again with “PFAS-free” water (i.e., two scrubbings and four water rinsings total).
- Collect all rinsate in a sealed pail for disposal. Do not reuse decontamination solutions between sampling locations.

8.2 Borehole/Monitoring Well Development

If a drill rig is being used to drill for soil cores or to install monitoring wells, wear clean nitrile gloves before collecting each continuous soil sample. Additional requirements include the following:

- Verify in writing with the manufacturer that single-use liners used to collect each sample are made of a material that does not contain PFAS;
- Collect soil samples in laboratory-supplied HDPE bottles.
- Store the sample bottles in coolers and keep at a temperature of 0 to 6ºC until transported to the laboratory.

8.2.1 Well Condition Survey/ Water Level Monitoring

Using equipment that has been thoroughly decontaminated according to the procedures in Section 7.1, conduct the well condition surveys and water level monitoring:

- Conduct monitoring well inspections and record water levels.
- Use an interface probe to evaluate the presence/absence of non-aqueous phase liquid (NAPL).
- Measure the depth to water from the top of the polyvinyl chloride (PVC) riser and the total depth of the well.
- Record information in the field notes.

8.2.2 Monitoring Well Development and Purging

Follow these requirements for monitoring well development and purging:

- Do not use Teflon™ tubing for purging or sample collection. HDPE tubing is acceptable.
- Do not re-use materials between wells. Upon completion of use, remove all disposable materials (such as HDPE and/or silicone tubing) and place in heavy duty garbage bags for disposal.
- During development of the well, create sufficient energy to agitate the water column and create flow reversals in the well screen, filter pack and formation to loosen fine-grained materials and draw them into the well. The pumping or bailing action should then draw all drilling fluids and fine-grained material out of the borehole and adjacent formation and then out of the well. Review the Arcadis Monitoring Well Development guidance (Arcadis 2010) for more detailed information.
- Follow the low-flow purge and sampling techniques per the U.S. Protection Agency's (EPA's) guidance document titled *Low Stress (Low Flow) purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells* (2010) and ASTM's standard titled *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations* (2002). Also available for review is the Arcadis Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells (Arcadis 2011).
- To purge the well, if using HDPE tubing and a peristaltic pump, insert the end of the tubing to the approximate depth of the midpoint of the screened section of the monitoring wells. Measure the length of HDPE tubing to be inserted into each monitoring well and pre-cut it to approximate lengths (such as the previously measured arm span of a field technician) to avoid contact with any materials other than the monitoring well and peristaltic pump. Flow rates should be as low as can be reasonably achieved. Collect and appropriately dispose of purge water.
- Silicone tubing should direct the purge water through a flow-through cell for field parameter measurements of pH, conductivity, temperature, dissolved oxygen, and turbidity. Calibrate the instrument in the field prior to use.
- Record field parameters in intervals (generally of 3-minute duration) to ensure purge water has cycled through the flow-through cell. Sample the wells after field parameter measurements indicate stabilization, which allows collection of representative formation water (generally acceptable standards are three consecutive pH readings to within ±0.1 units, and three consecutive conductivity, temperature and dissolved oxygen measurements to within 3%). Turbidity must be monitored but does not need to be used as a stabilization indicator of purge completion. Record field parameter measurements at each well. Drawdown should be monitored throughout the purge. Prior to collecting sample, disconnect tubing from flow-through cell and collect sample directly from tubing coming out of the monitoring well.
- If wells are suspected to be dewatering throughout the purge (i.e., reduced flow rate/difficulty pumping water or bubbles begin to come through the flow through cell), turn off the pump and allow the water level to recover for ½ hour, followed by sample collection. Document these activities in the field notes.

8.3 Sample Collection

Different laboratories may supply sample collection bottles of varying sizes depending on the type of media to be sampled. This section focuses on the collection of only soil, groundwater, surface water, and sediment. Different media may not follow these procedures. For example, AFFF concentrate should be sampled in accordance with DoD AFFF01 (DoD 2021).

8.3.1 Sample Containers

- Collect samples in HDPE bottles fitted with a HDPE lined (no Teflon™) screw cap.
- Complete bottle labels after the caps have been placed back on each bottle.
- Do not use glass bottles due to potential loss of analyte through adsorption. This is particularly important for aqueous samples.
- Review with analytical lab the sample size, sample container, etc. depending upon the type of PFAS analysis that is being requested.

8.3.2 Soil Sampling

Before Sample Collection

- Place LDPE plastic sheeting adjacent to the sample location for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Trowels or drilling equipment that will come into contact with a sample should be decontaminated prior to sample collection, preferably with methanol/isopropanol/acetone;
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.

During Sample Collection

- Collect soil samples using a clean stainless-steel trowel or with single-use PFAS-free liners;
- Place soil samples in HDPE bottles supplied by the laboratory.
- Note the time on the sample label.
- Collect any necessary duplicates/co-located samples and matrix spikes – verify with laboratory whether they need to be collected in separate sample bottles.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated.

- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

After Sample Collection

- Place each sample bottle in two sealed Ziploc® bags. Another brand of LDPE bag is acceptable.
- Record the label information and time of sampling in the field notes.
- Place soil sample bottles in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. Do not use blue ice.

8.3.3 Groundwater Sampling

Before Sample Collection

- Place LDPE plastic sheeting adjacent to the sample location for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPEbottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.
- Measure depth to water and field parameters. Turbidity and the physical appearance of the purged water should be noted on the Groundwater Sampling Log.

During Sample Collection

- Start groundwater sample collection upon stabilization of field parameters.
- If low-flow groundwater sampling techniques are being used, disconnect the silicone tubing from the flow-through cell, enabling collection of groundwater samples without passing through the cell.
- Hydrasleeves are also considered acceptable for sampling of PFAS in groundwater – consult the project manager to determine which technique should be used. In general, low flow sampling is preferable.
- Collect groundwater samples (to the neck of the bottle, some headspace is acceptable) from the dedicated sampling ports at the center of the well screen. While collecting the sample, make sure the bottle cap remains in the other hand of the sampler, until replaced on the bottle.
- To mitigate cross contamination, collect groundwater samples in a pre-determined order from least impacted to greater impacted based on previous analytical data or knowledge about past activities at the site. If no analytical data are available, samples are to be collected in the following order:
    1. First sample the upgradient well(s).
    2. Next, sample the well located furthest downgradient of the interpreted or known source.
    3. The remaining wells should be progressively sampled in order from downgradient to upgradient, such that the wells closest to the interpreted or known source are sampled last.

- NOTE: If high concentrations of PFAS related to class B firefighting foams are expected in a groundwater sample, conduct a Shaker test by collecting and shaking a small portion of the sample (~10 to 25 mL) on site in a small disposable vial. If foaming is noted within the sample, document the foaming when samples are submitted for analysis; the 'shaker test' vial can then be disposed. This shaker test provides information about how each of the samples should be handled analytically.
- After collecting the sample, tightly screw on the polypropylene cap (snug, but not too tight). This will minimize leaking or cross contamination of the sample.
- Note the time on the sample label.
- Collect any necessary duplicates and matrix spikes. As the laboratory should be analyzing the entire aqueous sample rather than sub-sampling, separate bottles will be required for these samples.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.
- Do not rinse PFAS sample bottles during sampling. Do not filter samples.

After Sample Collection

- Place each sample bottle in two sealed Ziploc® bags. Another brand of LDPE bag is acceptable.
- Record the label information and time of sampling in the field notes and COC. Note ‘shake test’ results if appropriate.
- Place groundwater samples in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**

  Treat all disposable sampling materials as single use and dispose of them appropriately after sampling at each monitoring well.

8.3.4 Surface Water Sampling

Before Sample Collection

- Place LDPE plastic sheeting adjacent to the sample location for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.

During Sample Collection

- Avoid sampling the surface, in general.
- However, for Air Force investigations, collect samples from the water surface.
- Where surface water samples and sediment samples are collected at the same location, collect surface water samples first to minimize siltation.
- Collect surface water samples directly into laboratory-supplied bottles; wide-mouth bottles may be preferable to narrow mouth bottles for ease of surface water collection.
- Make sure bottle caps remain in the gloved hand of the sampler until sampling is complete and caps are replaced on the bottle.
- Note the time on the sample bottle.
- Collect any necessary duplicates and matrix spikes. As the laboratory should be analyzing the entire aqueous sample rather than sub-sampling, separate bottles will be required for these samples.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

After Sample Collection

- Place each sample bottle in two sealed Ziploc® bags. Another brand of LDPE bag is acceptable.
- Record the label information and time of sampling in the field notes.
- Place samples in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Measure surface water pH, conductivity, temperature, and TDS at each location **after** both surface water and sediment sampling.

8.3.5 Sediment Sampling

Before Sample Collection

- Place LDPE plastic sheeting adjacent to the sample location for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.

During Sample Collection

- Where surface water samples and sediment samples are collected at the same location, collect surface water samples first to minimize siltation.
- Collect sediment samples either manually using a stainless-steel trowel or using a petite ponar grab sampler, depending on field conditions at each sampling location during sampling program.
- Collect sediment samples from the upper 10 cm of sediment.
- For a sample to be acceptable overlying, low turbidity water must be present.
- Decant the overlying water and use a stainless-steel trowel to collect only the upper 5 centimeters (cm) of sediment.
- Collect sediment samples directly into laboratory-supplied bottles that are suitable in both material and size.
- Do not overfill the sample bottle.
- Make sure that the sample does not contain vegetation, that the sediment is undisturbed, and that the sampler shows no signs of winnowing or leaking.
- Make sure bottle caps remain in the gloved hand of the sampler until sampling is complete and caps are replaced on the bottle.
- Note the time on the sample label.
- Collect any necessary duplicates and matrix spikes.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

After Sample Collection

- Place each sample bottle in two sealed Ziploc® bags. Another brand of LDPE bag is acceptable.
- Record the label information and time of sampling in the field notes.
- Place samples in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Measure surface water pH, conductivity, temperature, and total dissolved solids (TDS) at each location **after** both surface water and sediment sampling is completed.

8.4 Shipping

- If samples cannot be shipped the same day as collected, arrange an appropriate means of keeping the samples cool overnight and maintain the temperature between 0 and 10°C for the first 48 hours after collection, and then between 0 and 6°C thereafter.

- Store samples in appropriate transport bottles (coolers) with ice (Ziploc© bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Complete the appropriate procedures for COC, handling, packing, and shipping.
- Fill out and check COC Forms against the labels on the sample bottles progressively after each sample is collected.
- Place all disposable sampling materials (such as plastic sheeting, and health and safety equipment) in appropriate containers.
- Ship samples via courier service with priority overnight delivery. Tracking numbers for all shipments should be provided and recorded after they have been sent out to ensure their timely delivery.
- Confirm with the laboratory before shipping samples via Fed Ex for Saturday delivery.

9 Waste Management

All rinsate should be collected in a sealed pail for disposal. Drill cuttings and purge water will be managed as specified in the Field Sampling Plan (FSP) or Work Plan, and according to state and/or federal requirements. PPE and decontaminated fluids will be contained separately and staged at the sampling location. Containers must be labeled at the time of collection. Labels will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, groundwater, PPE). General guidelines for investigation derived waste (IDW) handling and storage are set forth in a separate IDW guidance document (Arcadis 2009).

Typical waste characterization procedures include collection of a composite sample of the drill cutting material and a composite sample of the purge water for laboratory analysis. Samples are typically analyzed for disposal toxicity characteristic leaching procedure (TCLP) analysis for metals and VOCs. For PFAS, a simple leach test with neutral pH water may be more indicative of actual risk. Additionally, generators of waste are required to include analysis of other constituents that are reasonably believed to be present including (in this case) PFAS.

Waste storage and final waste disposition should be determined in the site specific workplan.

10 Data Recording and Management

Digital data collection is the Arcadis standard using available FieldNow® applications that enable real-time, paperless data collection, entry, and automated reporting. Paper forms should only be used as backup to FieldNow® digital data collection and/or as necessary to collect data not captured by available FieldNow® applications. The Field Now® digital form applications follow a standardized approach, correlate to most TGIs and are available to all projects accessible with a PC or capable mobile device. Once the digital forms are saved within FieldNow®, the data is instantly available for review on a web interface. This facilitates review by project management team members and SMEs enabling error or anomalous data detection for correction while the staff are still in the field. Continual improvements of FieldNow® applications are ongoing, and revisions are made as necessary in response to feedback from users and subject matter experts.

If digital data collection isn't possible, waterproof field books should be avoided for field notes. Instead, field notes on loose paper on Masonite, plastic, or aluminum clip boards is preferred. Please note that newer Rite in the Rain® notebooks are approved for PFAS sampling. Other requirements for field notes include:

- Pens, pencils, and fine/ultra-fine point Sharpies® may be used.
- Keep field notes and writing implements away from samples and sampling materials.
- One person should conduct sampling while another records field notes.
- Do not write on sampling bottles unless they are closed.

10.1 Other Project Documentation

- Complete groundwater and/or soil sampling logs.
- Make sure COC Forms are properly completed. Verify which PFAS analytes and methods (e.g., just PFOS/PFOA, some or all of the /1633 lists, etc.) are required for analysis and note on the COC.

11 Quality Assurance

Refer to quality control requirements for the project to ensure that appropriate quality assurance and quality control (QA/QC) samples are collected. When collecting QA/QC samples, the same guidelines apply as when collecting regular samples – specifically that:

- Samples should be collected in laboratory-supplied HDPE bottles;
- Bottle caps must remain in the hand of the sampler until replaced on the bottle;
- Labels must be completed after the caps have been placed back on each bottle; and
- Samples must be stored in appropriate transport bottles (coolers) with ice (Ziploc© bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**

11.1 Equipment Blanks (if relevant)

QA/QC sampling typically includes daily collection of equipment blanks using the laboratory-supplied “PFAS-free” water. For peristaltic pump tubing, laboratory supplied “PFAS-free” water should be poured into a clean HDPE sample bottle and then pumped through new HDPE tubing using the peristaltic pump (with new silicone tubing). The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated. Note that an equipment blank can also be collected if an unapproved or potentially suspect hazard control is needed for health and safety and it contacts a sample, i.e., that material would be exposed to PFAS free water then the water would be collected in a separate sample container.

11.2 Field Duplicates

QA/QC sampling typically includes the collection of one field duplicate for every 10 or 20 samples collected. Each duplicate sample will be collected immediately after the initial sample of which it is a duplicate into a separate laboratory-provided sample bottle. Do not indicate to the laboratory which sample the duplicate replicates, i.e., it should be given a blind reference on the COC and sample name such as “Duplicate-01”.

11.3 Field Reagent Blanks

QA/QC sampling for PFAS typically includes the submission of one laboratory supplied field reagent blank per day. The field reagent blank sample is brought to the site in a laboratory-supplied sample bottle. Field staff transfer the laboratory-supplied reagent blank to an empty sample bottle. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel and should be placed in the same cooler as the other PFAS samples.

11.4 Matrix Spikes (optional in some cases)

QA/QC sampling includes submitting samples to be used as a matrix spike and matrix spike duplicate (MS/MSD) if the project requires it. If separate sample bottles are required, additional samples will be collected immediately after the initial sample of which it is a duplicate into separate laboratory-supplied sample bottles.

11.5 Laboratory Analytical QA/QC

- Arcadis recommends that any request for PFAS analysis in groundwater or soil should be conducted by an ELAP-accredited method compliant with QSM 5.3 Table B-15. Requirements laid out in Table B-15 strictly govern acceptable laboratory data quality for PFAS analysis in environmental samples. **For all data collection efforts at DoD sites, PFAS data must be obtained using a method that is DoD ELAP-accredited under QSM 5.3 or later.**
- Laboratory QA/QC should consist of one laboratory blank and one laboratory control sample (or blank spike) per batch of samples, and additional QA/QCs as indicated by the laboratory QA/QC procedures.
- Isotope dilution must be used for quantification with isotope-labeled spiked standards (extracted internal standards EIS), as available, according to the guidelines of QSM 5.3 Table B-15. See EPA method 1633 and DoD QSM 5.4 Table B-24 for quantification requirements by isotope dilution with EIS standards. The USEPA has two drinking water methods (USEPA Method 537.1 and USEPA Method 533).
- For drinking water, groundwater, and surface water samples, laboratories must extract the entire sample and include a solvent rinse of the bottle for analysis. Aqueous samples should generally not be sub-sampled prior to analysis, unless they are high concentration and require serial dilution (US DoD 2017).
- Soil samples should be analyzed in their entirety or thoroughly homogenized before extraction and analysis.
- As part of the internal QA/QC of laboratory results, relative percent difference (RPD) should be calculated between samples and corresponding field or laboratory duplicates. The laboratory quality assurance portion of the laboratory certificates should be reviewed to verify that all calculations/recoveries were within acceptable limits as established by the laboratory method and guidelines in Table B-15 of QSM 5.3 or later (USDoD 2019).

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Arcadis U.S., Inc.
630 Plaza Drive, Suite 200
Highlands Ranch
Colorado 80129
Phone: 720 344 3500
Fax: 720 344 3535
www.arcadis.com

TGI – Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells

Rev: 3

Rev Date: April 5, 2023

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
	0	October 12, 2018	All	Updated and re-written as TGI with new branding and content	Marc Killingstad
	1	May 8, 2020	Pages 5, 10-11	Added clarification/details for equipment requirements and procedure steps based on USEPA guidance	Marc Killingstad
	2	April 5, 2022	All	Updated to new branding template and minor edits	Marc Killingstad
	3	April 5, 2023	All	Annual review completed by SME. Document version number and document date updated.	Marc Killingstad

Approval Signatures

Prepared by:	Xuan Xu	4/5/2023
	Xuan Xu (Preparer)	Date
Reviewed by:		4/5/2023
	Marc Killingstad (Subject Matter Expert)	Date

1 Introduction

Groundwater samples are collected from monitoring wells to evaluate groundwater quality. The protocol presented in this Technical Guidance Instruction (TGI) describes the procedures to purge monitoring wells and collect groundwater samples using the low flow purging/sampling methodology. This protocol has been developed in accordance with the United States Environmental Protection Agency (USEPA) Region I *Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells* (EQASOP-GW4; September 19, 2017).

2 Intended Use and Responsibilities

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

3 Scope and Application

Both filtered and unfiltered groundwater samples may be collected using this low-flow sampling method. Filtered samples will be obtained using a 0.45-micron disposable filter. Project teams will evaluate the last time the monitoring wells were developed and determine if additional development might be necessary. Water samples will not be taken immediately following well development. Sufficient time will be allowed for the groundwater flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well

construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

4 Personnel Qualifications

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations,such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as identified in the site-specific Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. The HASP will also identify any access control requirements.

Prior to mobilizing to the field, the groundwater sampling team will review and be thoroughly familiar withrelevant site-specific documents including but not limited to the task-specific work plan or field implementation plan (FIP)/field sampling plan, Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Additionally, the groundwater sampling team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

5 Equipment List

Specific to this activity, the following materials (or equivalent) will be used:

- Site-specific HASP and health and safety documents identified in the HASP
- Field Implementation Plan (FIP) that includes site map, well construction records, sampling plan (sample analyses, sample volume required, and sample holding time), and prior groundwater sampling records (if available)
- Field notebook and/or smart device (phone or tablet)
- Low-flow sampling field forms (**Attachment A**)
- Appropriate personal protective equipment (PPE) (e.g., latex or nitrile gloves, safety glasses, etc.)as specified in the HASP
- Well keys and other tools to remove manhole covers (manual torque wrench with 9/16” socket and flat head screwdriver typical)
- Photoionization detector (PID) or Flame ionization detector (FID) (as appropriate, depending onsite-specific constituents of concern)
- Electronic water-level indicator (e.g., Solinist Model 101) or oil/water interface probe with 0.01- foot accuracy (oil/water as appropriate, note that sampling will not be performed when sheen orlight non-aqueous phase liquid [LNAPL] is present)
- Down-hole multi-parameter water-quality sonde (temperature/pH/specific conductivity/oxidationreduction [ORP]/turbidity/dissolved oxygen) meter coupled with flow-through-cell for measurements, for example:

  - YSI 6-Series Multi-Parameter Instrument
  - Horiba U-22 Multi-Parameter Instrument.
  - Hydrolab Series 3 or Series 4a Multiprobe and Display.

  NOTE: *Transparent, small volume flow-through-cells (e.g., 250 milliliters or less) are preferred as they allow for easy detection of air bubbles and sediment buildup in the cell, which can interfere with the monitoring instrument probes. A small volume cell also allows for quick turnover of water in the cell between measurements of the indicator field parameters. It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.*

- Plastic sheeting (e.g., Weatherall Visqueen) to protect all down-hole sampling equipment from contact with potential sources of contamination.
- Decontamination equipment
  - Non-phosphate laboratory soap (Alconox or equivalent), brushes, and clean buckets, and/or clean wash tubs—new buckets or tubs will be purchased if it cannot be determined if the present items are clean
  - Distilled or de-ionized water for equipment decontamination
- Indelible ink pen
- 150-foot measuring tape (or sufficient length for the maximum site depth requirement)
- Sampling pump, which may consist of one or more of the following:
  - Submersible pump (e.g., Grundfos Redi-Flo 2)
  - Peristaltic pump (e.g., ISCO Model 150)
  - Bladder pump (e.g., Marschalk System 1, QED Micropurge, Geotech)
- Appropriate controller and power source for pump:
  - Submersible and peristaltic pumps require electric power from either a generator or a deep cell battery
  - Submersible pumps such as Grundfos require a pump controller to run the pump
  - Bladder pumps require a pump controller and a gas source (e.g., air compressor or compressed N_2 or CO_2 gas cylinders)
- Teflon® tubing or Teflon®-lined polyethylene tubing of an appropriate size for the pump being used
  - For peristaltic pumps, dedicated Tygon® tubing (or other type as specified by the manufacturer) will be used through the pump apparatus
  - Teflon® will not be used when sampling for per- and polyfluoroalkyl substances (PFAS)
- Graduated cylinder and stopwatch or other device to measure time to determine pumping rate
- Appropriate water sample containers (supplied by the laboratory)
- Appropriate blanks (trip blank supplied by the laboratory)
- Sample labels and Chain-of-Custody forms (COC)
- 0.45-micron disposable filters (if field filtering is required)

- A supplemental turbidity meter (e.g., Horiba U-10, Hach 2100P, LaMotte 2020) may be required for specific projects and will be specified in the project FIP/ work plan and the kick-off notes.
    - If used, in-line 'T' and valve allows for collection of water for turbidity measurements before the pump discharge enters the flow-through cell

NOTE: *The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment will be serviced by a qualified technician.*

6 Cautions

Different USEPA regions and/or state regulatory agencies may stipulate deviations from this document. Itis the responsibility of the Project Team (Project Manager and Technical Lead) to be fully aware of the requirements from the applicable regulatory framework.

Weather

- If heavy precipitation occurs, and no cover over the sampling area and monitoring well can be erected, sampling may be discontinued until adequate cover is provided. Rainwater could compromise groundwater samples.
- Avoid extreme weather situations. Be aware that thermal currents and vertical mixing of cold and warm water inside the well casing could create a convection cell within the well and compromise data collection (e.g., biological mechanisms).
    - Direct sunlight and hot ambient temperatures may cause the groundwater in the tubing orflow-through-cell to heat up and de-gas. This may result in the loss of volatile organic compounds (VOCs) and dissolved gases. Shade the equipment from direct sunlight, keep the tubing as short as possible and avoid the hottest times of the day.
    - Sampling during freezing conditions may adversely impact the data quality objectives. USEPA recommends low-flow sampling be conducted at air temperatures above 32°F (0°C) or taking special precautions to prevent groundwater from freezing in the equipment.

Cross-Contamination

- To mitigate potential cross-contamination, groundwater samples are to be collected in a pre- determined order from least impacted to impacted based on previous analytical data. If no analytical data are available, collect samples in order of up-gradient, then furthest down-gradient tosource area locations.
- Note that permanent markers could introduce volatile constituents into the samples*; therefore, indelible ink is recommended* to be used for labels on sample containers or sample coolers.
- When using a gasoline generator, this power source will be set-up at least 30 feet downwind from the well to avoid exhaust fumes to contaminate samples.

Pumps

- Preferred methods of extracting groundwater are adjustable rate, submersible pumps - such as centrifugal pumps or bladder pumps – constructed of stainless steel or polytetrafluoroethylene (PTFE, i.e., Teflon®). However, *PTFE will not be used when sampling for per- and polyfluoroalkyl substances (PFAS). PTFE could contain PFAS*.

- When using a bladder pump for collecting VOCs and dissolved gases, “best practice” is to set-up the pump to deliver sufficient water to fill a 40 mL VOC vial.
- The use of peristaltic pumps will be based on the type of data to be collected. *Because the use a peristaltic pump can result in de-gassing of VOC and / or dissolved gases from groundwater, a different type of pump will be considered if these compounds are of concern.*
- *Manual or motor driven inertial pumping devices are not recommended because they cause greater disturbance during purging and pumping than regular pumps and are less easily controlled. This could cause a higher degree of data variability.*

Tubing

- When sampling for VOCs, SVOCs, pesticides, PCBs and inorganics, use of PTFE (Teflon®) or PTFE-lined tubing is preferred. However, PTFE tubing will not be used when sampling for PFAS.
- PVC, polypropylene or polyethelene tubing may be used when sampling for metals or other inorganics.
- Tubing with inside diameters of 1/4 or 3/8 inch is recommended because this will help ensure tubing remains water filled when operating at very low pumping rates.

General Precautions

- Store and/or stage empty and full sample containers and coolers out of direct sunlight.
- It may be necessary to field filter the groundwater for some parameters (e.g., metals) during collection, depending on preservation, analytical method, and project quality objectives. The task-kick-off notes and the FIP/work plan will list the samples that require field filtering.
- Be careful not to overtighten lids with Teflon® liners or septa (e.g., 40 mL vials). Over-tightening can cause the glass to shatter or impair the integrity of the Teflon® seal.

7 Health and Safety Considerations

The HASP will be followed, as appropriate, to ensure the safety of field personnel.

Appropriate personal protective equipment (PPE) will be always worn in line with the task and the site-specific HASP.

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work.

Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or non-aqueous phase liquid (NAPL) (e.g., oil). Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards (e.g. ticks in long grass/weeds around well head), and potentially the use of sharp cutting tools (scissors, knife)—open well caps slowly and keep face and body away to allow to vent any built-up pressure; only use non-toxic peppermint oil spray for stinging insect nests; review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives, and use appropriate hand protection.

Generators and cord and plug equipment will employ an overcurrent protection device such as an integrated ground fault circuit interrupter (GFCI) cord. Grundfos pump controllers will not run properly with a GFCI, so the power source will be equipped with other overcurrent protection means.

Overtightening of lids with Teflon® liners can cause the glass to shatter and create a risk for hand injuries.

8 Procedure

Field personnel will set up and perform low-flow sampling in accordance with the following procedures.

1. Review FIP and groundwater sampling records from previous sampling events (if available) prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for each well to perform sampling as efficiently as possible (i.e., reach a stabilized pumping condition).
2. Calibrate field instruments according to manufacturer procedures for calibration and record calibration procedure and results in field log.
3. All equipment will either be new or decontaminated in accordance with appropriate guidance document *(TGI – Groundwater and Soil Sampling Equipment Decontamination)* prior to use.
4. Visually inspect the well to ensure that it is undamaged, properly labeled and secured
   a. Damage or other conditions that may affect the integrity of the well will be recorded in the Field Activity Daily Log and brought to the attention of the designated Field Manager and/or Project Manager
   b. Record well construction and conditions on the Low-Flow Sampling Field Form **(Attachment A)**.
5. Place clean plastic sheeting on the ground near the well to keep monitoring and sampling equipment off the surface unless the equipment is elevated above the ground (e.g., on a table).
6. Open the well cover while standing upwind of the well. Remove the well cap and place it on the plastic sheeting. If appropriate or required for site-specific conditions, insert the photoionization detector (PID) probe approximately 4 to 6 inches into the casing or the well headspace and cover it with a gloved hand. Record the PID reading in the field log. Perform air monitoring in the breathing zone according to the HASP and/or JSA.
7. Measure and record the initial depth to groundwater prior to placing the pumps.
8. Prepare and install the pump in the well.

   NOTE: *Groundwater will be purged from the wells using an appropriate pump. If the depth to water is below the sampling range of a peristaltic pump (approximately 25 feet below ground surface), a submersible or bladder pump will be used, provided that the well is constructed with a casing diameter of at least two (2) inches (the minimum well diameter capable of accommodating such pumps). For smaller diameter wells, where the depth to water is below the sampling range of a peristaltic pump, alternative sampling methods (i.e., bailing or small diameter bladder pumps) will be used to purge and sample the groundwater. Bladder pumps are preferred over peristaltic and submersible pumps to prevent volatilization if sampling of VOCs and/or dissolved gasses is required. Purge water will be collected and containerized according to the direction of the project team.*

   a. For submersible and non-dedicated bladder pumps, decontaminate the pump according to site decontamination procedures. Non-dedicated bladder pumps will require a new bladder and attachment of an air-line, sample discharge line, and safety cable prior to placement in the well. Attach the air-line tubing to the air-port on the top of the bladder pump. Attach the sample discharge tubing to the water port on the top of the bladder pump. Take care not to reverse the air and discharge tubing lines during bladder pump setup, as this could result in bladder failure or rupture. Attach and secure a safety cable to the eyebolt on the top of pump (if present, depending on pump model used). Slowly lower the pump, safety cable, tubing, and electrical lines into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Avoid twisting

and tangling of safety cable, tubing, and electrical lines while lowering the pump into the well; twisted and tangled lines could result in the pump becoming stuck in the well casing. Also, make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well, as this could lead to unintended contamination.

b. If using a bladder pump, connect the air-line to the pump controller output port. The pump controller will be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose. Tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon® tape may be used on the threads of the cylinder to provide a tighter seal. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin the gas flow. Turn on the pump controller power (if an on/off switch is present) and verify that all batteries are charged and fully functioning before starting the pump.

c. If a peristaltic pump is being used, slowly lower the sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. The pump intake or sampling tube must be kept at least two (2) feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.

d. If using an in-line 'T' and valve, install between pump discharge water line and the bottom inlet port of the flow-through cell. Attach a short piece of tubing to the outlet. This set-up will be used to collect samples for turbidity readings.

9. Connect the pump discharge water line to the bottom inlet port on the flow-through cell connected to the multi-parameter water-quality sonde and make sure to record equipment/instrument identification (manufacturer and model number).

10. Before starting the pump, ensure that the water level inside the well has stabilized (i.e., measure the water level multiple times after deploying the pump in the well).

11. Start pumping the well at 200 to 500 milliliters (mL) per minute (or at lower site-specific rate if specified) and adjust the pumping rate to cause little or no water level drawdown in the well (less than 0.3 feet below the initial static depth to water measurement): the water level should stabilize, however, this is not always possible.

12. If the well diameter is of sufficient size, measure the water level every 3 to 5 minutes (or as appropriate, lower flow rates may require longer time between readings) during pumping.

13. Maintain a steady flow rate to the extent practicable and do not break pump suction or cause entrainment of air in the sample.

14. Record pumping rate adjustments and depths to water.

    If necessary, reduce pumping rates to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters; if the recharge rate of the well is very low, use alternative purging techniques, which will vary based on the well construction and screen position.

    For wells screened across the water table, the well may be pumped dry, and sampling can commence as soon as the volume in the well has recovered sufficiently to permit collection of samples.

    For wells screened entirely below the water table, the well can be pumped until a stabilized level (which may be greater than the maximum displacement goal of 0.3 feet) is maintained and monitoring for stabilization of field indicator parameters can commence; if a lower stabilization level cannot be

maintained, the well may be pumped until the drawdown is at a level slightly higher than top of the well screen.

15. After water levels have stabilized and a sufficient volume has been purged (see note below), continue pumping and begin monitoring field indicator parameters using a multi-parameter water-quality sonde coupled with a flow-through-cell.

    NOTE: *The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.*

16. Use the flow to measure all indicator field parameters, except for turbidity, every 3 to 5 minutes (or after each volume of the flow-through cell has been purged or other appropriate interval); turbidity samples will be collected before the flow-through-cell using the T-valve and a clean container such as a glass beaker.

17. Record field indicator parameters on the groundwater sampling log.

18. The well is considered stabilized and ready for sample collection when three consecutive readings are within the following limits:

    - **Turbidity** within ± 10% for values greater than 5 nephelometric turbidity units [NTUs] or if three turbidity values are less than 5 NTUs, consider the values stabilized
    - **Dissolved Oxygen (DO)** within ± 10% for values greater than 0.5 mg/L or if three DO values are less than 0.5 mg/L, consider the values stabilized
    - **Specific Conductance** within ± 3%
    - **Temperature** within ± 3%
    - **pH** within ± 0.1 unit
    - **Oxidation/Reduction Potential (ORP)** within ±10 millivolts (mV)

    NOTE: *Alternate stabilization goals may exist in different geographic regions, consult the site- specific FIP/work plan for stabilization criteria).*

    NOTE: *While achieving turbidity levels less than 5 NTU and a stable drawdown of less than 0.3 feet is desirable, sample collection may still take place provided the indicator field parameter criteria in this procedure are met.*

19. If the parameters have stabilized but turbidity remains relatively high (e.g., greater than 50 NTUs), the pump flow rate may be decreased to a minimum rate of 100 mL/min to reduce turbidity levels as low as possible. If groundwater turbidity has been minimized (i.e., consecutive readings within ± 10%) and the values for all other parameters have stabilized, the well may be sampled; however, consult specifications in the FIP/work plan and/or the project technical lead prior to sampling.

20. If after one (1) hour of purging indicator field parameters have not stabilized, consult specifications in the FIP/work plan and/or the project technical lead prior to sampling.

    In general, three potential options are available if stabilization criteria are not met:

    a. Continue purging until stabilization is achieved.

    b. Discontinue purging, do not collect any samples, and record in field logbook/on the sampling form that stabilization could not be achieved (documentation must describe attempts to achieve stabilization).

c. Discontinue purging, collect samples, and provide full explanation of attempts to achieve stabilization. There is a risk that the analytical data obtained under these conditions, particularly metals and hydrophobic organic analytes, may reflect a sampling bias and, as a result, the data may not meet the data quality objectives of the sampling event.

NOTE: *DO is extremely susceptible to various external influences (including temperature or the presence of bubbles on the DO meter); therefore, great care will be taken to minimize the agitation or other disturbance of water within the flow-through cell while collecting these measurements. If air bubbles are present on the DO probe or in the discharge tubing, remove them before taking a measurement. If DO values are not within acceptable range for the temperature of groundwater, again check for and remove air bubbles on the probe before re-measuring. The table below may be used as a general guide for DO values under various temperatures; however, understand that the table corresponds to freshwater solubility and groundwater contaminants may affect oxygen solubility. If DO value is 0.00 or less, then the meter will be serviced and re-calibrated. If DO values are above possible results, then the meter will be serviced and re-calibrated.*

NOTE: *During extreme weather conditions, stabilization of field indicator parameters may be difficult to attain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) will be documented in the field logbook/on the sampling form.*

NOTE: *If other field conditions are suspected of preventing stabilization of certain parameters, detailed observations will be documented in the field logbook/on the sampling form.*

Oxygen Solubility in Fresh Water

Temperature (degrees C)	Dissolved Oxygen (mg/L)
0	14.6
1	14.19
2	13.81
3	13.44
4	13.09
5	12.75
6	12.43
7	12.12
8	11.83
9	11.55
10	11.27
11	11.01
12	10.76
13	10.52
14	10.29
15	10.07
16	9.85
17	9.65
18	9.45
19	9.26
20	9.07
21	8.9
22	8.72
23	8.56
24	8.4
25	8.24
26	8.09
27	7.95
28	7.81
29	7.67
30	7.54
31	7.41
32	7.28
33	7.16
34	7.05
35	6.93

Reference: Vesilind, P.A., Introduction to Environmental Engineering, PWS Publishing Company, Boston, 468 pages (1996)

21. Complete the sample label(s) and cover the label(s) with clear packing tape to secure the label onto the container.
22. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container.
    a. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell will be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection.
    b. Under no circumstances will analytical samples be collected from the discharge of the flow- through cell.
    c. If an in-line ‘T’ and valve are used, the valve needs to be removed as well.

d. Samples will be collected in the following order: VOCs, total organic carbon (TOC), semi- volatile organic compounds (SVOCs), metals and cyanide, and others (or other order as defined in the site-specific FIP/work plan).
e. When the container is full, tightly screw on the cap.

23. If sampling for total and filtered metals and/or polychlorinated biphenyls (PCBs), a filtered and unfiltered sample will be collected.
    a. Install an in-line, disposable 0.45-micron particle filter on the discharge tubing after the appropriate unfiltered groundwater sample has been collected.
    b. Continue to run the pump until an initial volume of "flush" water has been run through the filter in accordance with the manufacturer's directions (generally 100 to 300 mL).
    c. Collect the filtered groundwater sample by diverting flow out of the filter into the appropriately labeled sample container.
    d. When the container is full, tightly screw on the cap.
24. Secure with packing material and store the samples on ice in an insulated transport container provided by the laboratory and include a temperature blank in each container to be shipped.
25. Record on the Low-Flow Sampling Field Form (and bound field logbook) the time at which sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance and the presence or lack of odors or sheens), and the values of the stabilized field indicator parameters as measured during the final reading during purging **(see Attachment A)**.
26. Turn off the pump and air compressor or close the gas cylinder valve if using a bladder pump setup.
27. Slowly remove the pump, tubing, lines, and safety cable from the well.
    a. If using dedicated tubing, do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them.
    b. If using dedicated tubing, it will be folded - without pinching it - to a length that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events.
    c. Use a length of rope or string to tie the tubing to the well cap.
    d. Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date, coil the tubing neatly and placed in a clean plastic bag that is clearly labeled with the well ID ensuring the bag is tightly sealed before placing it in storage.
28. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment.
29. Complete the procedures for packaging, shipping, and handling with the associated Chain-of- Custody.
30. Complete decontamination for flow-through analytical cell and submersible or bladder pump, as appropriate *(TGI – Groundwater and Soil Sampling Equipment Decontamination).*
31. At the end of each day of the sampling event, perform calibration check of field instruments and record procedure and results in field log.

9 Waste Management

Materials generated during groundwater sampling activities, including disposable equipment and excess purge water, will be stored on site in appropriately labeled containers and disposed of properly. Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage*, the procedures identified in the

FIP or QAPP as well as state-, federal- or client-specific requirements. Be certain that waste containers are properly labeled and documented in the field logbook.

10 Data Recording and Management

Digital data collection is the Arcadis standard using available FieldNow® applications that enable real-time, paperless data collection, entry, and automated reporting. Paper forms should only be used as backup to FieldNow® digital data collection and/or as necessary to collect data not captured by available FieldNow® applications. The Field Now® digital form applications follow a standardized approach, correlate to most TGIs and are available to all projects accessible with a PC or capable mobile device. Once the digital forms are saved within FieldNow®, the data is instantly available for review on a web interface. This facilitates review by project management team members and SMEs enabling error or anomalous data detection for correction while the staff are still in the field. Continual improvements of FieldNow® applications are ongoing, and revisions are made as necessary in response to feedback from users and subject matter experts.

Management of the original documents from the field will be completed in accordance with the site- specific QAPP.

In general, forms (e.g., Low-Flow Sampling Field Forms), logs/notes (including daily field and calibration logs), digital records, and Chain-of-Custody records will be maintained by the field team lead.

Field logs and Chain-of-Custody records will be transmitted to the Arcadis Project Manager and/or Task Manager, as appropriate, at the end of each day unless otherwise directed. Electronic data files will be sent to the project team and uploaded to the electronic project folder daily.

Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements.

11 Quality Assurance

Quality assurance procedures shall be conducted in accordance with the Arcadis Quality Management System or the site-specific QAPP.

Unless described otherwise in the project-specific FIP/work plan, QAPP, or Sampling and Analysis Plan, quality assurance/quality control samples will be collected as follows:

- One duplicate for every 10 samples
- One laboratory matrix/matrix spike sample for every 20 samples
- In addition to the quality control samples to be collected in accordance with this TGI, the following quality control procedures will be observed in the field:
- Collect samples from monitoring wells, in order of increasing concentration, to the extent known based on review of historical site information if available
- Equipment blanks will include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well)
- Collect equipment blanks after wells with higher concentrations (if known) have been sampled

- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures—calibrate instruments at the beginning of each day, verify the calibration at the end of each day, and record all calibration activities in the field notebook
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well following the procedure for equipment decontamination

12 References

USEPA. 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* (September 1986).

USEPA. 1991. *Handbook Groundwater, Volume II Methodology*, Office of Research and Development, Washington, DC. USEPN62S, /6-90/016b (July 1991).

USEPA Region I. 2017. *Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells (*EQASOP-GW4; September 19, 2017).

U.S. Geological Survey (USGS). 1977. *National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination*. Reston, Virginia.

13 Attachments

Attachment A – Low Flow Sampling Field Form

Attachment A

Low-Flow Sampling Field Form

GROUNDWATER SAMPLING FORM

Project No. _____ Well ID _____ Date _____

Project Name/Location _____ Weather _____

Measuring Pt. Description _____ Screen Setting (ft-bmp) _____ Casing Diameter (in.) _____ Well Material ____ PVC ____ SS

Static Water Level (ft-bmp) _____ Total Depth (ft-bmp) _____ Water Column (ft) _____ Gallons in Well _____

MP Elevation _____ Pump Intake (ft-bmp) _____ Purge Method: _____ Sample Method _____

Pump On/Off _____ Centrifugal _____ Submersible _____ Other _____

Sample Time: _____ Volume Purged _____

Purge Start _____ Gallons Purged _____ Sample ID _____ Sampled by _____

Purge End _____ Replicate/Code No. _____

Time	Minutes Elapsed	Rate (gpm)/(mL/min) 200mL/min +	Depth to Water (ft) -0.3	Gallons Purged	pH ± 0.1	Cond. (µMhos)/(mS/cm) ± 3%	Turbidity (NTU) ± 10%	DO (mg/L) ± 10%	Temp. (°C)/(°F) ± 3%	Redox (mV) ± 10mV	Appearance	
											Color	Odor
Stabilization Calculations (±)												
Stabilization Criteria					**± 0.1 s.u.**	**±3%**	**± 10% or within 1 NTU (1)**	**± 10%**	**±3%**	**±10 mV**		

(1) **Turbidity** < 50 NTU and ±10% or within 1 NTU of a previous reading when <10 NTU

Constituents Sampled	Container	Number	Preservative

Comments _____

Well Casing Volumes

Gallons/Foot					
	1" = 0.04	*1.5" = 0.09*	*2.5" = 0.26*	*3.5" = 0.50*	*6" = 1.47*
	1.25" = 0.06	*2" = 0.16*	*3" = 0.37*	*4" = 0.65*	

Well Information

Well Location: _____ Well Locked at Arrival: Yes / No

Condition of Well: _____ Well Locked at Departure: Yes / No

Well Completion: Flush Mount / Stick Up Key Number To Well: _____

Arcadis U.S., Inc.
630 Plaza Drive, Suite 200
Highlands Ranch
Colorado 80129
Phone: 720 344 3500
Fax: 720 344 3535
www.arcadis.com

TGI – Groundwater and Soil Sampling Equipment Decontamination

Rev: 3

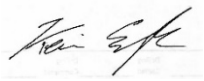
Rev Date: August 30, 2023

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
	0	February 23, 2017	All	Conversion from SOP to TGI	Cassandra McCloud / Pete Frederick
	1	May 8, 2020	4, 5	Added note regarding use of Liquinox and 1,4-Dioxane	Marc Killingstad
	2	June 14, 2022	All	Conversion to new TGI format and minor edits.	Kevin Engle / Marc Killingstad
	3	August 30, 2023	All	Annual review completed by SME. Updated Rev 1.	Marc Killingstad

Approval Signatures

Prepared by: 8/30/2023



Name (Preparer) Date

Reviewed by: 8/30/2023

Marc Killingstad (Subject Matter Expert) Date

1 Introduction

This document is intended to provide guidance to staff performing decontamination procedures at project sites. The content in this document describes the intended use, scope and application, personnel qualifications, equipment, cautions, health and safety considerations, procedures, waste management, data recording and management, and quality assurance of decontamination procedures.

2 Intended Use and Responsibilities

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

3 Scope and Application

Decontamination is performed on sampling equipment prior to sample collection to ensure that the sampling equipment that contacts a sample, or monitoring equipment that is brought into contact with environmental media to be sampled, is free from analytes of interest and/or constituents that could interfere with laboratory analysis for analytes of interest. Sampling equipment must be appropriately cleaned prior to use for sampling or coming into contact with environmental media to be sampled and following completion of the sampling event prior to shipment or storage. The effectiveness of the decontamination procedure should be verified by collecting and analyzing equipment blank samples.

The sampling equipment cleaning procedures described herein includes pre-field, in the field, and post- field cleaning of sampling equipment which may be conducted at an established equipment decontamination area (EDA) on site, as appropriate and necessary. Sampling equipment that may require decontamination at a given site include soil sampling tools; groundwater, sediment, and surface-water sampling devices; water testing instruments; down-hole instruments; and other activity-specific sampling equipment. Non-disposable equipment will be cleaned before collecting each sample, between each sample collected, and prior to placing sampling equipment in protective cases, or containers for transport. Cleaning procedures for sampling equipment should be monitored by collecting equipment blank samples as required in project work plans, field sampling plans, quality assurance project plans (QAPP), or other pertinent project documents. Dedicated and/or single-use (i.e., not to be re-used) sampling equipment will not require decontamination.

4 Personnel Qualifications

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour hazardous waste operations and emergency response (HAZWOPER) training and/or Occupational Safety and Health Administration (OSHA) HAZWOPER site supervisor training. Arcadis personnel will also have current training as specified in the Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and Technical Guidance Instructions (TGIs) and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The project HASP and other documents will identify other training requirements or access control requirements.

5 Equipment List

The equipment required for equipment decontamination is presented below. Note that certain contaminants may require specific materials be used that are not captured in this list. Always review project and contaminant specific TGIs or work plans to ensure proper equipment is utilized. Note for per- and polyfluoroalkyl substances (PFAS) see *TGI – Per- and Polyfluoroalkyl Substances (PFAS) Field Sampling Guide*.

- Health and safety equipment, including appropriate personal protective equipment (PPE), as required in the site HASP
- Deionized water that meets the analytical criteria for deionized water with no detectable constituents above the reporting limits for the methods to be used and analytes being analyzed for. Deionized water is used for inorganics, and organic-free water for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, etc.
- Non-phosphate detergent such as Alconox® or, if sampling for phosphorus or phosphorus- containing compounds, Liquinox (or equivalent). NOTE: Liquinox has shown to provide false positives for 1,4-Dioxane and should not be used at sites where that may be a constituent of concern (COC).
- Tap water
- Rinsate collection plastic containers

- Department of Transportation (DOT)-approved waste shipping container(s), as specified in the work plan, field sampling plan, or regulatory requirements if decontamination waste is to be shipped for disposal
- Brushes
- Large heavy-duty garbage bags
- Spray bottles
- (Optional) – Isopropyl alcohol (free of ketones) or methanol. These can be wipes or diluted with water (usually 1part isopropyl/methanol to 10 parts water) if a spray is needed.
- Airtight, sealable plastic baggies, such as Ziploc®-type
- Plastic sheeting

6 Cautions

Rinse equipment thoroughly and allow the equipment to dry before re-use or storage to prevent introducing solvent into sample medium. If manual drying of equipment is required, use clean lint-free material to wipe the equipment dry. Ensure all rinse materials do not adversely affect sample collection efficiency or analytical results.

Store decontaminated equipment in a clean, dry environment. Do not store near combustion engine exhausts. Properly containerize equipment to ensure cross-contamination doesn't happen from other uncontaminated surfaces or equipment.

If equipment is damaged to the extent that decontamination is uncertain due to cracks, gouges, crevices, or dents, the equipment should not be used and should be discarded or submitted for repair prior to use for sample collection.

A proper shipping determination regarding hazardous materials will be performed by a DOT-trained individual for cleaning materials shipped by Arcadis.

Caution should be exercised to avoid contact with the pump casing and water in the container while the pump is running (do not use metal drums or garbage cans) to avoid electric shock.

7 Health and Safety Considerations

Review the safety data sheets (SDS) for the cleaning agents and materials used in decontamination. If solvent is used during decontamination, use appropriate PPE and work in a well-ventilated area and stand upwind while applying solvent to equipment. Apply solvent in a manner that minimizes potential for exposure to workers and bystanders. Follow health and safety procedures outlined in the HASP.

8 Procedure

A designated area will be established to clean sampling equipment in the field prior to and following sample collection. Equipment cleaning areas will be set up within or adjacent to the specific work area, but not at a location that expose equipment to contamination (i.e., exposed to combustion engine exhaust). Detergent solutions will be prepared in clean containers for use in equipment decontamination. Decontaminated equipment

will be handled by workers wearing clean gloves, properly changed to prevent cross-contamination. The procedures detailed in this section provide an overview of common decontamination techniques. Additional steps may be required based on the type of contaminant present or client/site requirements.

Cleaning Sampling Equipment

1. Wash the equipment/pump with potable water.
2. Wash with detergent solution (Alconox®, Liquinox® or equivalent) to remove all visible particulate matter and any residual oils or grease. NOTE: Liquinox® has shown to provide false positives for 1,4-Dioxane and will not be used at sites where that may be a COC.
3. If equipment is very dirty, precleaning gross debris with a brush and tap water may be necessary.
4. If non-aqueous phase liquids are present, the use of isopropyl alcohol (free of ketones) or methanol is recommended. Cloth wipes or diluted solution can be used to remove the non-aqueous phase liquids that are hard to remove with detergent solution in step 2. Consult with project manager if non-aqueous phase liquids are present onsite and design an appropriate decontamination procedure that includes step 4.
5. Rinse with deionized water.

Decontaminating Submersible Pumps

Submersible pumps may be used during well development, groundwater sampling, or other investigative activities. The pumps must be cleaned and flushed before and between uses. This cleaning process will consist of an external detergent solution wash and tap water rinse, a flush of detergent solution through the pump, followed by a flush of potable water through the pump. Flushing will be accomplished by using an appropriate container filled with detergent solution and another container filled with potable water. The pump will be be flushed with deionized water as the last step prior to use. The pump will run long enough to effectively flush the pump housing and hose (unless new, disposable hose is used). Disconnect the pump from the power source before handling. The pump and hose will be placed on or in clean polyethylene sheeting to avoid contact with the ground surface.

9 Waste Management

Equipment decontamination rinsate will be managed in conjunction with all other waste produced during the field sampling effort. Waste management procedures are outlined in the work plan or Waste Management Plan (WMP).

10 Data Recording and Management

Digital data collection is the Arcadis standard using available FieldNow® applications that enable real-time, paperless data collection, entry, and automated reporting. Paper forms should only be used as backup to FieldNow® digital data collection and/or as necessary to collect data not captured by available FieldNow® applications. The Field Now® digital form applications follow a standardized approach, correlate to most TGIs and are available to all projects accessible with a PC or capable mobile device. Once the digital forms are saved within FieldNow®, the data is instantly available for review on a web interface. This facilitates review by project management team members and SMEs enabling error or anomalous data detection for correction while the staff

are still in the field. Continual improvements of FieldNow® applications are ongoing, and revisions are made as necessary in response to feedback from users and subject matter experts.

Equipment cleaning and decontamination will be noted during project documentation. Information will include the type of equipment cleaned, the decontamination location, specific procedures utilized, solvents and/or cleaning agents used, source of water, and deviations or omissions from this TGI.

Unusual field conditions should be noted if there is potential to impact the efficacy of the decontamination or subsequent sample collection.

An inventory of the solvents brought on site and used and removed from the site will be maintained in the project documentation. Records will be maintained for solvents used in decontamination, including lot number and expiration date.

Containers with decontamination fluids will be labeled.

11 Quality Assurance

Equipment blanks should be collected to verify that the decontamination procedures are effective in minimizing potential for cross contamination. The equipment blank is prepared by pouring deionized water (or organic-free water, for organic analyses) over the clean and dry tools and collecting the water into appropriate sample containers. Equipment blanks should be analyzed for the same set of parameters that are performed on the field samples collected with the equipment that was cleaned as specified in the sampling and analysis plan. Equipment blanks are collected per equipment set, which represents all the tools needed to collect a specific sample.

12 References

USEPA Region 9 - Field Sampling Guidance #1230, Sampling Equipment Decontamination.

USEPA Region 1 - Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

Arcadis U.S., Inc.
630 Plaza Drive, Suite 200
Highlands Ranch
Colorado 80129
Phone: 720 344 3500
Fax: 720 344 3535
www.arcadis.com

TGI - Equipment and Reagent Blank Sample Collection for PFAS Analysis

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Version Control

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Outdated template	1	December 10, 2021	All	Updated to current TGI format. Also updated sections to match the most recent TGI for PFAS Field Sampling Guidance (Arcadis 2021)	Kevin Engle
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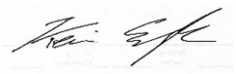
Prepared by:		3/20/2025
	Kevin Engle (Preparer)	Date
Reviewed by:		3/20/2025
	Johnsie Lang, PhD (Subject Matter Expert)	Date

1 Introduction

This document is intended to provide guidance to field staff collected equipment blanks for Per- and Polyfluoroalkyl Substances (PFAS). The content in this document describes the intended use, scope and application, personnel qualifications, equipment, cautions, health and safety considerations, procedures, waste management, data recording and management, and quality assurance of PFAS sampling.

2 Intended Use and Responsibilities

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

3 Scope and Application

Equipment and reagent blanks will be collected in the field during sampling activities and submitted for laboratory analysis. These samples are primarily intended to verify that sampling and decontamination practices are effectively preventing cross-contamination caused by reusable sample equipment or (PFAS)-containing materials.

The intent of this Technical Guidance Instruction (TGI) is to provide instructions for collection of equipment and reagent blanks. More detailed instructions related to general PFAS sampling considerations is provided in the TGI Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance.

4 Personnel Qualifications

Equipment and reagent samples will be collected by persons who have been trained in proper sampling procedures under the guidance of an experienced field geologist, engineer, or technician. Blank sampling should be completed with a two-person sampling team.

5 Equipment List

The following equipment and materials must be available for equipment and reagent blank sampling:

- Site plan which specifies frequency/quantity of blank sampling;
- Relevant work plan (e.g., PQAPP);
- Site Safety and Health Plan (SSHP);
- Appropriate health and safety equipment, as specified in the SSHP;
- Laboratory-provided “PFAS-free” water;
- Nitrile gloves;
- Dedicated plastic sheeting (preferably low-density polyethylene) or other clean surface to prevent sample contact with the ground;
- Pail or bucket with closable lid for excess rinse water;
- Garbage bags;
- Appropriate sample containers and labels:
    - Labeled high density polypropylene (HDPE) sample bottles: see the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2021) for PFAS-specific considerations;
    - Ziploc®-style bags to hold ice and samples;
    - Packing and shipping materials;
    - Chain-of-Custody (COC) Forms; see the Sample Chain of Custody Standard Operating Procedure (SOP) for reference (Arcadis 2017a); and
    - Appropriate transport containers (coolers) with ice and appropriate labeling; no blue ice is to be used.
- Decontamination:
    - Equipment cleaning materials: see the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2021) or the Groundwater and Soil Sampling Equipment Decontamination TGI (Arcadis 2017b) as applicable;
    - An organic solvent such as isopropanol, methanol, or acetone should be used to decontaminate reusable equipment if it can be brought to the site safely. While strongly recommended, the use of solvents may be excluded for project-specific health and safety concerns. Refer to Section 7.1.1 for more details; and
    - Drum labels as required for investigation-derived waste handling: see the Investigation-Derived Waste Handling and Storage TGI for details.

- Field Notes:
    - Pens, pencils, and/or fine point Sharpies® for writing;
    - Appropriate field forms; and
    - Clipboards, field binders, field notebook, and field note pages that are not waterproof.

6 Cautions

In general, sampling techniques used for PFAS sample collection are consistent with conventional sampling techniques used in the environmental industry, but special consideration is made regarding PFAS-containing materials and cross-contamination potential. The most important consideration during PFAS-related sampling is to prevent contact between sample media and suspect PFAS sources. During collection of equipment and reagent blanks, the sampled media (i.e., PFAS-free water) should not contact anything but the sample container. New nitrile gloves should be donned after handling of any non-dedicated sampling equipment; contact with contaminated surfaces; and whenever judged necessary by field personnel. When in doubt change your gloves. More detailed instructions related to general PFAS sampling considerations is provided in the TGI - Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance.

7 Health and Safety Considerations

Field activities associated with equipment and reagent blank sampling will be performed in accordance with the SSHP, a copy of which will be present on site during such activities. Additional health and safety considerations can be found in TGI for PFAS Field Sampling Guidance.

8 Procedure

The specific procedure for equipment and reagent blank sampling was developed after careful review and consideration of project data quality objectives. Procedures for equipment blank sampling and reagent blank sampling are further described in this section. Note: the laboratory has to analyze the entire sample bottle for aqueous solutions of PFASs. When collecting each blank, fill two sample bottles and instruct the lab to hold one of them in reserve. If an unacceptable detection occurs in a blank, the second bottle of sample may be analyzed.

For additional sampling considerations, reference the TGI for PFAS Field Sampling Guidance.

8.1 Blank Sampling

8.1.1 Decontamination

Prior to collecting blank samples, the applicable piece of equipment should be properly decontaminated following these steps:

- Hand Tools and Sampling Devices (including hand augers and bladder pumps)
    1. Don new pair of nitrile gloves prior to decontamination.
    2. Remove O-rings and bladder (applies only to bladder pump).

3. Scrub using a plastic brush and a non-phosphate soap free of volatile organic compounds (VOCs) (e.g., Liquinox, Alconox);
4. Double-rinse in deionized or distilled water;
5. Rinse once with the site-approved organic rinsing solvent (e.g., isopropanol, methanol, acetone);
6. Rinse once with PFAS-free water;
7. Collect all rinsate in a sealed pail for disposal;
8. Allowed time to air dry prior to re-use; and
9. Insert new o-rings and bladder (applies only to bladder pump);

While strongly recommended, the use of solvents may be excluded for project-specific health and safety concerns. If solvents are prohibited, then additional procedures should be evaluated by the project team. Contingencies could include the use of dedicated sampling equipment at each sampling location or amending laboratory procedures to mitigate the increased risk of cross-contamination.

The following decontamination procedure could be utilized when organic solvent use is not possible:

1. Don new pair of nitrile gloves prior to decontamination.
2. Remove o-rings and bladder (applies only to bladder pump);
3. Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox);
4. Single-rinse in deionized or distilled water;
5. Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox);
6. Rinse twice with deionized water and once with PFAS-free water;
7. Collect all rinsate in a sealed pail for disposal;
8. Allowed time to air dry prior to re-use.
9. Insert new o-rings and bladder (applies only to bladder pump)

- Drilling Rods
    - Drive casings and other drilling equipment will be steam cleaned or replaced with new equipment between boreholes.
    - The drilling equipment will be cleaned in an area designated by the supervising engineer or geologist that is located outside of the work zone.

After verifying the piece of equipment is properly decontaminated, and after determining an equipment blank is warranted per the sampling quality assurance and quality control (QA and QC) plan, follow the specific procedures for the relevant type of equipment found in the following sections.

8.1.2 Drilling Equipment (Hand Auger or Cutting Shoe/Drill Rod)

Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should pour the rinse water.

The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
3. Place the sealable bucket or pail on top of plastic sheeting.
4. Don a new pair of nitrile gloves prior to blank collection (Field Personnel #1 and #2). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
5. Open the sample container and position the piece of clean, decontaminated sample equipment (i.e., hand auger or drilling rod/cutting shoe) above the container (Field Personnel #1). Keep the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle.
    a. The bucket of the hand auger can be removed from the rods/handle and held manually.
    b. The drillers should assist the field staff with removing the cutting shoe from the drill string and positioning it for sampling.
6. Slowly pour laboratory-provided “PFAS-free” water over any surface of the decontaminated sampling device that previously contacted sampled material (Field Personnel #2).
    a. Pour water through the inside of the hand auger bucket while manually rotating the bucket so that “PFAS-free” water contacts all sides of the sampling device. Collect runoff in the sample container (Field Personnel #1), making sure that any excess “PFAS-free” water is contained in the sealable bucket or pail.
    b. Pour water through the inside of cutting shoe while drilling contractor holds and manually rotates the shoe so that “PFAS-free” water contacts all sides of the shoe (Field Personnel #2). Collect runoff in the sample container, making sure that any excess “PFAS-free” water is contained in the sealable bucket or pail.
7. After collecting the necessary sample volume, place cap back on the sample bottle (Field Personnel #1). The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
8. Collect the second bottle with the same procedure (Steps 5 to 7), if collecting a backup.
9. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
10. Add sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
11. Place sealed Ziploc® bag into the sample cooler. Store PFAS samples in separate cooler from any other types of samples.
12. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

8.1.3 Reusable Sediment Sampling Equipment (Stainless-Steel Hand Tools, Petite Ponar Grab Sampler)

Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should pour the rinse water.

The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
3. Place sealable bucket or pail on top of plastic sheeting.
4. Don new pair of nitrile gloves prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
5. Open sample container and position the clean, decontaminated piece of sample equipment (i.e., hand tool, grab sampler) above the container (Field Personnel #1). Keep the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle.
6. Slowly pour the laboratory-provided “PFAS-free” water over any surface of the sampling device that contacted sampled material (Field Personnel #2).
    a. Pour water over front and back of all decontaminated hand tools such as spoons, spatulas, and trowels so that “PFAS-free” water touches all sides of the sampling device. Collect runoff in the sample container, making sure that any excess “PFAS-free” water is contained in the sealable bucket or pail (Field Personnel #1).
    b. Pour water through inside of the decontaminated Petite Ponar Grab Sampler while rotating the sampler (or the “PFAS-free” water container) so that “PFAS-free” water contacts all interior sides of the sampler (Field Personnel #2). Collect runoff in the sample container, making sure that any excess “PFAS-free” water is contained in the sealable bucket or pail.
7. After collecting the necessary sample volume, place cap back on the sample bottle (Field Personnel #1). The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
8. Collect the second bottle with the same procedure (Steps 5 to 7), if collecting a backup.
9. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
10. Add the sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
11. Place sealed Ziploc® bag into the sample cooler. Store PFAS samples in separate cooler from any other types of samples.
12. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

8.1.4 Disposable Sediment Sampling Equipment (Lexan TM Liner Sleeve)

Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should pour the rinse water.

The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep the bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
3. Place sealable bucket or pail on top of plastic sheeting.
4. Don new pair of nitrile gloves prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
5. Open sample container and position a clean, new, and unused section of Lexan™ liner above the container (Field Personnel #1). Keep the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle.
6. Slowly pour laboratory-provided "PFAS-free" water over any surface of the sampling device that contacted sampled material (Field Personnel #2).
    a. Pour water through inside of Lexan™ liner while rotating the liner so that "PFAS-free" water contacts all interior sides of the liner. Collect runoff in the sample container, making sure that any excess "PFAS-free" water is contained in the sealable bucket or pail.
7. After collecting the necessary sample volume, place cap back on the sample bottle (Field Personnel #1). The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
8. Collect the second bottle with the same procedure (Steps 5 to 7), if collecting a backup.
9. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
10. Add sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
11. Place sealed Ziploc® bag into the sample cooler. Store PFAS samples in separate cooler from any other types of samples.
12. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

8.1.5 Reusable Water Sampling Equipment (Peristaltic Pump, Bladder Pump, Stainless-Steel Bailer)

8.1.5.1 Peristaltic Pump

Two field personnel should participate in the collection of the equipment blank. One person ("Field Personnel #1") should hold the sampling bottle and collect the sample, and the second person ("Field Personnel #2") should set up the pump and pour/ transfer the blank water.

The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep bottle lid on until immediately prior to sample collection.

2. Lay down dedicated plastic sheeting other clean surface to prevent sample contact with the ground.
3. Don new pair of nitrile gloved prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
4. Pour laboratory-supplied “PFAS-free” water into a clean HDPE sample bottle (Field Personnel #2).
5. Insert new HDPE tubing into the HDPE bottle containing “PFAS-free” water and connect tubing to peristaltic pump (with new silicone tubing) (Field Personnel #2).
6. Open sample container, keeping the sample cap in the hand of the sampler until it is replaced on the bottle (Field Personnel #1).
7. Turn the peristaltic pump on and slowly pump the “PFAS-free” water into the labeled sample container (Field Personnel #2).
8. After collecting the necessary sample volume, place cap back on the sample bottle (Field Personnel #1). The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
9. Collect the second bottle with the same procedure (Steps 6 to 8), if collecting a backup.
10. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
11. Add the sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
12. Place sealed Ziploc® bag into the sample cooler. Store PFAS samples in separate cooler from any other types of samples.
13. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

8.1.5.2 Bladder Pump

1. Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should set up the pump and pour/ transfer the blank water.
2. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.
3. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep the bottle lid on until immediately prior to sample collection.
4. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
5. Don new pair of nitrile gloved prior to blank collection (both field personnel). Do not use gloved hands to handle papers, pens, clothes, equipment, etc., before collecting samples.
6. Pour laboratory-supplied “PFAS-free” water into an approved container (to avoid PFAS cross-contamination) large enough to submerge the bladder pump.
7. After properly decontaminating the bladder pump and replacing the bladder, attach a new section of HDPE tubing to the bladder pump, long enough to hold and direct flow into the labeled sample container. Submerge the bladder pump into the approved container of “PFAS-free” water (Field Personnel #2).

8. Open sample container, keeping the sample cap in the hand of the sampler until it is replaced on the bottle (Field Personnel #1).
9. Turn the bladder pump on and slowly pump the “PFAS-free” water into the labeled sample container (Field Personnel #2).
10. After collecting the necessary sample volume, place cap back on the sample bottle. The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
11. Collect the second bottle with the same procedure (Steps 6 to 8), if collecting a backup.
12. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
13. Add sample to laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
14. Place sealed Ziploc® bag into the sample cooler. Store PFAS samples in separate cooler from any other types of samples.
15. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

8.1.5.3 Stainless-Steel Bailer

Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should pour the rinse water.

The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
3. Place sealable bucket or pail on top of plastic sheeting.
4. Don new pair of nitrile gloves prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
5. Open sample container (Field Personnel #1) and position the bailer above the container (Field Personnel #2). Keep the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle.
6. Fill the stainless-steel bailer with enough laboratory-provided “PFAS-free” water to collect the necessary sample volume (Field Personnel #2).
7. Slowly pour laboratory-provided “PFAS-free” water from the stainless-steel bailer into the sample container (Field Personnel #2).
8. After collecting the necessary sample volume, place cap back on the sample bottle. The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
9. Collect the second bottle with the same procedure (Steps 5 to 8), if collecting a backup.

10. Place filled sample bottles in sealed Ziploc® bags, record any label information that was not pre-filled out, if necessary (e.g., sample time). Record the label information and time of sampling in the field notes and sampling forms.
11. Fill out the laboratory COC and check against the labels on the Equipment Blank sample bottle(s) progressively after each Equipment Blank is collected. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
12. Place sealed Ziploc® bag into the sample cooler. Store PFAS samples in a separate cooler from any other types of samples.
13. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

8.1.6 Field Reagent Blank Sampling

Two field personnel should participate in the collection of the reagent blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should pour the blank water.

This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep the bottle lid on until immediately prior to sample collection.
2. Don new pair of nitrile gloves prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
3. Open sample container, keeping the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle (Field Personnel #1).
4. Slowly pour laboratory-provided “PFAS-free” water from the laboratory-provided container into the sample container (“Field Personnel #2”).
5. After collecting the necessary sample volume, place cap back on the sample bottle. The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
6. Collect the second bottle with the same procedure (Steps 3 to 5) if collecting a backup.
7. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
8. Add sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
9. Place sealed Ziploc® bag into the sample cooler. Store PFAS samples in separate cooler from any other types of samples.
10. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

9 Waste Management

Excess water generated during equipment and reagent blank collection procedures will be collected and contained on site in appropriate containers, (see TGI for Investigation-Derived Waste Handling and Storage, for details). All investigation-derived waste (IDW) generated will be placed in Department of Transportation approved containers, sealed, and labeled. Containerized IDW will be stored on site until it is profiled and subsequently transported to an approved facility for disposal or recycling. Waste manifests for all IDW suspected to have come into contact with PFAS should clearly note the presence of PFAS. Additional IDW sampling and management details will be provided in the site-specific Work Plan (Quality Assurance Project Plan, QAPP addendum) and will be consistent with applicable client policies and requirements. Disposable personal protective equipment (e.g., gloves, disposable clothing, disposable equipment) will be placed in plastic bags. These bags will be transferred into appropriately labeled containers for appropriate disposal.

10 Data Recording and Management

Digital data collection is the Arcadis standard using available FieldNow® applications that enable real-time, paperless data collection, entry, and automated reporting. Paper forms should only be used as backup to FieldNow® digital data collection and/or as necessary to collect data not captured by available FieldNow® applications. The Field Now® digital form applications follow a standardized approach, correlate to most TGIs and are available to all projects accessible with a PC or capable mobile device. Once the digital forms are saved within FieldNow®, the data is instantly available for review on a web interface. This facilitates review by project management team members and SMEs enabling error or anomalous data detection for correction while the staff are still in the field. Continual improvements of FieldNow® applications are ongoing, and revisions are made as necessary in response to feedback from users and subject matter experts.

If digital data collection isn't possible, waterproof field books should be avoided for field notes. Instead, field notes on loose paper on Masonite, plastic, or aluminum clip boards is preferred. Please note that newer Rite in the Rain® notebooks are approved for PFAS sampling. Other requirements for field notes include:

- Pens, pencils, and fine point Sharpies® may be used.
- Keep field notes and writing implements away from samples and sampling materials.
- Do not write on sampling bottle labels unless the sample bottle covers are tightly closed.
- Complete sampling logs in their entirety.
- Make sure COC forms are properly completed. Verify that the analysis method requested is US EPA Method 537.1 for potable water and includes the appropriate analytes desired for analysis.

11 Quality Assurance

Refer to quality control requirements for the project to ensure that appropriate QA and QC samples are collected. When collecting QA and QC samples, the same guidelines apply as when collecting regular samples – specifically:

- **Duplicate samples of each equipment blank and reagent blank should be collected and submitted to the laboratory with instructions to hold for analysis. The purpose of this sample is to provide analytical back-up in case there are any issues with the original blank sample.**

- Samples should be collected in laboratory-supplied HDPE bottles.
- Bottle caps must remain in the hand of the sampler until replaced on the bottle;
- Labels must be completed after the caps have been placed back on each bottle.

Samples must be stored in appropriate transport containers (coolers) with ice (Ziploc®-type bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**

12 References

Arcadis TGI – TGI for Per- and Polyfluoroalkyl Substances (PFAS) Field Sampling Guide.pdf

Arcadis SOP – TGI for Sample Chain of Custody.pdf

Arcadis TGI – TGI for Groundwater and Soil Sampling Equipment Decontamination.pdf

Arcadis TGI – TGI for Investigation-Derived Waste Handling and Storage.pdf

Arcadis U.S., Inc.
630 Plaza Drive, Suite 200
Highlands Ranch
Colorado 80129
Phone: 720 344 3500
Fax: 720 344 3535
www.arcadis.com

Attachment 2

Laboratory Standard Operating Procedure for ASTM D7979

STANDARD OPERATING PROCEDURE

POLYFLUORINATED COMPOUNDS (PFCS) LIQUID CHROMATOGRAPHY/MASS SPECTROMETRY (LC/MS/MS) ASTM METHOD D8421 & ASTM METHOD D8535

APPROVALS:

Barbara Ball

02/19/2026

QA Officer — Date

Maya Mushaben

02/19/2026

Technical Director — Date

Number	Description of Change	Date
001	Emergency Amendment Forms (additional compounds and soil prep)	02/06/2020
002	2020 Internal Audit revisions	02/08/2021
003	Emergency Amendment Forms for biosolids and WI soil procedure	08/25/2021
004	Wisconsin Audit requested changes	10/06/2021
005	Emergency SOP Amendment Form	03/08/2023
006	Updated to ASTM Methods 8421 and 8535	02/19/2026
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1.0 SCOPE AND APPLICATION

This SOP covers a method for analysis of selected polyfluorinated compounds (PFCs) in water, soil, and biosolids matrices by liquid chromatography/tandem mass spectrometry analysis. The samples are prepared in 50% methanol (sludge and soil samples are adjusted to pH of approximately 9-10 with ammonium hydroxide), optionally filtered, and then acidified with acetic acid (pH ~ 3-4) and analyzed by liquid chromatography/tandem mass spectrometry.

2.0 SUMMARY OF METHOD

A sample (5 mL for water and 2g for soil) is spiked with mass labelled analytes to be used as internals for the purpose of quantitation (all samples) and target PFC compounds (laboratory control and matrix spike samples), water samples are tumbled for 20 minutes after adding 5 mL of methanol. Acetic acid (10 µL) is added to all the samples to adjust to pH ~ 3-4 and the sample is analyzed by LC/MS/MS. For sludge samples, the pH is adjusted to ~ 9-10 (adding ~ 20 µl of ammonium hydroxide) before extraction and ~ 50 uL of acetic acid is needed for acidification. Soil samples are tumbled for 60 minutes after adding 5 mL of MeOH, 5 mL of DI water, and 20 µL pf Ammonium Hydroxide. 50 µL of Acetic acid is added to bring the pH to ~3-4 and the samples are centrifuged. Sample may be filtered before analysis using Acrodisc GxF/0.2µm GHP membrane syringe driven filter unit.

The target compounds are identified by comparing the dynamic multiple reaction monitoring (dMRM) transitions in the sample to the DMRM transitions in the standards (Appendix Figure 2). Certain PFC analytes only have a primary DMRM transition that is used for identification and quantitation. The retention time (RT) for the analytes of interest must also agree with the RT of the calibration verification standard by ±5%. The target compounds are quantitated using the DMRM transitions of the target compounds utilizing isotopically diluted mass labelled isotopes used as internal standards for the purpose of quantitation. The response of the mass labelled internals should be 50-150% of the calibration verification.

3.0 INTERFERENCES

Method interferences may be caused by contaminants in solvents, reagents, glassware, LC vials/caps, disposable pipettes, and other apparatus that lead to discrete artifacts or elevated baseline in the selected ion current profiles.

Matrix interferences may be caused by contaminants from the sample, sampling devices, or storage containers. The extent of matrix interferences will vary considerably from sample source to sample source, depending upon variations of the sample matrix.

All reagents and solvents should be of pesticide-residue purity or higher to minimize interference problems, preferably LC/MS grade.

Contaminants have been found in reagents, glassware, tubing, polytetrafluoroethylene (PTFE) LC vial caps, glass disposable pipettes, filters, degassers, and other apparatus that release polyfluorinated compounds. All of these materials are routinely demonstrated to be free from interferences by analyzing laboratory reagent and method blanks under the same conditions as the samples. All the supplies should be checked to determine the release of target analytes of interest. If found, measures should be taken to remove the contamination or data should be qualified.

The Liquid Chromatography system used should have components replaced, when possible, with materials known to not contain fluorinated target analytes of interest. In particular, PTFE lines should be replaced with PEEK™ tubing where possible and especially post-delay column.

Polyethylene LC autosampler vial caps or target analyte-free vial caps should be used.

Polyethylene disposable pipettes or target analyte-free pipettes should be used.

All disposable pipettes should be checked for release of target analytes of interest.

Degassers are important to continuous LC operation and are most commonly made of fluorinated polymers. To enable use, a delay column is placed after the degasser and before the sample injection valve.

4.0 APPARATUS AND MATERIALS

Liquid Chromatograph (LC) System – Agilent 1290 infinity II or Agilent 1260 infinity II with flow-through needle design.

Analytical Column - An analytical column, Zorbax Eclipse Plus C18 rapid resolution HD 3.0x50mm 1.8-micron

Isolator Column – Zorbax Eclipse Plus C18 rapid resolution 4.6x50mm 3.5-micron

Mass Spectrometer (MS) System – Agilent (2) 6495 triple quadrupole mass spectrometer. A mass spectrometer capable of DMRM analysis with fast enough cycle time to obtain at least 10 scans over a peak is needed with adequate sensitivity.

Data System – Masshunter software must be interfaced to the LC/MS/MS that allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program.

Analytical balance accurate to ±1% of sample mass.

Vials Agilent 1ml polypropylene autosampler vials or Agilent 2ml amber autosampler vials

Agilent Polyethylene autosampler vial caps

Syringe – 10-25 mL filter-adaptable polypropylene or polyethylene disposable syringe rinsed with methanol.

15 mL polypropylene tubes

4ml narrow mouth polypropylene containers

Gases - ultrapure nitrogen and nitrogen

Class A volumetric glassware
Microsyringes – Hamilton microsyringes of various sizes
Glass syringe- 5ml Glass syringe.
Acrodisc GxF/0.2µm GHP membrane syringe-driven filter unit. The Acrodisc filters in combination with the disposable syringes are washed with 20 mL methanol prior to use.
Polyethylene disposable pipettes

5.0 REAGENTS

NOTE: Standard mixes are available from Wellington Labs, Phenova and Absolute and contain each analyte at a given concentration, either at 1 or 2 µg/mL. The target spike mix concentrations can be changed to account for the rigidity in standard sources when using mixes. The concentration of PFBA may be at the same concentration as the other analytes in all solutions. If the sensitivity for this analyte at the lower concentrations is poor, the reporting limit will need to be adjusted. Also, other isotopically labeled compounds may be used as isotopically diluted internals as the number of available options is a rapidly changing landscape.

Deionized (DI) water taken from the PFAS lab.

Water, LC/MS grade.

Acetonitrile, LC/MS grade or equivalent (CAS # 75-05-8).

Methanol, LC/MS grade or equivalent (CAS# 67-56-1)

Isopropyl alcohol, LC/MS grade of equivalent (CAS # 67-63-0)

Ammonium hydroxide (CAS# 1336-21-6)

Ammonium acetate (CAS# 631-61-8)

Acetic acid (CAS # 64-19-7)

Polyfluoroalkyl sulfonates (PFAS)

- Absolute mix 64029 (PFOA-DOD)
- Phenova mix AL0-131048 (Custom PFAS Mix)

- Wellington standard L-PFPrS (sodium perfluoro-1-propanesulfonate)

Polyfluoroalkyl carboxylic acids (PFAC)

- Absolute mix 64029 (PFOA-DOD)
- Phenova mix AL0-131048 (Custom PFAS Mix)
- Cambridge standard ULM-11323-A-S (perfluoropropanoic acid (PFPrA) (unlabeled))

Polyfluorinated sulfonamides and sulfonamidoacetic acids

- Absolute mix 64029 (PFOA-DOD)
- Phenova mix AL0-131048 (Custom PFAS Mix)
- Absolute standard 011025 (bis(Trifluoromethane)sulfonimide) [HQ-115]

PFC mass labelled mix for isotopic dilution utilizing internal calibration for quantitation.

- Wellington mix MPFAC-24ES
- Cambridge standard CLM-11324-A-S (perfluoropropanoic acid (PFPrA) (CP97%) (13C3, 99%)
- Cambridge standard CLM-11757-S (sodium perfluoro-*n*-tridecanoate (PFTrDA) (1,2,3,4,5,6-$^{13}C_6$, 99%)
- Wellington standard d7-N-MeFOSE-M (2-(N-methyl-d_3-perfluoro-1-octanesulfonamido)ethan-d4-ol
- Wellington standard d9-N-EtFOSE-M (2-(N-Ethyl-d_5-perfluoro-1-octanesulfonamido)ethan-d4-ol
- Wellington standard d-N-EtFOSA-M (n-Ethyl-d_5-perfluoro-1-octanesulfonamide)
- Wellington standard d-N-MeFOSA-M (n-Methyl-d_3-perfluoro-1-octanesulfonamide)
- Wellington standard M3HFPO-DA (2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)($^{13}C_3$)-propanoic acid)

Second source standard

- Phenova mix AL0-101852 (1633 PFAS Calibration Standard)

- AccuStandard standard PFOS-030S-0.02X (Bis(trifluoromethane sulfonimide lithium salt (HQ-115)
- AccuStandard standard PFOA-015S-0.02X (2,2,3,3,3-Pentafluoropropionic acid (PFPrA)
- Cambridge standard ULM-11655-S (sodium perfluoro-1-propanesulfonate (PFPrS) (unlabeled)
- Wellington standard FBSA-I (Perfluoro-1-butanesulfonamide)
- Wellington standard FHxSA-I (Perfluoro-1-hexanesulfonamide)
- Wellington standard PFECHS (Potassium perfluoro-4-ethylcyclohexanesulfonate (isomeric mixture)

CAUTION: All standards must be kept away from PFC-containing packaging and materials used in preparation and storage. In order to prevent standard solutions from degrading, all standard solutions are stored at < 6º C in the refrigerator.

The instructions for the preparation of stock standards, spiking solutions, and QC batch samples are listed below.

The calibration levels and second source calibration check are prepared prior to calibration. Reagent blank and all batch QC are made for each batch of field samples. The CV may be taken from the appropriate calibration standard as monitoring the stability over time may provide necessary insight into sample behavior. If a sample requires dilution it may be done from the already processed sample and the corresponding method blank and the reporting limit check should be run with it to verify instrument sensitivity. Alternatively, the reporting limit check from a new batch may be used if a new preparatory batch is being analyzed as the efficacy of the original preparation will have already been verified.

Surrogate spiking solution

- A surrogate spiking solution containing fourteen isotopically-labeled PFCs is added to all samples. This surrogate spiking solution is added to achieve a concentration of 160 ng/L in a 5 mL water sample (i.e. 100 µL of a 8 µg/L solution prepared in methanol is added to a 5 mL sample). Example dilution: The PFC surrogate mix solutions were purchased from Wellington and 240ul of the stock solution (1000ug/L) is added to 29.76 ml methanol producing a 8 µg/L spiking solution.

MS/MSD and LCS/LCSD spiking solution

- Each MS/MSD or LCS/LCSD sample is spiked with target PFCs to achieve a concentration of 100 ng/L in a 5 mL water sample. This is achieved by making a 5ug/L solution from the stock solution at

1000ug/L by adding 15ul of the stock solution to 2985ul of methanol and spiking 100ul of the 5ug/L solution into 5ml of water (sample or LCS).

Reporting limit check spiking solution

- The reporting limit check sample is prepared by spiking a 5 mL water sample with target analytes at the reporting limit. Example: Using the 1ug/L working standard spike 50ul into 5ml of water to achieve 10ng/L,

Calibration standards

- Calibration standards are prepared as shown in Table 3. All calibration standards should contain 50:50 methanol and water with 0.1% acetic acid.

Second source calibration check solution

- A second source calibration check solution should be prepared and analyzed at a concentration inside the calibration curve and at the same composition of the calibration solvent.

- Preparation of Standards - When a compound purity is assayed to be 98% or greater, the weight can be used without correction to calculate the concentration of the stock standard. Sorption of PFAS analytes in methanol solution to glass surfaces after prolonged storage has not been evaluated. PFAS analyte and isotopically labeled analogues commercially purchased in glass ampoules are acceptable; however, all subsequent transfers or dilutions performed by the analyst must be stored in polypropylene containers. Solution concentrations listed in this section were used to develop this SOP and are included as examples. Alternate concentrations may be used as necessary depending on instrument sensitivity and the calibration range used. Standards for sample fortification generally should be prepared in the smallest volume that can be accurately measured to minimize the addition of excess organic solvent to aqueous samples. Standard QC practices are used to determine when standards need to be replaced. The analyte supplier's guidelines may be helpful when making this determination.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

For water, 5.0 mL grab samples are collected in 15 mL polypropylene containers. For soil, 2.0 g samples are collected in 15 mL polypropylene containers. Alternatively, soil samples may be collected in 125ml plastic containers and weighed out in the lab. Extra samples must be collected in order to analyze duplicate and matrix spike samples for QA/QC purposes upon client request.

CAUTION: PTFE containers and contact surfaces with PTFE must be avoided. Field blanks are needed to follow conventional sampling practices. Surface binding of target compounds to collection devices may bias data and must be minimized. Each Aqueous QC sample must be collected in its own container, including matrix spike, matrix spike duplicate, and duplicate samples.

Sample containers will be checked for PFCs by lot prior to distributing to clients. The lab PFC free DI water, is tested prior to distribution and is tracked by lot.

Since surface binding of target compounds may bias data, it is best to collect a 5.0 mL sample in a graduated 15 mL polypropylene tube in the field so that the whole sample is processed in the lab.

CAUTION: Taking a sub-sample for aqueous matrices is not recommended in this SOP, whether in the field during sample collection, or in the lab at the bench.

In order to have accurate volumes, the weight of the 15 mL polypropylene tube should be taken before and after sample processing in order to calculate an exact volume or weight. The density of water is assumed to be 1.0 g/mL unless otherwise instructed by the client/sampler. Sample containers will be tared prior to distribution to clients. If a tare weight is not provided, tubes are weighed after sample processing to determine the sample weight.

If a larger sample is collected in the field, a 5.0 mL or 2.0 g aliquot of that sample will be processed, not taking into account any PFCs that may adhere to the surface of the original container. This practice is not recommended for aqueous matrices. The use of such containers will be noted in the report.

All samples are refrigerated between 0 and 6°C from the time of collection until sample analysis. At the laboratory, prepared samples are stored in the refrigerator between 0 and 6°C at all times while not being analyzed. Holding time for all matrices is 28 days from the date of collection.

7.0 PROCEDURE

A. Sample preparation

Each batch of samples (20 field samples plus QC) shall contain at least, a Method Blank, a Laboratory Control Sample and Laboratory Control Sample Duplicate, a Reporting Limit Check Sample and upon request a Duplicate, a Matrix Spike and Matrix Spike Duplicate, provided enough individual sample containers are submitted.

1. Method blank

   The method blank is prepared by measuring 5 mL of Deionized water or 2 g of blank sand in a 15 mL polypropylene tube, spiking with 100 µL of the surrogate spike solution, and then taking it through the sample preparation procedure.

2. Laboratory control sample/laboratory control sample duplicate

   Add 5 mL of Deionized water or 2 g of blank sand to each of two 15 mL polypropylene centrifuge tubes. The samples are spiked with 100 µL of surrogate spiking solution, 100 µL of the working spike solution (5ug/L) and then taking it through sample preparation.

3. Reporting limit check

- Add 5 mL of Deionized water or 2 g of blank sand to a 15 mL polypropylene centrifuge tube. The sample is spiked with 100 µL of surrogate spiking solution and 50 µL of the working spike solution (1ug/L) and then taking it through sample preparation for a 10ng/L limit. Alternate volumes and concentrations may be used to achieve the same limit or a different limit as needed.

4. Sample and sample duplicate

   The 5.0 mL water sample or 2.0 g soil sample collected in a 15 mL polypropylene centrifuge tube is spiked with 100 µL of surrogate spiking solution and then taking it through sample preparation.

5. Matrix spike/matrix spike duplicate

   Additional field-collected 5.0 mL water samples or 2.0 g soil sample in each of two 15 mL polypropylene centrifuge tubes are used for the MS and MSD. The samples are spiked with 100 µL of surrogate spiking solution, 100 µL of the working spike solution (5ug/L) and then taking it through sample preparation.

B. Sample preparation – Step II

1. To all samples, add 5 mL of methanol and hand shake/vortex for ~ 2 minutes or tumble for 20 minutes. For soil samples, add 5 ml DI water, 5 ml MeOH, and 20 µL ammonium hydroxide and tumble for 60 minutes.
2. After vortexing, the pH of sludge samples is adjusted to pH ~ 9-10 with ammonium hydroxide (~ 20 µL) and hand shaken/vortexed again for ~ 2 minutes or tumbled for 20 minutes. This step is not required for water, wastewater, influent, or effluent unless high percent solids are present or low recoveries were observed historically when no base was added.
3. The samples may be filtered through an Acrodisc GxF/0.2µm GHP membrane syringe-driven filter unit to remove particulates in the samples or centrifuged as needed. 10 uL of acetic acid is then added to all water and 50 µL to all soil samples to adjust the pH ~ 3-4 after filtration

or centrifugation. Approximately a 0.5 mL aliquot of that solution is transferred to a polypropylene LC autosampler vial and may then be analyzed. The final volume of the solution is assessed by the graduated tube and dilution factor calculated. Soils are corrected for percent moisture.

CAUTION: Use only polyethylene caps to seal the LC autosampler vials. All prepared LC autosampler vials should only be injected once since some of the analytes or solvent may evaporate after the vial cap is pierced; the polyethylene caps are not self-sealing.

4. The Acrodisc filters, if used, are washed in conjunction with the disposable syringes with at least 20 mL of methanol prior to use.

C. Analytical procedure

1. Sample analysis procedure

   Instrument conditions for LC/MS/MS are described in Figure 2. The target compounds are identified by comparing the dynamic multiple reaction monitoring (DMRM) transitions in the sample to the DMRM transitions in the standards. A confirmatory transition is available for most of the analytes. The retention time (RT) for the analytes of interest must also agree with the RT of the calibration verification standard by ±5%. The target compounds are quantitated using the primary DMRM transitions of the target compounds utilizing isotopic internal calibration.

   If the absolute amount of a target compound in a sample exceeds the working calibration range, the sample must be diluted and re-analyzed. If a sample requires a small dilution it can be diluted and re-analyzed. If a larger dilution is required it may require additional labelled isotopes for quantitation purposes or the original sample can be diluted and re-extracted.

2. Qualitative and quantitative analysis

   The quantitation of the target analytes and surrogates is accomplished with Masshunter software. An isotopic dilution internal calibration is used. The quantitation method is set as an internal calibration using the realative peak areas in ppt units (ng/L).

   The DMRM analysis provides qualitative identification by isolating the precursor ion and fragmenting it into the product ions, which are then used to calculate ion ratios that can be compared between samples and standards to confirm the identification of the analyte. The retention times of the analytes are also monitored between samples and standards to further confirm the identification. The signal/noise ratio for all peaks should be ≥ 3. If not, it should be investigated, the system re-optimized, and, if not corrected, the reporting limit must be raised to account for the lack of sensitivity and mentioned in the narrative.

If there are two or more analyses for a sample due to dilution, the analyst must determine which is best to report based on evaluation of all available data relevant to a given sample. The target compounds are identified by comparing the primary DMRM transition and its confirmatory DMRM transition in the sample to the DMRM transitions in the standards. Confirmatory transitions are available for most of the analytes. The primary/confirmatory DMRM ion ratio shall meet the criteria established by the most recent calibration verification by ± 30%. This ratio will vary depending on the instrument acquisition parameters. Analyst experience is important in determining if outliers are due to indeterminate interference resulting in elevated reporting limits and an associated flag or report the result acknowledging these outliers.

NOTE: Depending on sensitivity and matrix interference issues, a confirmatory DMRM transition might be used as a primary DMRM transition for quantitation during the analysis. This shall be explained in the case narrative if these changes are made.

The confirmatory ion ratios in "weathered samples" may not match the ion ratios in the calibration standards for the target analytes that may contain isomeric mixtures. The complete isomer grouping shall be quantitated consistently for all samples. These differences for PFHxS and PFOS can be found in groundwater samples and may either be the cause of different compositions used, weathering, degradation, or the affinity of the branched isomers to be more soluble than the linear in water and leach into the water from the soil at a higher rate than the linear.

Regression fits should be weighted in regards to concentration or by 1/concentration in order to increase the accuracy of the curve at the lower concentrations.. If the low and/or high points are excluded, a six-point curve is acceptable for quadratic fit and five point for a linear fit, but the calibration range and reporting limits must be modified to reflect this change. Points can be dropped from both the high and/or the low end of the curve as long as the reporting range is adjusted accordingly. The calculated calibration level concentrations used to generate the curve should be < ±30% deviation from the concentration of the generated curve, alternatively the %RSE can be calculated for the entire curve with a limit of 30%.

The retention time window of the DMRM transitions must be within 5% of the retention time of the analyte in the calibration verification standard. If this is not true the analyte is referred to as an unknown.

If there is no confirmatory transition for the analyte and the presence of the analyte in the sample cannot be confirmed with a primary transition and retention time, the analyte is listed as a non-detect or as having a matrix interference present.

D. Instrument mass calibration and standardization procedures

1. Mass calibration of mass spectrometer

   The Agilent 6495 is autotuned using the Agilent Masshunter software and tuning protocols. The autotune is set to unit resolution for both positive and negative polarities. The tuning solution used is the Agilent ESI-L low concentration tuning mix. Part #G1969-85000.

   A Check-tune should be run prior to calibration and any failures should be corrected by auto-tuning the instrument. An example check-tune is in Figure 3.

2. Mass calibration criteria and parameters

   a) The instrument must be calibrated over the calibration range for all analytes.

   b) Instrument operating conditions: Analytical conditions (acquisition methods) are listed in Figure 2.

   c) Calibration

      i. **Initial calibration**: The initial calibration typically contains a thirteen-point curve. The sensitivity and calibration curve responses may vary. At a minimum, a five point linear or a six-point quadratic calibration curve will be utilized for all analytes. The calibration must be verified at the beginning and end of every 24 hour period. It is strongly advised to run intermediate ending calibration verifications when more than one set of batch QC and samples is run.

      ii. **Second source calibration check**: The second source calibration check, analyzed after an initial calibration at or near the midpoint of the calibration curve, should be run. The second source calibration check should yield measured concentrations within ± 30% of the expected concentrations for all target compounds present in the standard. If the measured concentration of any of these compounds varies from the expected concentration by > ± 30%, the results for the compounds exceeding these criteria are qualified accordingly or preferably a new calibration is performed following any corrective action that may resolve the issue.

      iii. **Calibration verification (CV)**: At the beginning and end of any 24 hour period of analysis a calibration verification standard at or near the lower quadrant of the calibration curve must be run. If the high end calibration points are utilized the calibration verification should still be analyzed in the lower quadrant of the curve as this is closer to a concentration that is typically more project sensitive. If project goals

dictate, a CV in the higher portion of the curve may also be analyzed or used as the ending CV. If the measured concentration of any of the analytes varies from the expected concentration by > 30%, and the samples cannot be re-analyzed this failure is noted in the data report..

iv. **Autosampler schedule/analytical sequence**: Prepare a sequence that includes all relevant items. Beginning CV, Reporting limit check, LCS, LCSD, and Method Blank. Then all accompanying samples followed by and ending CV.

E. Equations

1. Example calculation of sample concentration reported

$$\frac{V_f}{V_i}(C_u) = C_f$$

Where:

V_f = Final Volume

V_i = Initial Volume

C_u= Uncorrected Concentration

C_f = Final Concentration (Corrected for Dilution)

2. Relative Percent Difference:

$$RPD = \frac{(S-D)}{\left[\frac{S+D}{2}\right]} \times 100$$

Where: S = Initial sample result

D = Duplicate sample result

3. Spike Recovery Percent Recovery:

$$\frac{SSR - SR}{SA} \times 100$$

Where: SSR = Spike sample result

SR = Sample (un-spiked) result

SA = Spike added

8.0 QUALITY CONTROL

Internals (Isotopic Dilution)

- All samples are spiked with an internal (isotopic dilution) standard spiking solution as described in Section 4. The recovery limits are set to 50-150% from the initial calibration verification.
- The list of mass labelled compounds utilized is given in Table 1.

Method blank

- For every 20 field samples, a method blank will be prepared in reagent water to investigate for contamination throughout sample preparation, extraction, and analysis.
- The concentration of target analytes in the blank shall be less than half the reporting limit or the associated data shall be qualified for high bias due to blank contamination. Alternatively, the reporting limit in the associated field sample(s) can be raised such that the blank contamination is less than half the RL.

Reporting limit check samples

- For every 20 field samples, a reporting limit check sample will be prepared in reagent water and spiked at the reporting limit as described in Section 4. to verify that the target analytes are present and can be qualitatively identified at the reporting limit. The recovery criteria for the reporting limit check sample is 50-150%.
- If the target analytes are not present or biased low in the reporting limit check sample, the data for all non-detects are qualified if detected up to a passing LCS concentration level. If the recovery is biased high, non-detects in field samples are not qualified, but detects are qualified to the level of a passing LCS concentration.

Laboratory control samples

- For every 20 field samples, at least one LCS/LCSD pair will be prepared in reagent water and spiked at the LCS/LCSD level as described in Section 4. to monitor spike accuracy and method performance in a clean matrix. The percent recovery limits for each target compound are set to 70-130% and the RPD limit is 30%.

Matrix spike and Dup samples

- Upon client request and with adequate sample containers every 20 field samples, at least one MS/MSD or MS/DUP pair will be prepared in a field sample matrix and spiked at the LCS/LCSD level as described in Section 4. to monitor spike accuracy and method performance in a sample matrix. The percent recovery limits for each target compound are set to 70-130% and the RPD limit is 30%.

9.0 METHOD PERFORMANCE

The MDLs and PQLs can be found in Merit's LIMS system are from the most recent detection limit studies.

10.0 EQUIPMENT MAINTENANCE AND TROUBLESHOOTING

Each instrument is assigned a maintenance logbook. All maintenance performed on the instrument must be recorded. Maintenance procedures provided in the equipment manual shall be followed.

Symptom: inadequate abundance or sensitivity
Dirty or contaminated ion source, electron multiplier, or quadrupole rod surfaces.
Potentials of ion source elements at wrong values due to open or short circuits.
Faulty ion source electronics, detector electronics, or power supply.

Symptom: improper isotope ratios
High "background" levels of undesired substances (contamination from earlier sample injections) which contribute additional abundance at the isotope mass. Bake out the ion source assembly and condition the column.
Resolution of adjacent masses set improperly/higher than normal ratios due to poor resolution (peaks too wide) or lower ratios due to over resolution (narrow peaks).

Symptom: poor reproducibility
Loose or intermittent connection either to a printed circuit or to one or more ion source or quadrupole elements inside the analyzer assembly.

Symptom: high background
Dirty or contaminated ion source, electron multiplier, or quadrupole rod surfaces.
"Yesterday's" samples - There is the possibility that some previously injected sample can still be present in the vacuum system long after it was thought to be evacuated. This phenomenon depends on sample volatility, temperature, etc.
Contamination in a recently cleaned vacuum system - After any venting of a vacuum system for maintenance, there is the potential for introducing new substances into the vacuum system. Some substances are normal and can be pumped out, while others require more cleaning or baking.
Solvents used in the cleaning process - These will be present for a while but should be pumped out as heat is applied to the vacuum system.
Water absorbed on the metal surfaces while vented - This will pump out with heat.
"Fingerprints" - Heavy organic substances from inadequate clean room procedures may not be pumped out and may require source cleaning.

Symptom: mass spectrometer does not respond.

The mass spectrometer electronics are not on; check the switch.

Secondary fuse blown - Check the secondary fuses on the rear of the mass spectrometer and replace the faulty fuse(s).

Board failure

Communication loss - reboot mass spectrometer, PC, and LC.

Computer software and firmware can be found on Merit's network at F:\data\MERIT\EQUIPMENT\Instrument-Software Version List.200818.xls.

11.0 SAFETY

Eye protection and gloves must be worn while performing the analyses. Every laboratory area has eyewash, emergency shower, and fire extinguisher. The metals lab also has dust masks available for use with dust samples. The air system throughout the laboratory area is on a 100% fresh air exchange system, this system exchanges 100% the air in the laboratory area with air from outside 6 times per hour and 30 times per hour when the emergency purge button is hit. A reference file of material safety data sheets (MSDSs) is available to all personnel.

12.0 WASTE DISPOSAL AND POLLUTION PREVENTION

All laboratory waste must be managed, stored, and disposed in accordance with all federal and state laws and regulations. Additional information can be found in the Sample Disposal SOP and Merit's Waste Management Plan and Handbook.

13.0 DEFINITIONS

Method Detection Limit (MDL): The minimum concentration of analyte that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

Sample Batch: samples of the same or similar matrix; for this method, a sample batch consists of 20 samples or less.

Method Blank: an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in the sample processing. The method blank is carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

Laboratory Control Sample (LCS) (also known as Laboratory Fortified Blank, Spiked Blank, or QC Check Sample): a Sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-

laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system.

Matrix Spike (also known as Spiked Sample or Fortified Sample): a sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.

Matrix Spike Duplicate (also known as Spiked Sample or Fortified Sample Duplicate): a second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

Surrogate: an organic compound which is similar to the target analytes in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. Its use is to monitor the performance of the extraction, cleanup (as needed), the analytical system, and the effectiveness of the method.

ASTM Type I Water: Shall conform to ASTM Standard D1193 specifications.

Reagent Water: Reagent water is defined as water with no interferants at or near the RL for all reagent compounds. The in-house Milli-Q water has been found acceptable for use. It is tested for each batch of samples by using it as a Method Blank.

DMRM Transition: Dynamic multiple reaction monitoring transition.

14.0 REFERENCES

ASTM D8421-25

ASTM D8535-23

Department of Defense, Quality Systems Manual for Environmental Laboratories (DoD QSM), DoD Environmental Data Quality Workgroup, Department of Navy, Lead Service, Based on ISO/IEC 17025:2005 and The NELAC Institute (TNI) Standards, Volume 1, (September 2009), Version 6.0, 2023

Table 1. Method Parameters

Analyte	RT (min)	Quant transition (amu)	Type	Associated Isotope	Cas #
PFPrA	2.239	163.0 -> 119.0	Target	13C3PFPrA	422-64-0
13C3PFPrA	2.245	166.0 -> 121.0	ISTD		
MPFBA	5.184	217.0 -> 172.0	ISTD		
PFBA	5.189	213.0 -> 168.9	Target	MPFBA	375-22-4
PFMPA	5.779	229.0 -> 85.0	Target	M8PFOS	377-73-1
FPrPA	6.017	241.0 -> 177.0	Target	M5PFPeA	356-02-5
PFPrS	6.568	249.0 -> 99.0	Target	M3PFBS	423-41-6
M5PFPeA	6.586	268.0 -> 223.0	ISTD		
PFPeA	6.588	263.0 -> 218.9	Target	M5PFPeA	2706-90-3
PFMBA	6.956	279.0 -> 85.0	Target	M8PFOS	863090-89-5
M2-4:2FTSA	7.312	329.0 -> 81.0	ISTD		
4:2FTSA	7.314	327.0 -> 306.9	Target	M2-4:2FTSA	757124-72-4
NFDHA	7.572	201.0 -> 85.0	Target	M8PFOS	151772-58-6
M5PFHxA	7.68	318.0 -> 273.0	ISTD		
PFHxA	7.681	313.0 -> 269.0	Target	M5PFHxA	307-24-4
M3PFBS	7.865	302.0 -> 80.0	ISTD		
PFBS	7.867	299.0 -> 80.0	Target	M3PFBS	375-73-5
MHFPO-DA	8.03	287.0 -> 169.0	ISTD		
HFPO-DA	8.031	285.0 -> 169.0	Target	MHFPO-DA	13252-13-6
FPePA	8.15	341.0 -> 237.0	Target	M5PFHxA	914637-49-3
PFEESA	8.371	315.0 -> 135.0	Target	M8PFOS	113507-82-7
PFHpA	8.582	363.0 -> 319.0	Target	M4PFHpA	375-85-9
M4PFHpA	8.594	367.0 -> 322.0	ISTD		
ADONA	8.91	377.0 -> 251.0	Target	M8PFOA	919005-14-4
PFPeS	8.913	348.9 -> 79.9	Target	M3PFBS	2706-91-4
M2-6:2FTSA	9.034	429.0 -> 81.0	ISTD		
6:2FTSA	9.036	427.0 -> 406.8	Target	M2-6:2FTSA	27619-97-2
FBSA	9.056	298.0 -> 78.0	Target	M8FOSA	30334-69-1
HQ-115	9.138	279.9 -> 211.0	Target	M8PFOS	90076-65-6
M8PFOA	9.412	421.0 -> 376.0	ISTD		
PFOA	9.412	413.0 -> 369.0	Target	M8PFOA	335-67-1
PFHxS	9.699	399.0 -> 80.0	Target	M3PFHxS	355-46-4
M3PFHxS	9.825	402.0 -> 80.0	ISTD		
FHpPA	9.911	441.0 -> 337.0	Target	M8PFOA	812-70-4
M9-PFNA	10.198	472.0 -> 427.0	ISTD		
PFNA	10.21	463.0 -> 419.0	Target	M9-PFNA	375-95-1
M2-8:2FTSA	10.57	529.0 -> 81.0	ISTD		
8:2FTSA	10.571	527.0 -> 506.8	Target	M2-8:2FTSA	39108-34-4
PFECHS	10.601	461.0 -> 381.0	Target	M8PFOS	80988-54-1
PFHpS	10.684	448.9 -> 79.7	Target	M3PFHxS	375-92-8
N-MeFOSAA	10.752	570.0 -> 418.9	Target	d3N-MeFOSAA	2355-31-9
d3N-MeFOSAA	10.933	573.0 -> 419.0	ISTD		
M6PFDA	10.996	519.0 -> 474.0	ISTD		
PFDA	10.997	513.0 -> 469.0	Target	M6PFDA	335-76-2
EtFOSAA	11.099	584.0 -> 418.9	Target	d5EtFOSAA	2991-50-6
d5EtFOSAA	11.258	589.0 -> 419.0	ISTD		

Analyte	RT (min)	Quant transition (amu)	Type	Associated Isotope	Cas #
FHxSA	11.394	398.0 -> 78.0	Target	M8FOSA	41997-13-1
M8PFOS	11.495	507.0 -> 80.0	ISTD		
PFOS	11.496	499.0 -> 80.0	Target	M8PFOS	1763-23-1
M7PFUnDA	11.762	570.0 -> 525.0	ISTD		
PFUnDA	11.764	563.0 -> 519.0	Target	M7PFUnDA	2058-94-8
9CL-PF3ONS	12.079	531.0 -> 351.0	Target	M8PFOS	756426-58-1
PFNS	12.271	548.9 -> 79.9	Target	M8PFOS	68259-12-1
MPFDoDA	12.521	615.0 -> 570.0	ISTD		
PFDoDA	12.522	613.0 -> 569.0	Target	MPFDoDA	307-55-1
PFDS	13.033	599.0 -> 80.0	Target	M8PFOS	335-77-3
FOSA	13.052	497.9 -> 77.9	Target	M8FOSA	754-91-6
M6PFTrDA	13.264	669.0 -> 624.0	ISTD		
PFTrDA	13.265	663.0 -> 619.0	Target	M6PFTrDA	72629-94-8
M8FOSA	13.338	506.0 -> 78.0	ISTD		
11CL-PF3OUDS	13.573	631.0 -> 451.0	Target	M8PFOS	763051-92-9
M2PFTeDA	13.88	715.0 -> 670.0	ISTD		
PFTeDA	13.893	713.0 -> 669.0	Target	M2PFTeDA	376-06-7
PFDoS	14.254	699.0 -> 80.0	Target	M8PFOS	79780-39-5
N-MeFOSE-M	14.823	616.0 -> 59.2	Target	d7-N-MeFOSE-M	24448-09-7
d7-N-MeFOSE-M	14.973	623.0 -> 59.2	ISTD		
N-MeFOSA-M	15.102	512.0 -> 169.0	Target	d-N-MeFOSA-M	31506-32-8
d3-N-MeFOSA-M	15.18	515.0 -> 169.0	ISTD		
N-EtFOSE-M	15.252	630.0 -> 59.2	Target	d9-N-EtFOSE-M	1691-99-2
d9-N-EtFOSE-M	15.442	639.0 -> 59.2	ISTD		
N-EtFOSA-M	15.453	526.0 -> 169.0	Target	d-N-EtFOSA-M	4151-50-2
d5-N-EtFOSA-M	15.614	531.0 -> 169.0	ISTD		

Table 2. Quality Control

QC Item	Frequency	Acceptance Criteria	Corrective Action
Initial Calibration	Prior to all analytical runs	Method-based	Examine the entire analytical system; some or all of the following: clean MS source, re-tune, clip/replace column, replace calibration standards, re-calibrate.
Tune Check	Prior to calibration	Manufacturer criteria	Re-tune the instrument.
Calibration Verification (CV)	At the beginning and end of any 24 hour period of analysis	70-130%	Re-attempt injection; some or all of the following: clean MS source, re-tune, clip/replace column, replace calibration standards, re-calibrate; failure requires the re-analysis of all associated analytical runs or data flagging.
Reporting Limit (RL) check	20 samples	50-150%	Not Applicable
LCS and MS	20 samples	70-130%	A failed LCS should be re-extracted and re-analyzed. A failed MS requires no action provided that the LCS is acceptable. If additional sample exists, the samples associated with a failed LCS should be re-extracted and re-analyzed.
Duplicate or MSD	20 samples	30% RPD	Relative Percent Differences (RPDs) are computed and included in the QC report
Method Blank	20 samples	<1/2 RL	Method blank contamination is flagged on the analytical report for any identified target compound. Blanks indicative of contaminated analytical system (typically the purge-and-trap system) should result in a thorough cleansing of the affected system and sample/blank re-analysis.
Internal Standard (Isotopic Dilution)	All samples	50-150% (from previous CV)	Adverse matrix effects on areas/recoveries are demonstrated either by screening the extract or re-analyzing the sample within a 24-hour QC batch. The resulting analytical report is flagged appropriately. A negative bias unrelated to matrix effects indicates the need to: clean the MS source, re-tune, and re-calibrate

Table 3. Preparation of Calibration Standards

ASTM CALIBRATION STANDARDS PREPARATION					
1000ppt	5ml MeOH	5ml H_20	100ul ISD (8ug/L)	100ul 10:1 PFA (100ug/L)	10ul acetic
Blank	5ml MeOH	5ml H_20	100ul ISD (8ug/L)		10ul acetic
ICV (1000ppt)	5ml MeOH	5ml H_20	100ul ISD (8ug/L)	100ul 10:1 IPFA (100ug/L)	10ul acetic

Standard	**Blank**	**1000ppt**
1000ppt		pipette
400ppt	300	200
200ppt	400	100
100ppt* (x2)	450	50
50ppt	475	25
		***100ppt**
20ppt	400	100
10ppt* (x2)	450	50
5ppt	475	25
		***10ppt**
2ppt	400	100
1ppt	450	50
0.5ppt	475	25
		PFA(1000ug/L)
10,000ppt	1980	20
		10,000ppt
5,000ppt	250	250
		ICV (1000ppt)
ICV (100ppt)	450	50

	MeOH	**PLIS (1000ug/L)**
ISD mix (8ug/L)	29.76ml	240
		10:1 PFA (100ug/L)
MS mix (5ug/L)	2850	150
		200:1 PFA (5ug/L)
RL mix (1ug/L)	1200	300

Table 4: ASTM8421 with isotopic dilution Merit Labs Accuracy/Precision Study

Analysis Date 10/13/2025–10/17/2025
Analytical Method D8421
Preparation Date 10/13/2025–10/17/2025
Preparation Method ASTMPFC
Spiked Value 50 (raw) 100 (5mL)
Estimated Limit
Samples 4

		10/17/2025	10/17/2025	10/13/2025	10/13/2025				
	Spike	**S1**	**S2**	**S3**	**S4**	**x**	**s**	**x (%)**	**%RSD**
Compound	(ppt)	(ppt)	(ppt)	(ppt)	(ppt)	(ppt)	(ppt)	**Accuracy**	
4:2FTSA	50.0	58.67	59.03	54.28	54.83	56.70	2.494	113.4%	4.399
6:2FTSA	50.0	60.48	59.52	53.7	54.58	57.07	3.425	114.1%	6.001
8:2FTSA	50.0	47.35	51.76	41.18	52.34	48.16	5.158	96.3%	10.710
EtFOSAA	50.0	43.34	44.58	45.15	43.16	44.06	0.964	88.1%	2.188
FOSA	50.0	51.8	50.15	45.82	49.3	49.27	2.522	98.5%	5.119
PFBA	50.0	49.93	48.36	44.89	45.06	47.06	2.492	94.1%	5.296
N-MeFOSAA	50.0	47.15	55.18	48.1	47.45	49.47	3.827	98.9%	7.737
PFBS	50.0	56.38	55.52	48.01	52.17	53.02	3.802	106.0%	7.171
PFDA	50.0	50.54	51.78	49.24	46.76	49.58	2.147	99.2%	4.330
PFDoDA	50.0	48.56	44.57	49.16	46.01	47.08	2.157	94.2%	4.583
PFDS	50.0	48.05	53.22	48.94	50.38	50.15	2.262	100.3%	4.511
PFHpA	50.0	54.02	55.23	47.49	50.82	51.89	3.474	103.8%	6.694
PFHpS	50.0	45.54	48.95	40.51	46.13	45.28	3.512	90.6%	7.757
PFHxA	50.0	55.78	41.77	46.31	43.86	46.93	6.185	93.9%	13.179
PFHxS	50.0	54.95	48.15	46.96	50.28	50.09	3.522	100.2%	7.032
PFNA	50.0	47.64	49.12	56.11	49.63	50.63	3.753	101.3%	7.413
PFNS	50.0	41.56	48.81	43.3	42.75	44.11	3.220	88.2%	7.300
PFOA	50.0	45.63	44.3	40.7	38.4	42.26	3.309	84.5%	7.831
PFOS	50.0	42.41	48.39	43.65	41.53	44.00	3.056	88.0%	6.947
PFPeA	50.0	52.04	53.05	50.49	49	51.15	1.776	102.3%	3.472
PFPeS	50.0	56.89	49.34	44.12	48.94	49.82	5.275	99.6%	10.588
PFTeDA	50.0	57.41	43.73	41.85	43.33	46.58	7.265	93.2%	15.597
PFTrDA	50.0	47.96	44.61	50.48	44.53	46.90	2.875	93.8%	6.131
PFUnDA	50.0	46.17	49.6	37.41	45.64	44.71	5.170	89.4%	11.566
11CL-PF3OUDS	50.0	44.69	52.02	53.38	47.84	49.48	3.971	99.0%	8.024
9CL-PF3ONS	50.0	40.43	43.63	45.82	42.83	43.18	2.225	86.4%	5.154
ADONA	50.0	48.28	47.99	42.12	45.87	46.07	2.841	92.1%	6.167
HFPO-DA	50.0	49.13	49.26	46.14	41.93	46.62	3.440	93.2%	7.379
PFECHS	50.0	38.19	46.94	41.1	39.12	41.34	3.927	82.7%	9.500
FBSA	50.0	47.41	47.76	41.52	44.25	45.24	2.937	90.5%	6.493
FHpPA	50.0	61.39	56.45	40.73	40.68	49.81	10.708	99.6%	21.497
FHxSA	50.0	51.51	44.61	41.27	43.83	45.31	4.376	90.6%	9.658
FPePA	50.0	55.92	45.95	39.78	44.78	46.61	6.760	93.2%	14.505
FPrPA	50.0	56.89	56.95	46.29	40.15	50.07	8.297	100.1%	16.572
NFDHA	50.0	39.45	42.23	41.29	35.81	39.70	2.836	79.4%	7.144
PFEESA	50.0	38.47	44.23	39.61	38.2	40.13	2.802	80.3%	6.984
PFMBA	50.0	36.52	40.17	40.32	33.73	37.69	3.168	75.4%	8.408
PFMPA	50.0	37.92	43.96	38.93	35.41	39.06	3.589	78.1%	9.190
PFPrS	50.0	50.83	49	41.92	44.99	46.69	4.005	93.4%	8.579
N-MeFOSA-M	50.0	50.82	46.78	47.69	46.27	47.89	2.040	95.8%	4.259
N-EtFOSA-M	50.0	47.27	50.39	48.12	45.41	47.80	2.066	95.6%	4.322
N-EtFOSE-M	50.0	49.5	46.13	48.65	47.63	47.98	1.450	96.0%	3.021
N-MeFOSE-M	50.0	46.74	50.64	47.6	45.6	47.65	2.158	95.3%	4.530
PFDoS	50.0	55.49	64.99	66.06	64	62.64	4.837	125.3%	7.723
PFPrA	50.0	57.57	59.17	46.44	42.99	51.54	8.035	103.1%	15.589
HQ-115	50.0	39.68	48.26	41.64	36.91	41.62	4.832	83.2%	11.609

Table 5: Precision & Accuracy Study 8535

D8535: Soil Precision Accuracy Study

Analysis Date 10/28/2025–11/04/2025
Analytical Method D8535
Preparation Date 10/28/2025–11/04/2025
Preparation Method ASTMPFC
Spiked Value 50 (raw) 250 (5g)
Estimated Limit
Samples 4

Compound	Spike (ppt)	11/4/2025 S1 (ppt)	11/4/2025 S2 (ppt)	10/28/2025 S3 (ppt)	10/28/2025 S4 (ppt)	x (ppt)	s (ppt)	x (%) Accuracy	%RSD
4:2FTSA	50.0	58.32	48.68	50.03	53.96	52.75	4.338	105.5%	8.224
6:2FTSA	50.0	47.13	44.25	42.32	47.94	45.41	2.598	90.8%	5.722
8:2FTSA	50.0	43.93	43.17	45.35	52.02	46.12	4.037	92.2%	8.755
EtFOSAA	50.0	46.92	46.91	44.7	42.23	45.19	2.233	90.4%	4.940
FOSA	50.0	50.96	48.06	49.33	48.54	49.22	1.271	98.4%	2.583
PFBA	50.0	46.2	45.96	44.01	44.82	45.25	1.021	90.5%	2.257
N-MeFOSAA	50.0	47.29	44.58	46.1	52.52	47.62	3.448	95.2%	7.241
PFBS	50.0	50.77	52.6	50.88	54.31	52.14	1.672	104.3%	3.206
PFDA	50.0	46.94	49.47	46.38	44.47	46.82	2.062	93.6%	4.404
PFDoDA	50.0	51.76	42.4	44.39	55.2	48.44	6.044	96.9%	12.479
PFDS	50.0	44.79	42.55	54.87	47.4	47.40	5.358	94.8%	11.304
PFHpA	50.0	51.97	40.3	47.28	54.27	48.46	6.166	96.9%	12.725
PFHpS	50.0	44.64	47.41	45.95	52.84	47.71	3.602	95.4%	7.550
PFHxA	50.0	45.24	44.95	41.19	43.1	43.62	1.877	87.2%	4.303
PFHxS	50.0	50.53	47.76	49.78	59.03	51.78	4.976	103.6%	9.611
PFNA	50.0	42.81	44.58	44.42	45.47	44.32	1.108	88.6%	2.499
PFNS	50.0	39.26	41.8	48.18	42.07	42.83	3.786	85.7%	8.841
PFOA	50.0	36.41	43.18	39.27	37.75	39.15	2.928	78.3%	7.479
PFOS	50.0	41.61	40.04	49.88	44.15	43.92	4.319	87.8%	9.834
PFPeA	50.0	54.3	51.95	48.4	50.9	51.39	2.447	102.8%	4.762
PFPeS	50.0	46.33	48.65	46.39	48.42	47.45	1.259	94.9%	2.654
PFTeDA	50.0	44.73	39.79	39.78	47.29	42.90	3.743	85.8%	8.725
PFTrDA	50.0	48.1	46.35	49.45	58.07	50.49	5.209	101.0%	10.316
PFUnDA	50.0	45.04	42.52	39.55	45.09	43.05	2.624	86.1%	6.095
11CL-PF3OUDS	50.0	41.91	45.41	52.22	43.15	45.67	4.599	91.3%	10.070
9CL-PF3ONS	50.0	38.37	38.24	43.55	39.5	39.92	2.489	79.8%	6.235
ADONA	50.0	40.69	49.8	42.54	46.66	44.92	4.099	89.8%	9.124
HFPO-DA	50.0	54.48	46.88	44.67	48.08	48.53	4.212	97.1%	8.680
PFECHS	50.0	38.34	37.26	42.68	39.4	39.42	2.342	78.8%	5.942
FBSA	50.0	53.16	47.94	43.22	39.54	45.97	5.902	91.9%	12.839
FHpPA	50.0	50.88	52.61	55.25	52.19	52.73	1.833	105.5%	3.476
FHxSA	50.0	46.81	44.07	45.11	43.92	44.98	1.331	90.0%	2.960
FPePA	50.0	58.9	48.61	55.16	50.31	53.25	4.681	106.5%	8.792
FPrPA	50.0	60.31	54.25	51.32	53.68	54.89	3.829	109.8%	6.977
NFDHA	50.0	42.6	43.29	48.85	42.81	44.39	2.989	88.8%	6.734
PFEESA	50.0	39.37	41.24	43.96	40.71	41.32	1.928	82.6%	4.666
PFMBA	50.0	35.19	35.03	39.42	38.66	37.08	2.291	74.2%	6.179
PFMPA	50.0	39.12	36.79	40.06	39.09	38.77	1.392	77.5%	3.590
PFPrS	50.0	44.4	43.63	46.95	46.17	45.29	1.536	90.6%	3.392
N-MeFOSA-M	50.0	43.97	44.8	45.29	45.84	44.98	0.793	90.0%	1.764
N-EtFOSA-M	50.0	46.81	45.28	47.67	46.93	46.67	1.003	93.3%	2.149
N-EtFOSE-M	50.0	52.01	43.88	47.09	45.43	47.10	3.524	94.2%	7.483
N-MeFOSE-M	50.0	48.28	47.04	49.23	50.07	48.66	1.301	97.3%	2.675
PFDoS	50.0	53.66	61.36	65.35	62.03	60.60	4.945	121.2%	8.159
PFPrA	50.0	50.83	50.95	51.46	51.25	51.12	0.286	102.2%	0.560
HQ-115	50.0	45.66	47.93	50.41	44.23	47.06	2.705	94.1%	5.748

Figure 1: ASTM Water Prep Benchsheet

MeOH Lot #: _____
Reagent H2O Source Lot #: _____
Acetic acid Lot #: _____
Base #: _____
ISD #: _____
Spike #: _____ *RL Spike #: _____

PFAS Extraction/Dilution
Method ASTMD7979

WATER MATRIX

Analyst: _____
Date: _____
Time Started: _____
Time Ended: _____
Batch ID#: _____

#	Merit #	Sample Volume (ml)	Filled weight (g)	Tare weight (g)	MeOH Vol (ml)	Final Vol (ml)	ISD Vol (ul)	Spike Vol (ul)	Tumble (min)	Acetic acid vol (ul)	Notes
Initial Q.C	BLANK	5			5	10	100	---	20	10	
	LCS	5			5	10	100	100	20	10	
	LCSD	5			5	10	100	100	20	10	
	RL check	5			5	10	100		20	10	
	RL check	5			5	10	100		20	10	
MS									20		
DUP									20		
1									20		
2									20		
3									20		
4									20		
5									20		
6									20		
7									20		
8									20		
9									20		
10									20		
11									20		
12									20		
13									20		
14									20		
15									20		
16									20		
17									20		
18									20		
19									20		
20									20		
21									20		
22									20		
23									20		

Reviewed by: _____ On: _____ Balance ID: _____ Prepared by: Merit Laboratories, Inc.
EXT-F15 Effective Date 3/23/2021

Figure 2: Acquisition Method Report for ASTM D8421 and D8535

Acquisition Method Report

Agilent Technologies

Acquisition Method Info

Method Name d7979251114_46list.m

Method Path D:\MassHunter\Methods\d7979251114_46list.m

Method Description LC-gradient, Zorbax Eclipse Plus C18, 3.0 x 50 mm, 1.8 um, 80A

Device List

Multisampler
Binary Pump
Column Comp.
QQQ

MS QQQ Mass Spectrometer

Ion Source	AJS ESI	**Tune File**	D:\MassHunter\Tune\QQQ\G6495B \atunes.TUNE.XML
Stop Mode	No Limit/As Pump	**Stop Time (min)**	2.4
Time Filter	On	**Time Filter Width (min)**	0.03
LC->Waste Pre Row	0	**LC->Waste Post Row**	17

Time Segments

Index	Start Time (min)	Scan Type	Ion Mode	Div Valve	Delta EMV	Store	Cycle Time (ms)	Triggered?	MRM Repeats
1	0.5	DynamicMRM	ESI+Agilent Jet Stream	To MS	200	Yes	650	No	3

Time Segment 1

Scan Segments

Cpd Name	ISTD?	Prec Ion	MS1 Res	Prod Ion	MS2 Res	Frag (V)	CE (V)	Cell Acc (V)	Ret Time (min)	Ret Window	Polarity
11Cl-PF3OUdS	No	631	Unit/Enh (6490)	451	Unit/Enh (6490)	380	33	2	13.71	1	Negative
11Cl-PF3OUdS	No	631	Unit/Enh (6490)	83	Unit/Enh (6490)	380	33	2	13.71	1	Negative
13C3PFPrA	Yes	166	Unit/Enh (6490)	121	Unit/Enh (6490)	380	9	2	2.15	3	Negative
4:2FTSA	No	327	Unit/Enh (6490)	306.9	Unit/Enh (6490)	380	22	2	7.34	1	Negative
4:2FTSA	No	327	Unit/Enh (6490)	80.9	Unit/Enh (6490)	380	36	2	7.34	1	Negative
6:2FTSA	No	427	Unit/Enh (6490)	406.8	Unit/Enh (6490)	380	26	2	9.05	1	Negative
6:2FTSA	No	427	Unit/Enh (6490)	80.9	Unit/Enh (6490)	380	45	2	9.05	1	Negative
8:2FTSA	No	527	Unit/Enh (6490)	506.8	Unit/Enh (6490)	380	33	2	10.61	1	Negative
8:2FTSA	No	527	Unit/Enh (6490)	80.9	Unit/Enh (6490)	380	55	2	10.61	1	Negative
9Cl-PF3ONS	No	531	Unit/Enh (6490)	351	Unit/Enh (6490)	380	24	2	12.18	1	Negative
9Cl-PF3ONS	No	531	Unit/Enh (6490)	83	Unit/Enh (6490)	380	24	2	12.18	1	Negative
ADONA	No	377	Unit/Enh (6490)	251	Unit/Enh (6490)	380	12	2	8.93	1	Negative
ADONA	No	377	Unit/Enh (6490)	85	Unit/Enh (6490)	380	36	2	8.93	1	Negative
d3N-MeFOSAA	Yes	573	Unit/Enh (6490)	419	Unit/Enh (6490)	380	20	2	10.94	1	Negative
d5EtFOSA	Yes	589	Unit/Enh (6490)	419	Unit/Enh (6490)	380	20	2	11.28	1	Negative
d7-N-MeFOSE-M	Yes	623	Unit/Enh (6490)	59.2	Unit/Enh (6490)	380	70	2	14.89	1	Negative
d9-N-EtFOSE-M	Yes	639	Unit/Enh (6490)	59.2	Unit/Enh (6490)	380	55	2	15.37	1	Negative
d-N-EtFOSA-M	No	531	Unit/Enh (6490)	169	Unit/Enh (6490)	380	30	2	15.55	1	Negative
d-N-MeFOSA-M	No	515	Unit/Enh (6490)	169	Unit/Enh (6490)	380	30	2	15.11	1	Negative
EtFOSAA	No	584	Unit/Enh (6490)	526	Unit/Enh (6490)	380	20	2	11.28	1	Negative
EtFOSAA	No	584	Unit/Enh (6490)	483	Unit/Enh (6490)	380	20	2	11.28	1	Negative
EtFOSAA	No	584	Unit/Enh (6490)	418.9	Unit/Enh (6490)	380	25	2	11.28	1	Negative
FBSA	No	298	Unit/Enh (6490)	78	Unit/Enh (6490)	380	30	2	9.02	1	Negative

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Cpd Name	ISTD?	Prec Ion	MS1 Res	Prod Ion	MS2 Res	Frag (V)	CE (V)	Cell Acc (V)	Ret Time (min)	Ret Window	Polarity
FHpPA	No	441	Unit/Enh (6490)	337	Unit/Enh (6490)	380	17	2	9.87	1	Negative
FHpPA	No	441	Unit/Enh (6490)	316.9	Unit/Enh (6490)	380	17	2	9.87	1	Negative
FHxSA	No	398	Unit/Enh (6490)	78	Unit/Enh (6490)	380	30	2	11.29	1	Negative
FOSA	No	497.9	Unit/Enh (6490)	478	Unit/Enh (6490)	380	30	2	13.04	1	Negative
FOSA	No	497.9	Unit/Enh (6490)	77.9	Unit/Enh (6490)	380	30	2	13.04	1	Negative
FOSA	No	497.9	Unit/Enh (6490)	47.9	Unit/Enh (6490)	380	60	2	13.04	1	Negative
FPePA	No	341	Unit/Enh (6490)	237	Unit/Enh (6490)	380	12	2	8.15	1	Negative
FPePA	No	341	Unit/Enh (6490)	217	Unit/Enh (6490)	380	12	2	8.15	1	Negative
FPrPA	No	241	Unit/Enh (6490)	177	Unit/Enh (6490)	380	4	2	6.09	1	Negative
FPrPA	No	241	Unit/Enh (6490)	117	Unit/Enh (6490)	380	30	2	6.09	1	Negative
HFPO-DA	No	285	Unit/Enh (6490)	185	Unit/Enh (6490)	380	20	2	8.08	1	Negative
HFPO-DA	No	285	Unit/Enh (6490)	169	Unit/Enh (6490)	380	8	2	8.08	1	Negative
HQ-115	No	279.9	Unit/Enh (6490)	211	Unit/Enh (6490)	380	16	2	9.22	2	Negative
HQ-115	No	279.9	Unit/Enh (6490)	147	Unit/Enh (6490)	380	18	2	9.22	2	Negative
M2-4:2FTSA	Yes	329	Unit/Enh (6490)	309	Unit/Enh (6490)	380	20	2	7.35	1	Negative
M2-4:2FTSA	Yes	329	Unit/Enh (6490)	81	Unit/Enh (6490)	380	36	2	7.35	1	Negative
M2-6:2FTSA	Yes	429	Unit/Enh (6490)	409	Unit/Enh (6490)	380	24	2	9.05	1	Negative
M2-6:2FTSA	Yes	429	Unit/Enh (6490)	81	Unit/Enh (6490)	380	45	2	9.05	1	Negative
M2-8:2FTSA	Yes	529	Unit/Enh (6490)	509	Unit/Enh (6490)	380	38	2	10.6	1	Negative
M2-8:2FTSA	Yes	529	Unit/Enh (6490)	81	Unit/Enh (6490)	380	55	2	10.6	1	Negative
M2PFTeDA	Yes	715	Unit/Enh (6490)	670	Unit/Enh (6490)	380	9	2	14.01	1	Negative
M3PFBS	Yes	302	Unit/Enh (6490)	99	Unit/Enh (6490)	380	33	2	7.92	1	Negative
M3PFBS	Yes	302	Unit/Enh (6490)	80	Unit/Enh (6490)	380	33	2	7.92	1	Negative
M3PFHxS	Yes	402	Unit/Enh (6490)	80	Unit/Enh (6490)	380	45	2	9.87	1	Negative
M4PFHpA	Yes	367	Unit/Enh (6490)	322	Unit/Enh (6490)	380	8	2	8.61	1	Negative
M5PFHxA	Yes	318	Unit/Enh (6490)	273	Unit/Enh (6490)	380	8	2	7.7	1	Negative
M5PFPeA	Yes	268	Unit/Enh (6490)	223	Unit/Enh (6490)	380	8	2	6.65	1	Negative
M6PFDA	Yes	519	Unit/Enh (6490)	474	Unit/Enh (6490)	380	12	2	11.03	1	Negative
M6PFTrDA	Yes	669	Unit/Enh (6490)	624	Unit/Enh (6490)	380	11	2	13.37	1	Negative
M7PFUnDA	Yes	570	Unit/Enh (6490)	525	Unit/Enh (6490)	380	11	2	11.83	1	Negative
M8FOSA	Yes	506	Unit/Enh (6490)	78	Unit/Enh (6490)	380	40	2	13.26	1	Negative
M8PFOA	Yes	421	Unit/Enh (6490)	376	Unit/Enh (6490)	380	9	2	9.44	1	Negative
M8PFOS	Yes	507	Unit/Enh (6490)	80	Unit/Enh (6490)	380	50	2	11.57	1	Negative
M9-PFNA	Yes	472	Unit/Enh (6490)	427	Unit/Enh (6490)	380	9	2	10.24	1	Negative
MHFPO-DA	Yes	287	Unit/Enh (6490)	169	Unit/Enh (6490)	380	8	2	8.06	1	Negative
MPFBA	Yes	217	Unit/Enh (6490)	172	Unit/Enh (6490)	380	8	2	5.28	2	Negative
MPFDoDA	Yes	615	Unit/Enh (6490)	570	Unit/Enh (6490)	380	11	2	12.62	1	Negative
N-EtFOSA-M	No	526	Unit/Enh (6490)	218.9	Unit/Enh (6490)	380	28	2	15.55	2	Negative
N-EtFOSA-M	No	526	Unit/Enh (6490)	169	Unit/Enh (6490)	380	30	2	15.55	2	Negative
N-EtFOSE-M	No	630	Unit/Enh (6490)	59.2	Unit/Enh (6490)	380	44	2	15.4	2	Negative
NFDHA	No	295	Unit/Enh (6490)	201	Unit/Enh (6490)	380	14	2	7.61	1	Negative
NFDHA	No	295	Unit/Enh (6490)	84.9	Unit/Enh (6490)	380	30	2	7.61	1	Negative
NFDHA	No	201	Unit/Enh (6490)	85	Unit/Enh (6490)	380	2	2	7.61	1	Negative

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Cpd Name	ISTD?	Prec Ion	MS1 Res	Prod Ion	MS2 Res	Frag (V)	CE (V)	Cell Acc (V)	Ret Time (min)	Ret Window	Polarity
N-MeFOSAA	No	570	Unit/Enh (6490)	482.9	Unit/Enh (6490)	380	16	2	10.94	2	Negative
N-MeFOSAA	No	570	Unit/Enh (6490)	418.9	Unit/Enh (6490)	380	25	2	10.94	2	Negative
N-MeFOSA-M	No	512	Unit/Enh (6490)	218.9	Unit/Enh (6490)	380	28	2	15.11	2	Negative
N-MeFOSA-M	No	512	Unit/Enh (6490)	169	Unit/Enh (6490)	380	30	2	15.11	2	Negative
N-MeFOSE-M	No	616	Unit/Enh (6490)	59.2	Unit/Enh (6490)	380	16	2	14.93	2	Negative
PFBA	No	213	Unit/Enh (6490)	168.9	Unit/Enh (6490)	380	8	2	5.28	2	Negative
PFBS	No	299	Unit/Enh (6490)	98.9	Unit/Enh (6490)	380	33	2	7.92	1	Negative
PFBS	No	299	Unit/Enh (6490)	80	Unit/Enh (6490)	380	45	2	7.92	1	Negative
PFDA	No	513	Unit/Enh (6490)	469	Unit/Enh (6490)	380	14	2	11.04	1	Negative
PFDA	No	513	Unit/Enh (6490)	218.7	Unit/Enh (6490)	380	19	2	11.04	1	Negative
PFDoDA	No	613	Unit/Enh (6490)	569	Unit/Enh (6490)	380	11	2	12.62	1	Negative
PFDoDA	No	613	Unit/Enh (6490)	319	Unit/Enh (6490)	380	22	2	12.62	1	Negative
PFDoDA	No	613	Unit/Enh (6490)	169	Unit/Enh (6490)	380	20	2	12.62	1	Negative
PFDoS	No	699	Unit/Enh (6490)	98.9	Unit/Enh (6490)	380	75	2	14.39	1	Negative
PFDoS	No	699	Unit/Enh (6490)	80	Unit/Enh (6490)	380	80	2	14.39	1	Negative
PFDS	No	599	Unit/Enh (6490)	99	Unit/Enh (6490)	380	50	2	13.18	1	Negative
PFDS	No	599	Unit/Enh (6490)	80	Unit/Enh (6490)	380	58	2	13.18	1	Negative
PFECHS	No	461	Unit/Enh (6490)	381	Unit/Enh (6490)	380	30	2	10.66	1	Negative
PFECHS	No	461	Unit/Enh (6490)	99	Unit/Enh (6490)	380	29	2	10.66	1	Negative
PFEESA	No	315	Unit/Enh (6490)	135	Unit/Enh (6490)	380	17	2	8.43	1	Negative
PFEESA	No	315	Unit/Enh (6490)	82.9	Unit/Enh (6490)	380	25	2	8.43	1	Negative
PFHpA	No	363	Unit/Enh (6490)	319	Unit/Enh (6490)	380	7	2	8.62	1	Negative
PFHpA	No	363	Unit/Enh (6490)	169	Unit/Enh (6490)	380	17	2	8.62	1	Negative
PFHpS	No	448.9	Unit/Enh (6490)	98.7	Unit/Enh (6490)	380	54	2	10.73	1	Negative
PFHpS	No	448.9	Unit/Enh (6490)	79.7	Unit/Enh (6490)	380	48	2	10.73	1	Negative
PFHxA	No	313	Unit/Enh (6490)	269	Unit/Enh (6490)	380	8	2	7.72	1	Negative
PFHxA	No	313	Unit/Enh (6490)	119	Unit/Enh (6490)	380	22	2	7.72	1	Negative
PFHxS	No	399	Unit/Enh (6490)	99	Unit/Enh (6490)	380	35	2	9.57	2	Negative
PFHxS	No	399	Unit/Enh (6490)	80	Unit/Enh (6490)	380	54	2	9.57	2	Negative
PFMBA	No	279	Unit/Enh (6490)	85	Unit/Enh (6490)	380	35	2	7	1	Negative
PFMPA	No	229	Unit/Enh (6490)	85	Unit/Enh (6490)	380	35	2	5.86	1	Negative
PFNA	No	463	Unit/Enh (6490)	419	Unit/Enh (6490)	380	9	2	10.05	2	Negative
PFNA	No	463	Unit/Enh (6490)	219	Unit/Enh (6490)	380	21	2	10.05	2	Negative
PFNS	No	548.9	Unit/Enh (6490)	98.9	Unit/Enh (6490)	380	58	2	12.38	1	Negative
PFNS	No	548.9	Unit/Enh (6490)	79.9	Unit/Enh (6490)	380	64	2	12.38	1	Negative
PFOA	No	413	Unit/Enh (6490)	369	Unit/Enh (6490)	380	9	2	9.44	2	Negative
PFOA	No	413	Unit/Enh (6490)	169	Unit/Enh (6490)	380	23	2	9.44	2	Negative
PFOS	No	499	Unit/Enh (6490)	99	Unit/Enh (6490)	380	50	2	11.26	2	Negative
PFOS	No	499	Unit/Enh (6490)	80	Unit/Enh (6490)	380	52	2	11.26	2	Negative
PFPeA	No	263	Unit/Enh (6490)	218.9	Unit/Enh (6490)	380	6	2	6.65	1	Negative
PFPeA	No	263	Unit/Enh (6490)	69	Unit/Enh (6490)	380	48	2	6.65	1	Negative
PFPeS	No	348.9	Unit/Enh (6490)	98.9	Unit/Enh (6490)	380	40	2	8.95	1	Negative

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Cpd Name	ISTD?	Prec Ion	MS1 Res	Prod Ion	MS2 Res	Frag (V)	CE (V)	Cell Acc (V)	Ret Time (min)	Ret Window	Polarity
PFPeS	No	348.9	Unit/Enh (6490)	79.9	Unit/Enh (6490)	380	38	2	8.95	1	Negative
PFPrA	No	163	Unit/Enh (6490)	119	Unit/Enh (6490)	380	9	2	2.13	3	Negative
PFPrS	No	249	Unit/Enh (6490)	99	Unit/Enh (6490)	380	30	2	6.64	1	Negative
PFTeDA	No	713	Unit/Enh (6490)	669	Unit/Enh (6490)	380	15	2	14.01	1	Negative
PFTeDA	No	713	Unit/Enh (6490)	169	Unit/Enh (6490)	380	40	2	14.01	1	Negative
PFTrDA	No	663	Unit/Enh (6490)	619	Unit/Enh (6490)	380	11	2	13.37	1	Negative
PFTrDA	No	663	Unit/Enh (6490)	169	Unit/Enh (6490)	380	30	2	13.37	1	Negative
PFUnDA	No	563	Unit/Enh (6490)	519	Unit/Enh (6490)	380	11	2	11.83	1	Negative
PFUnDA	No	563	Unit/Enh (6490)	269	Unit/Enh (6490)	380	20	2	11.83	1	Negative

Scan Parameters

Data Stg	Threshold
Centroid	0

Source Parameters

Parameter	Value (+)	Value (-)
Gas Temp (°C)	230	230
Gas Flow (l/min)	14	14
Nebulizer (psi)	20	20
SheathGasHeater	350	350
SheathGasFlow	9	9
Capillary (V)	3500	3000
VCharging	500	0

Ion Funnel Parameters

Pos High Pressure RF	150	Neg High Pressure RF	90
Pos Low Pressure RF	60	Neg Low Pressure RF	50

Chromatograms

Chrom Type	Label	Offset	Y-Range
TIC	TIC	0	10000000

Instrument Curves

Actual

Name: Multisampler **Module: G7167B**

Sampling Speed	
Draw Speed	200.0 µL/min
Eject Speed	200.0 µL/min
Wait Time After Drawing	0.0 s
Injection	
Needle Wash Mode	Standard Wash
Injection Volume	30.00 µL
Standard Needle Wash	
Needle Wash Mode	Wash Vial
Repetitions	4
Wash Location	Vial 1
High Throughput	
Injection Valve to Bypass for Delay Volume Reduction	No
Sample Flush-Out Factor	5.0
Overlapped Injection	
Overlap Injection Enabled	No
Needle Height Position	
Draw Position Offset	0.0 mm
Use Vial/Well Bottom Sensing	No
Stop Time	
Stoptime Mode	No Limit
Post Time	

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Acquisition Method Report

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Posttime Mode	Off

Name: Binary Pump **Module: G7120A**

Flow	0.300 mL/min
Use Solvent Types	Yes
Stroke Mode	Synchronized
Low Pressure Limit	0.00 bar
High Pressure Limit	600.00 bar
Max. Flow Ramp Up	100.000 mL/min²
Max. Flow Ramp Down	100.000 mL/min²
Expected Mixer	No check
Stroke A	
Automatic Stroke Calculation A	Yes
Stop Time	
Stoptime Mode	Time set
Stoptime	18.50 min
Post Time	
Posttime Mode	Time set
Posttime	0.75 min

Solvent Composition

	Channel	Ch. 1 Solv.	Name 1	Ch2 Solv.	Name 2	Selected	Used	Percent
1	A	100.0 % H20 (migrated)	w/ 5mM NH4	100.0 % Water V.03		Ch. 1	Yes	95.00 %
2	B	100.0 % ACN (migrated)		100.0 % Acetonitrile V.03		Ch. 1	Yes	5.00 %

Timetable

	Time	A	B	Flow
1	1.00 min	80.00 %	20.00 %	--- mL/min
2	6.00 min	55.00 %	45.00 %	--- mL/min
3	13.00 min	20.00 %	80.00 %	0.300 mL/min
4	14.00 min	0.00 %	100.00 %	0.400 mL/min
5	16.50 min	0.00 %	100.00 %	0.400 mL/min
6	16.51 min	95.00 %	5.00 %	0.600 mL/min

Name: Column Comp. **Module: G7116A**

Left Temperature Control	
Temperature Control Mode	Not Controlled
Enable Analysis Left Temperature	
Enable Analysis Left Temperature On	Yes
Enable Analysis Left Temperature Value	0.8 °C
Left Temp. Equilibration Time	0.0 min
Right Temperature Control	
Right temperature Control Mode	Temperature Set
Right temperature	40.0 °C
Enable Analysis Right Temperature	
Enable Analysis Right Temperature On	Yes
Enable Analysis Right Temperature Value	0.8 °C
Right Temp. Equilibration Time	0.0 min
Enforce column for run	
Enforce column for run enabled	No
Stop Time	
Stoptime Mode	As pump/injector
Post Time	
Posttime Mode	Off
Timetable	
Valve Position	Position 1 (Port 1 -> 6)

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	Pressure
1	--- bar
2	--- bar
3	--- bar
4	--- bar
5	--- bar
6	--- bar

Acquisition Method Report

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Position Switch After Run	Do not switch

Figure 3 Check Tune Report

QQQ Check Tune Report

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Instrument Name	Instrument 1
MS Model	G6495B
MS Instrument Serial	SG1646D102
Software_Firmware Version	B.09.00.B9037.0, FW: A.00.08.64
Tune Date & Time	14 January 2026 15:48:47
Data Path	D:\MassHunter\Tune\QQQ\G6495B\atunes.TUNE.XML
Ion Source	AJS ESI
Ionization Mode	AJS ESI
Tuned Resolution	All
Vacuum Pressure	2.53E+0[R], 3.13E-5[H]

Source Parameters

Parameter	Value
Gas Temp	220
Gas Flow	14
Nebulizer	20
Capillary	3000
Nozzle Voltage	1500
Sheath Gas Temp	250
Sheath Gas Flow	11

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QQQ Check Tune Report

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Negative Results

Analyzer: MS1 Polarity: Negative Width: Unit

m/z Expected	m/z Measured	Delta	Result	FWHM Expected	FWHM Measured	Delta	Result	Abundance
112.99	112.94	-0.05	Pass	0.70	0.71	0.01	Pass	262255
302.00	301.99	-0.01	Pass	0.70	0.73	0.03	Pass	127458
601.98	601.95	-0.03	Pass	0.70	0.76	0.06	Pass	185223
1033.99	1033.97	-0.02	Pass	0.70	0.68	-0.02	Pass	1343515
1633.95	1633.99	0.04	Pass	0.70	0.72	0.02	Pass	843319
2233.91	2233.84	-0.07	Pass	0.70	0.60	-0.10	Pass	328781

Analyzer: MS2 Polarity: Negative Width: Unit

m/z Expected	m/z Measured	Delta	Result	FWHM Expected	FWHM Measured	Delta	Result	Abundance
112.99	112.93	-0.06	Pass	0.70	0.80	0.10	Pass	566060
302.00	301.95	-0.05	Pass	0.70	0.77	0.07	Pass	231032
601.98	601.99	0.01	Pass	0.70	0.66	-0.04	Pass	381759
1033.99	1033.98	-0.01	Pass	0.70	0.67	-0.03	Pass	2042894
1633.95	1633.99	0.04	Pass	0.70	0.70	0.00	Pass	1330614
2233.91	2233.87	-0.04	Pass	0.70	0.83	0.13	Pass	1048208

Analyzer: MS1 Polarity: Negative Width: Wide

m/z Expected	m/z Measured	Delta	Result	FWHM Expected	FWHM Measured	Delta	Result	Abundance
112.99	112.99	0.00	Pass	1.20	1.23	0.03	Pass	323851
302.00	301.90	-0.10	Pass	1.20	1.41	0.21	Pass	110673
601.98	601.85	-0.13	Pass	1.20	1.63	0.43	Pass	221226
1033.99	1033.90	-0.09	Pass	1.20	1.38	0.18	Pass	3181960
1633.95	1634.01	0.06	Pass	1.20	1.47	0.27	Pass	1410559
2233.91	2233.96	0.05	Pass	1.20	1.47	0.27	Pass	529472

Analyzer: MS2 Polarity: Negative Width: Wide

m/z Expected	m/z Measured	Delta	Result	FWHM Expected	FWHM Measured	Delta	Result	Abundance
112.99	112.94	-0.05	Pass	1.20	1.25	0.05	Pass	567951
302.00	301.81	-0.19	Pass	1.20	1.34	0.14	Pass	259918
601.98	601.81	-0.17	Pass	1.20	1.60	0.40	Pass	529829
1033.99	1033.95	-0.04	Pass	1.20	1.65	0.45	Pass	3528219
1633.95	1633.97	0.02	Pass	1.20	1.62	0.42	Pass	3200580
2233.91	2233.80	-0.11	Pass	1.20	1.30	0.10	Pass	1888562

Analyzer: MS1 Polarity: Negative Width: Widest

m/z Expected	m/z Measured	Delta	Result	FWHM Expected	FWHM Measured	Delta	Result	Abundance
112.99	112.88	-0.11	Pass	2.50	2.56	0.06	Pass	347468
302.00	301.91	-0.09	Pass	2.50	2.94	0.44	Pass	184152
601.98	601.92	-0.06	Pass	2.50	3.16	0.66	Pass	396878
1033.99	1033.89	-0.10	Pass	2.50	2.94	0.44	Pass	4480619
1633.95	1634.13	0.18	Pass	2.50	2.10	-0.40	Pass	3119573
2233.91	2233.82	-0.09	Pass	2.50	2.64	0.14	Pass	1305242

Analyzer: MS2 Polarity: Negative Width: Widest

m/z Expected	m/z Measured	Delta	Result	FWHM Expected	FWHM Measured	Delta	Result	Abundance
112.99	112.84	-0.15	Pass	2.50	2.92	0.42	Pass	918995
302.00	301.73	-0.27	Pass	2.50	3.10	0.60	Pass	361597
601.98	602.03	0.05	Pass	2.50	3.34	0.84	Pass	648278
1033.99	1033.88	-0.11	Pass	2.50	3.37	0.87	Pass	4445013
1633.95	1633.89	-0.06	Pass	2.50	3.50	1.00	Pass	4432559
2233.91	2233.86	-0.05	Pass	2.50	2.49	-0.01	Pass	4142489

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Figure 4: ASTM Soil Prep Benchsheet

MeOH Lot #: _____
Reagent H2O Source Lot #: _____
Acetic acid Lot #: _____
Base #: _____
ISD #: _____
Spike #: _____

PFAS Extraction/Dilution
Method ASTMD7968

SOIL MATRIX

*RL Spike #: _____

Analyst: _____
Date: _____
Time Started: _____
Time Ended: _____
Batch ID#: _____

#	Merit #	Filled weight (g)	Tare weight (g)	H_2O Vol (ml)	MeOH Vol (ml)	Final Vol (ml)	ISD Vol (ul)	Spike Vol (ul)	Tumble (min)	Acetic (ul)	NH_4OH (uL)	Notes
Initial Q.C	BLANK			5	5	10	100	---	60	50	20	
	LCS			5	5	10	100	100	60	50	20	
	LCSD			5	5	10	100	100	60	50	20	
	RL check			5	5	10	100		60	50	20	
MS				5	5	10	100		60	50	20	
DUP				5	5	10	100		60	50	20	
1				5	5	10	100		60	50	20	
2				5	5	10	100		60	50	20	
3				5	5	10	100		60	50	20	
4				5	5	10	100		60	50	20	
5				5	5	10	100		60	50	20	
6				5	5	10	100		60	50	20	
7				5	5	10	100		60	50	20	
8				5	5	10	100		60	50	20	
9				5	5	10	100		60	50	20	
10				5	5	10	100		60	50	20	
11				5	5	10	100		60	50	20	
12				5	5	10	100		60	50	20	
13				5	5	10	100		60	50	20	
14				5	5	10	100		60	50	20	
15				5	5	10	100		60	50	20	
16				5	5	10	100		60	50	20	
17				5	5	10	100		60	50	20	
18				5	5	10	100		60	50	20	
19				5	5	10	100		60	50	20	
20				5	5	10	100		60	50	20	
21				5	5	10	100		60	50	20	
22				5	5	10	100		60	50	20	
23				5	5	10	100		60	50	20	
24				5	5	10	100		60	50	20	

Reviewed by: _____ On: _____ Balance ID: _____ Prepared by: Merit Laboratories, Inc.
EXT-F15 Effective Date 3/23/2021