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ENVIRONMENT

Subject:
PFAS Investigation Work Plan
RACER Trust, Plant 3, Lansing, Michigan

Date:
August 9, 2017

Contact:
Patrick Curry

Phone:
810 225 1926

Email:
patrick.curry@arcadis.com

Our ref:
B0064480.2017

Dear Mr. Quackenbush:

This work plan has been prepared by Arcadis on behalf of the Revitalizing Auto Communities Environmental Response (RACER) Trust for Plant 3 located in Lansing, Michigan (Site) to further evaluate poly and per-fluorinated alkyl substances (PFAS) initially detected in December 2016 and further evaluated during the spring of 2017.

During December 2016, four monitoring wells near the former chromium plating area were sampled for PFAS in association with vapor suppressants used for the former plating operations. The compound perfluorooctanesulfonic acid (PFOS) was detected in perched groundwater at concentrations exceeding 2016 proposed Michigan Part 201 Drinking Water (DW) and Groundwater Surface Water Interface (GSI) criteria. In addition, a concentration of the compound perfluorooctanoic acid (PFOA) exceeded the proposed Part 201 GSI criterion. In response, additional investigation was conducted in April 2017 consisting of 14 vertical aquifer profile (VAP) borings, sampling of two perched monitoring wells and three deep overburden monitoring wells, and sampling of the Plant 3 storm sewer outfall. The investigation established partial delineation to GSI criteria to the west and that impacts were limited to perched groundwater. The results of the investigation were summarized in the *MDEQ Update Meeting* presentation provided to the MDEQ on June 8, 2017.

Prior to developing this workplan, Arcadis sampled an additional five perched monitoring wells in attempt to delineate PFOS to the east and southeast. All five wells had PFOS concentrations exceeding proposed GSI criteria, and three of

the five wells exceeded proposed DW criteria. Additionally, Arcadis resampled the Plant 3 storm sewer outfall during baseflow conditions and found that storm sewer effluent still exceeds the proposed GSI criterion for PFOS.

Based on the results of the investigations, additional work is proposed to complete delineation of PFOS and PFOA concentrations to GSI Criteria and identify the portions of the storm sewer system contributing PFAS to the storm sewer.

This work will be completed as a part of the Resource Conservation and Recovery Act (RCRA) Facility Investigation. The specific objectives of this study are as follows:

1. Delineation of PFOS and PFOA to or near the proposed GSI criteria.
2. Refine our understanding of groundwater flow directions within the perched zone on northern Plant 3.
3. Evaluate where infiltration of impacted groundwater to the storm sewer occurs and locations for potential bulkheading to eliminate discharge of PFAS to the storm sewer outfall.

The delineation of PFAS exceedances will be accomplished through an adaptive investigation utilizing an on-site laboratory to provide rapid analytical results. The results of the PFAS delineation will be used to guide decisions on groundwater monitoring for PFAS. In addition, a storm sewer investigation will be completed to evaluate the GSI pathway encompassing the area of PFOS exceedances. The storm sewer investigation will consist of a camera survey of the two storm sewer mains that drain Plant 3, as well as selected laterals, and sampling of water from storm manholes throughout the investigation area. The results from the storm sewer investigation will be used to help evaluate potential elimination of the contribution of PFOS to the storm sewers through selective bulkheading.

UTILITY CLEARANCE

Prior to advancing borings at the Site, utility clearance will be completed for all proposed locations. Reliable lines of evidence that may be utilized in accordance with the site-specific utility clearance plan include: Miss Dig call, client provided maps of utilities, visual site inspection, and/or hand clearing to a depth of 5 feet below grade.

ADAPTIVE DELINEATION SCOPE OF WORK

The adaptive delineation scope of work was developed to complete delineation of the PFAS on Plant 3, and determine groundwater flow directions for perched water on northern Plant 3 The proposed VAP boring locations are depicted on **Figure 1**. The scope of work will include completion of eleven (11) prescriptive VAP borings and up to nineteen (19) additional adaptive VAP borings:

- Groundwater samples will be analyzed with an on-site mobile laboratory provided by Cascade Technical Services. A subset of the samples analyzed by the mobile laboratory will be submitted to Test America Laboratory (Test America) in Sacramento, California for comparative analysis.
    - The Cascade Technical Services mobile laboratory has completed the Environmental Laboratory Accreditation Program (ELAP) for evaluation of PFAS compounds using modified USEPA Method 537. Split samples will be compared to the Test America results for validation.

- Eleven (11) prescriptive VAP borings will be completed to a depth of 20 feet below ground surface (bgs) in areas to the north, east, and south of previously identified PFAS concentrations as shown on Figure 1.
  - One (1) boring due west of monitoring well P3-SB-07 to complete a gap between two previous VAP borings (SB-A14-CE94 and SB-A14-CS95).
  - One (1) boring to the north of VAP SB-A14-CD109 to delineate a PFOS concentration exceeding the proposed GSI criterion
  - Three (3) borings to the north and east of the French drain and former press pits to delineate GSI and DW exceedances detected along the French drain.
  - Four (4) borings to the east and south of the former UST basins and LNAPL areas to delineate DW and GSI exceedances detected in perched monitoring wells
  - One (1) boring slightly east of dry VAP boring SB-A14-DZ125 near the southern end of the French drain to confirm the lack of groundwater and delineation south of the former chrome plating pit.
  - One (1) boring to the southwest of monitoring well CH-14-RO to complete a gap in the delineation between VAP borings SB-A14-DB107 and SB-A14-DP125.
- Up to 19 adaptive VAP borings will be completed to 20 feet bgs, as needed to complete the delineation of PFOS and PFOA. The quantity and location of the adaptive locations will be based on rapid (24 hour) analytical results provided by the mobile lab.
- At each VAP boring location, one (1), and potentially two (2), vertical aquifer profile (VAP) groundwater samples will be collected, depending on saturated thickness and/or sand seams encountered.
- VAP borings for the PFAS delineation will be advanced using direct push drilling methods using a dual-tube setup that utilizes an outer 2.25” casing. Continuous soil cores will be obtained from the ground surface to glacial till below the perched zone (up to 20 feet bgs) at each boring location.
- Where groundwater is encountered, a one-inch diameter polyvinyl chloride (PVC) temporary well will be deployed to collect the sample. Arcadis will log and describe the overburden in accordance with the Arcadis Soil Description Standard Operating Procedures included with the MDEQ approved Field Sampling Plan (FSP, Arcadis 2011) as well as the PFAS Field Sampling Technical Guidance Instructions (TGI) included as Attachment 1.
- Depth to groundwater will be gauged at each temporary monitoring well prior to abandonment. Measurements will be taken from top of casing (TOC) to water and from TOC to ground surface, to allow for future groundwater elevation calculations. Groundwater elevation gauging will also be completed for existing perched monitoring wells in Northern Plant 3. Locations of existing monitoring wells are shown on Figure 1.

STORM SEWER INVESTIGATION SCOPE OF WORK

The storm sewer investigation was developed to determine where PFOS detected above the proposed GSI criterion of 12 ppt in samples collected from the northern Plant 3 storm sewer outfall (P3-MH-NE), is present within the storm sewer system. The storm sewer system on northern Plant 3 is depicted on **Figure 2**, and consists of a system of relatively shallow laterals connecting to floor drains and former roof drains that flow into two 36” to 48” diameter mains that flow north and converge near the outfall at the northern property boundary. Many of the junctions where laterals connect to the mains are inaccessible

due to a lack of manhole, or welded manhole covers. The investigation proposed in this scope of work is intended to evaluate whether water moving through the system contains PFOS and the construction details of the storm sewers. This scope of work includes:

- A camera survey to identify existing construction details including, but not limited to, depth, diameter, and materials. The camera survey will include the lengths of drain highlighted on Figure 2 including:
  - The main bordering the western edge of Area 14 which drains the investigation area to the west of the former plating pits and French drain.
  - The main on the east side of the Areas 17 and 18 which drains the investigation area to the east of the former plating pits and French drain.
  - Up to 2000 feet of storm sewer may be included in the camera survey.
- A minimum of 8 water samples will be collected at different points along the storm sewer system to evaluate whether water moving through the sewers contains PFOS:
  - Samples will be submitted to Test America for analysis of PFOS and PFOA using modified Method 537, and to Merit Laboratories in East Lansing, MI for total suspended solids (TSS) analysis using Method 2540D.
  - Samples will be collected from the accessible structures shown on Figure 2. Additional/alternate sampling points may be selected based on the results of the camera survey.
  - At each location, a grab sample will be collected using a peristaltic pump. Water samples will only be collected from the structures after an extended period (5 days or more) of less than 0.25-inch of cumulative precipitation.

Information gathered from the storm sewer investigation will be used to evaluate whether the GSI pathway for PFOS can be eliminated by selectively bulkheading storm sewer laterals, and if so, evaluate how and where bulkheading can be effectively implemented.

FIELD DOCUMENTATION

Field personnel will provide documentation covering all aspects of storm water and groundwater sampling, logging and description of soil cores, field screening results, and sample chain of custody (COC) procedures. This documentation will constitute of a record that will allow reconstruction of field events to aid in the data review and interpretation process. All documents, records and information relating to the performance of the fieldwork including but not limited to daily field logs, sampling logs, COCs and field equipment calibration logs will be retained in the project file.

REPORTING

Following completion of the field portion of the PFAS delineation, Arcadis will evaluate the analytical data and groundwater elevations, and determine the requirements for monitoring PFAS in groundwater on Plant 3, including potential installation of additional perched monitoring wells to supplement the existing wells. Arcadis will prepare a workplan with the locations and construction details of any proposed monitoring wells, as well as a proposed monitoring plan to be integrated into the IGMP. Arcadis will prepare a summary report outlining the results of the PFAS delineation. It is anticipated this report can be completed within 4 to 6 weeks after receipt of the analytical results from Cascade and Test America. The reports will include a brief discussion of the field activities, figures illustrating the results of the

investigations, analytical summary tables, and attachments including laboratory analytical reports and any other relevant information.

Following completion of the storm sewer investigation fieldwork and receipt of analytical data, Arcadis will review the results and prepare a summary report.

INVESTIGATION DERIVED WASTE (IDW) HANDLING

Soil cuttings and Liquid IDW (purge and decon water) will be placed in labeled and sealed 55-gallon steel drums and stored in a secured area. Liquid IDW will include water from decontamination of drilling tooling and purge water from VAP sampling.

SCHEDULE

The tentative scheduled start date for the adaptive delineation phase of this workplan is August 21, 2017 but is dependent upon the availability of the drilling firm and on-site lab. Note that the duration of the field event may vary based on the actual number of borings required to complete the delineation. The adaptive delineation phase is anticipated to take 3 to 4 days to complete.

The storm sewer camera survey schedule is currently being developed but likely will occur in September 2017. The storm sewer survey is estimated to require one to two days to complete, and storm sewer sampling will take one day to complete.

A PFAS Investigation report will be prepared within 4-6 weeks of receipt of the final analytical reports, and the storm sewer summary report will be completed within 4-6 weeks after receiving the final analytical results from the storm water samples.

If you have any questions regarding the scope of work described above, please contact Patrick Curry (Arcadis) at 810-225-1926 or Dave Favero (RACER Trust) at 734-879-9525.

Sincerely,

Arcadis of Michigan, LLC

Patrick Curry, PG, CPG
Principal Geologist

Copies:
Dave Favero, RACER Trust

Enclosures:

Figures

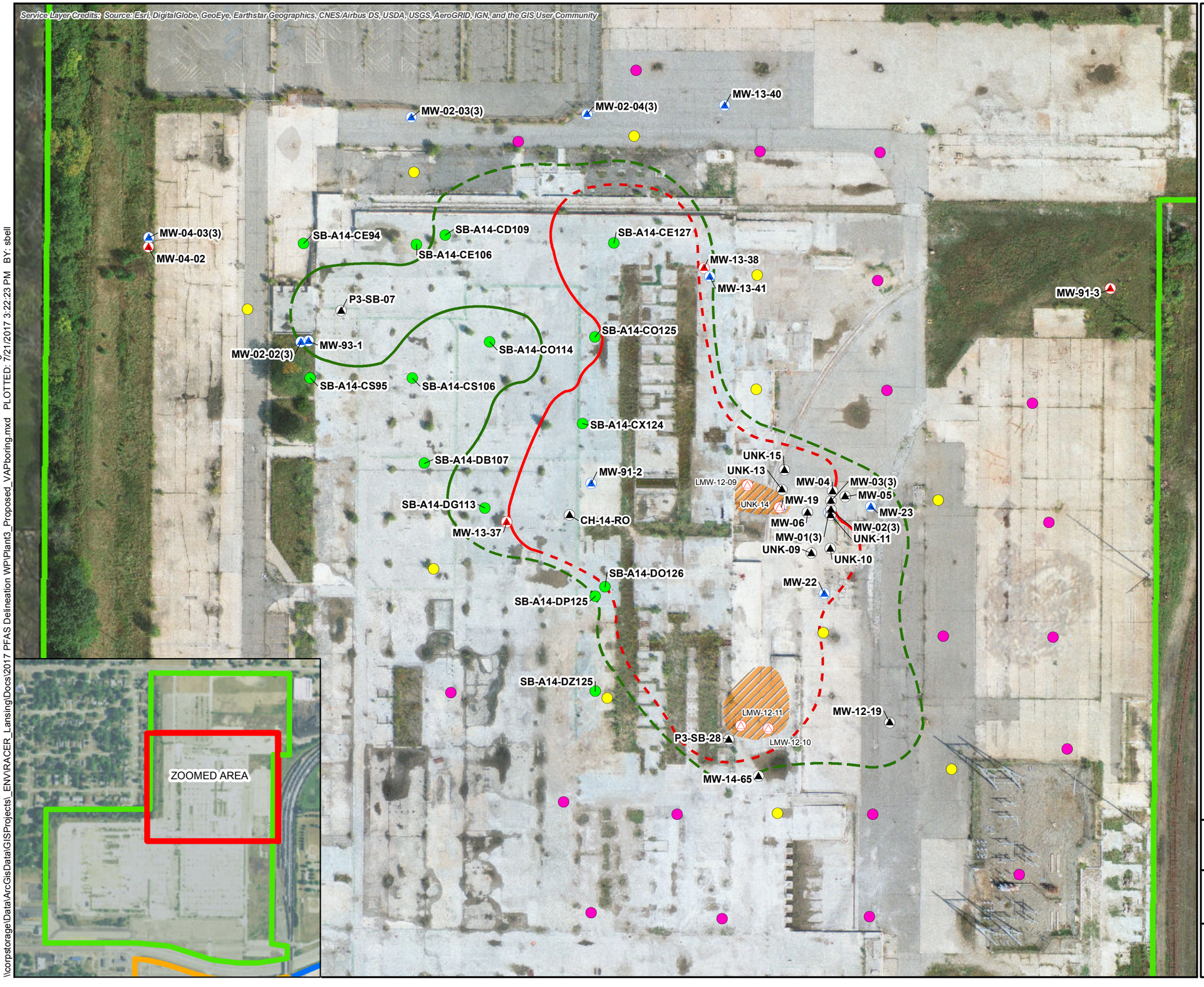
1 Proposed VAP Boring Locations

2 Proposed Storm Sewer Investigation

Attachments

1 PFAS Field Sampling Technical Guidance Instructions

FIGURES



LEGEND

- PRESCRIPTIVE VAP BORING (DAY 1-2)
- POTENTIAL ADAPTIVE VAP LOCATION (DAYS 2-3)
- APRIL 2017 VAP BORING
- LNAPL MONITORING WELL
- PERCHED ZONE MONITORING WELL
- DEEP OVERBURDEN MONITORING WELL
- WEATHERED BEDROCK MONITORING WELL
- BEDROCK MONITORING WELL
- EXTENT OF PFOS IN GW > DW CRITERION OF 80 PPT (DASHED LINE INDICATES ESTIMATED EXTENT)
- EXTENTOF PFOS IN GW >GSI CRITERION OF 12PPT (DASHED LINE INDICATES ESTIMATED EXTENT)
- APPROXIMATE EXTENT OF LNAPL
- PLANT 3

N

0 100 200

SCALE IN FEET

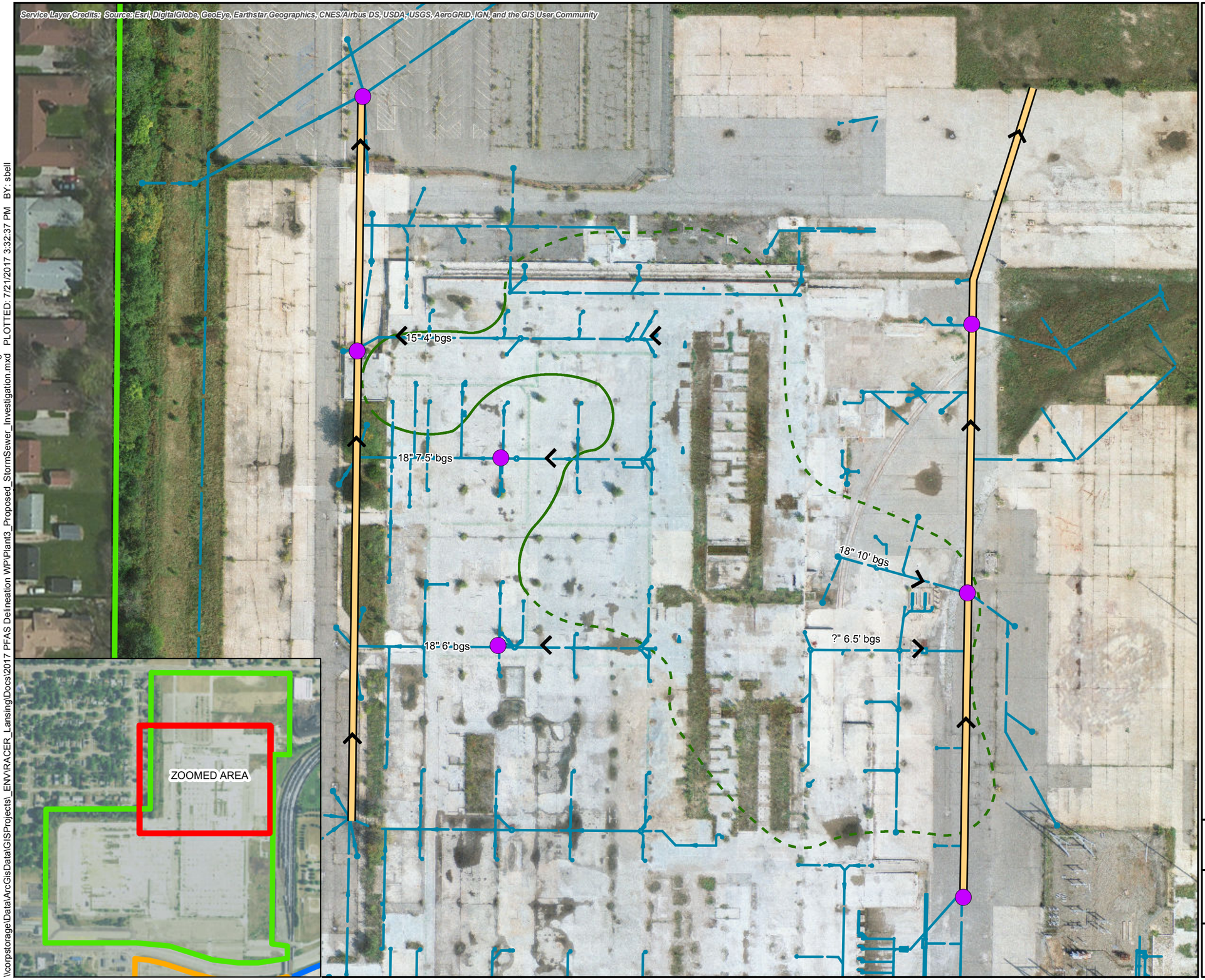
RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

Proposed VAP Boring Locations

ARCADIS Design & Consultancy for natural and built assets

FIGURE 1

CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
\\corpstorage\Data\ArcGisData\GISProjects_ENV\RACER_Lansing\Docs\2017 PFAS Delineation WP\Plant3_Proposed_VAPboring.mxd PLOTTED: 7/21/2017 3:22:23 PM BY: sbell



LEGEND

- PROPOSED SAMPLE LOCATION
- STORM SEWER SELECTED FOR CAMERA SURVEY
- STORM SEWER
- EXTENT OF PFOS IN GW > GSI CRITERION OF 12PPT (DASHED LINE INDICATES ESTIMATED EXTENT)
- PLANT 3

0 100 200

SCALE IN FEET

RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

Proposed Storm Sewer Investigation

ARCADIS Design & Consultancy for natural and built assets

FIGURE **2**

CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
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ATTACHMENT 1

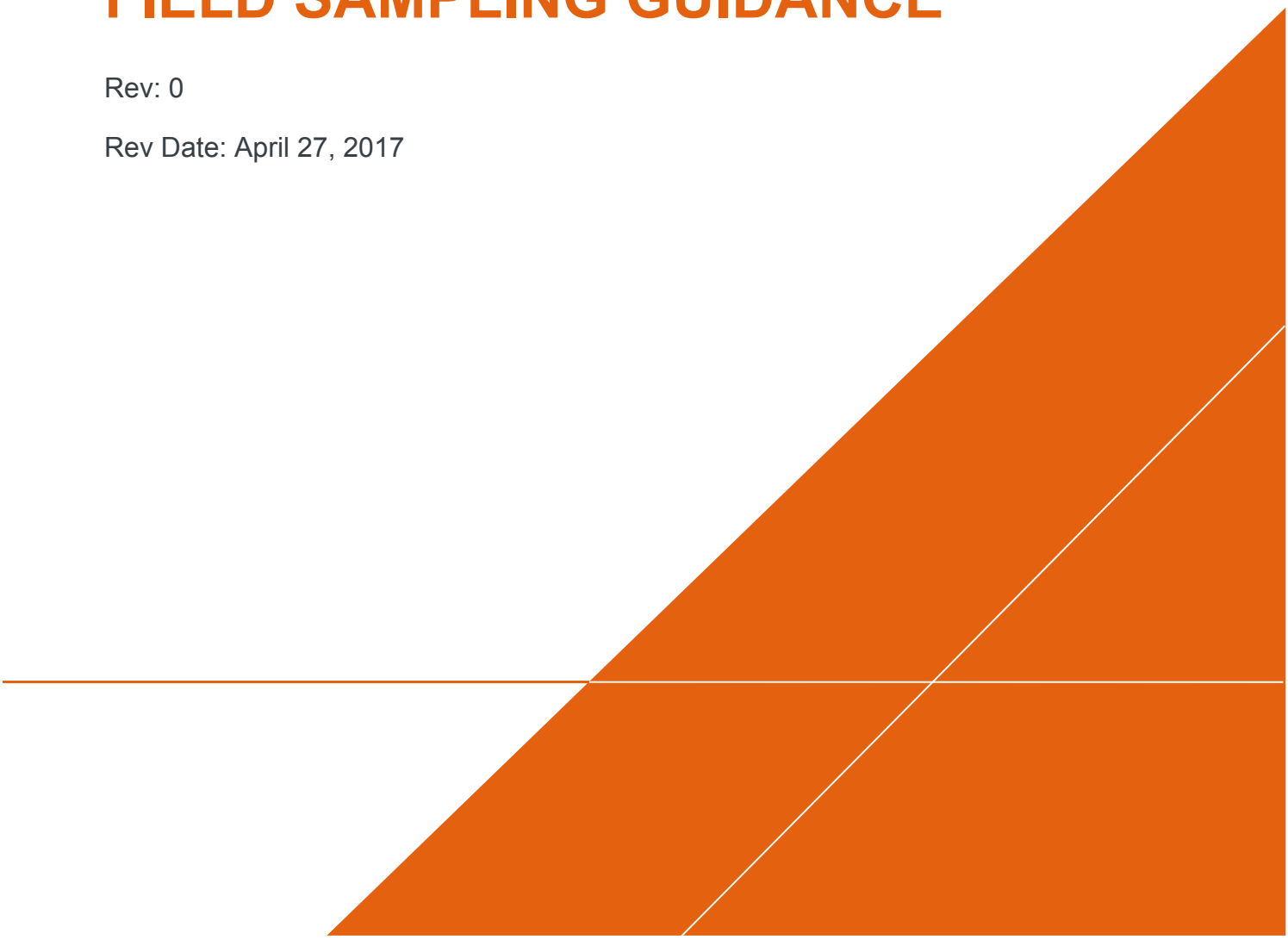
PFAS Field Sampling Technical Guidance Instructions

ARCADIS Design & Consultancy for natural and built assets

POLY- AND PERFLUORINATED ALKYL SUBSTANCES (PFAS) FIELD SAMPLING GUIDANCE

Rev: 0

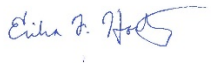
Rev Date: April 27, 2017



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	April 27, 2017	All	Initial Release	Erica Kalve Erika Houtz Sue Tauro

APPROVAL SIGNATURES

Prepared by:		04/26/2017
	Erika F. Houtz, PhD Environmental Engineer and PFAS Analytical Lead	Date
Reviewed by:		04/27/2017
	Erica Kalve, PG-CA Emerging Contaminants Focus Group Leader	Date:

1 INTRODUCTION

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 any and 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, state-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.

2 SCOPE AND APPLICATION

The purpose of this Technical Guidance Instructions (TGI) is to provide guidance on field sampling to be used for poly-and perfluorinated alkyl substances (PFAS). This protocol was adapted from various sources including Arcadis Australia, Transport Canada, and the U.S Army Corp of Engineers (USACE) Omaha.

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. 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.

3 PERSONNEL QUALIFICATIONS

3.1 Sampling Personnel

Field personnel must have current health and safety training, including 40-hour HAZWOPER training, 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.

3.2 Laboratories

These laboratories may be used to analyze environmental media for PFAS:

- United States: Test America, SGS, Vista, ALS, RTI, and Eurofins
- Canada: Axys-SGS and Maxxam Laboratories

Other laboratories may be used if they are accredited for PFAS analysis.

4 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 Sharpies for writing;
- Clipboards, field binders, and field note pages that are not waterproof;
- Labeled sample bottles:
    - Water: HDPE bottles fitted with polypropylene screw cap only; some types of PFAS samples (primarily drinking water) may require preservative, which will be indicated by the laboratory conducting the analysis. The laboratory will specify the sample bottle volume.
    - Soil and sediment: HDPE bottles fitted with polypropylene screw cap only; no preservatives. The laboratory will specify the sample bottle volume.
- If high concentrations of PFAS related to class B firefighting foams are expected, bring ‘shaker test' vials;

- Ziploc® bags to hold ice and samples;
- Appropriate blanks (field reagent blanks supplied by the laboratory);
- Appropriate transport bottles (coolers) with ice and appropriate labeling, no blue ice;
- Deionized water for initial decontamination rinsing;
- "PFAS-free" water provided by the laboratory for final decontamination rinsing;
- Methanol, if readily available; especially important for soil sampling;
- Alconox or Liquinox®;
- Packing and shipping materials;
- Groundwater Sampling Log; and
- Chain-of-Custody (COC) Forms.

5 CAUTIONS

5.1 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.

5.2 Field Gear

5.2.1 Clothing

Many types of clothing are treated with PFAS for stain and water resistance, in particular outdoor performance wear under brand names such as Gore-Tex®. 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 water proof.
- 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.
- Most importantly, avoid contacting your clothing with sampling equipment, bottles, and samples.

5.2.2 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. For the health and safety of field personnel, footwear must be protected at all times to avoid potential PFAS contamination. To do this:

- Do not touch your safety footwear in the immediate vicinity of the sampling port (i.e., within 10 meters [m]).

- Do not allow gloves used for sampling to come in contact with safety footwear.

Nitrile Gloves

Wear disposable nitrile gloves at all times. 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;
- 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.

5.3 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 ONLY if necessary for health and safety. If they are necessary, apply sunscreen and 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 m away). Wash hands after application.

5.4 Visitors

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

5.5 Rain Events

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

- Do not perform field sampling when rain fall is persistent at a consistent rate that saturates the ground (i.e., formation of puddles) because rain gear is not permitted while sampling. Intermittent showers or fog are acceptable conditions to proceed. If rain showers occur; field gear must be removed from the monitoring well location until the rain subsides.
- 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.

6 HEALTH AND SAFETY CONSIDERATIONS

- 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.

7 PROCEDURE

7.1 Field Equipment Cleaning

Field sampling equipment will require cleaning 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.

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 two times with distilled water or deionized water;
- Rinse one time with “PFAS-free” water or once with methanol, if it is available, and once with “PFAS-free” water; methanol is especially useful for decontaminating soil sampling equipment; and
- Collect all rinsate in a sealed pail for disposal. Do not reuse decontamination solutions between sampling locations.

Clean all field equipment used at locations that are suspected of containing class B firefighting foam (i.e., those that foam during shaking or are known to be near a class B firefighting foam source zone) using each of the above steps repeated twice.

7.2 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.

7.2.1 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 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.

7.2.2 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. Decontaminate the instrument and flow-through cell at each monitoring well location before purging.
- 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.
- 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.

7.3 Sample Collection

Different laboratories may supply sample collection bottles of varying sizes depending on the type of media to be sampled.

7.3.1 Sample Containers

- Collect samples in HDPE bottles fitted with an unlined (no Teflon™), polypropylene 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.

7.3.2 Soil Sampling

Before Sample Collection

- Place plastic sheeting (preferably HDPE) adjacent to the sample port 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;
- 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 labeled HDPE bottles supplied by the laboratory.
- Collect any necessary duplicates/co-located samples and matrix spikes – verify with laboratory whether they need to be collected in separate sample bottles.
- Note the time on the sample label.

After Sample Collection

- Place soil sample bottles in a sealed Ziploc© bag (optional).
- 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.**

7.3.3 Groundwater Sampling

Before Sample Collection

- Place plastic sheeting (preferably HDPE) adjacent to the sample port 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 labeled HDPE bottles 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 prior to 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, collect and shake a small portion of the sample (~10 to 25 mL) on site. 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. Most PFAS, including all analytes measured by USEPA Method 537, are not volatile at environmental pH.
- 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.
- Do not rinse PFAS sample bottles during sampling. Do not filter samples.

After Sample Collection

- Place groundwater sample bottles in a sealed Ziploc© bag (optional).
- 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.

7.3.4 Sediment Sampling

Before Sample Collection

- Place plastic sheeting (preferably HDPE) adjacent to the sample port 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.
- Collect any necessary duplicates and matrix spikes.

After Sample Collection

- Place sample bottles in a sealed Ziploc© bag (optional).
- 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.

7.3.5 Surface Water Sampling

Before Sample Collection

- Place plastic sheeting (preferably HDPE) adjacent to the sample port 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.
- 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.
- 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.
- Make sure bottle caps remain in the gloved hand of the sampler until sampling is complete and caps are replaced on the bottle.

After Sample Collection

- Place sample bottles in a sealed Ziploc© bag (optional).
- 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.

7.4 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.
- Do not ship samples via Fed Ex for Saturday delivery.

8 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.

Emerging contaminants pose a unique challenge for disposal because acceptance of such waste will be based on the local facility and their permit restrictions. Project teams will be required to identify appropriate facilities based on the facility's legal ability to accept the waste and the team should confirm that the facility is meeting the regulatory requirements for accepting waste containing PFAS. In general, facilities that provide solidification and/or incineration will be likely to meet the necessary requirements to accept PFAS-containing waste. The facility will then provide the definitive laboratory analysis requirements needed to meet their permit requirements for waste classification.

9 DATA RECORDING AND MANAGEMENT

9.1 Field Notes

Waterproof field books must not be used for field notes. Instead, field notes should be on loose paper on Masonite, plastic, or aluminum clip boards. Other requirements for field notes include:

- Pens, pencils, and 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.

9.2 Other Project Documentation

- Complete Groundwater Sampling Logs.
- Make sure COC Forms are properly completed. Verify which PFAS analytes (e.g., just PFOS and PFOA, some or all of the 537 list, etc.) are required for analysis and note on the COC.

10 QUALITY CONTROL

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.**

10.1 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).

10.2 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".

10.3 Field Blanks

QA/QC sampling for PFAS typically includes the submission of one laboratory supplied reagent field blank per day. The reagent field 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 reagent field blank should be placed in the same cooler as the other PFAS samples.

10.4 Matrix Spikes (optional in some cases)

QA/QC sampling includes submitting a sample to be used as a matrix spike if the project requires it. If a separate sample bottle is required, an additional sample will be collected immediately after the initial sample of which it is a duplicate into a separate laboratory-supplied sample bottle.

10.5 Laboratory Analytical QA/QC

- Internal 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 QAQC procedures. Isotope dilution should be used for quantification with isotope-labeled surrogate standards, as available.
- For groundwater and surface water samples, extract the entire groundwater and surface water sample and at least two sampling bottle solvent rinsates for analysis to increase sample accuracy. Avoid sub-sampling an aliquot of the sample bottle.
- Soil samples should be analyzed in their entirety or thoroughly homogenized before extraction and analysis.
- As part of the internal QA/QC, 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.

- In January 2017, the U.S. Department of Defense (DOD) and U.S. Department of Energy (DOE) Quality Systems Manual (QSM) 5.1 was finalized and introduced laboratory guidance for the measurement of PFAS in matrices other than drinking water. This guidance is not a detailed procedural method such as an EPA method, but it does recommend best practices around the analysis of PFAS. Laboratories are not required to comply with QSM 5.1 until 2019, although the recommendations around PFAS analysis are similar to what most laboratories are already implementing. Arcadis recommends that any request for PFAS analysis in groundwater or soil should specifically reference the need to comply with Table B-15 in the QSM 5.1.

11 REFERENCES

Arcadis Australia. 2017. Soil and Concrete Sampling for PFAS. April.

Arcadis. 2010. Monitoring Well Development, Rev. #2.2. March 22.

Arcadis. 2009. Investigation-Derived Waste Handling and Storage, Rev. #2. March 6.

Arcadis. 2011. Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells, Rev. #4. February 2.

ASTM. 2002. ASTM D6771-02 - Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations (Withdrawn 2011). Available at: https://www.astm.org/Standards/D6771.htm.

U.S. Army Corps of Engineers – Omaha District. 2016. Chemistry Requirements – PFAS.

U.S. Department of Defense (DoD). 2017. Consolidated Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1. In conjunction with the U.S. Department of Energy. January.

U.S. Environmental Protection Agency. 2009. USEPA Method 537: Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS), version 1.1, September. National Exposure Research Laboratory, Office of Research and Development.

U.S. Environmental Protection Agency. 2010. Low Stress (Low Flow) purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells. Available at: https://www.epa.gov/quality/low-stress-low-flow-purging-and-sampling-procedure-collection-groundwater-samples-monitoring.

Transport Canada. February 2016, Per-and Polyfluorinated Alkyl Substances (PFAS) Field Sampling Guidance.