State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Technical Assistance, Environmental Liability Clarification or Post-Closure Modification Request

Notice: Use this form to request **a written response (on agency letterhead)** from the Department of Natural Resources (DNR) regarding technical assistance, a post-closure change to a site, a specialized agreement or liability clarification for Property with known or suspected environmental contamination. A fee will be required as is authorized by s. 292.55, Wis. Stats., and NR 749, Wis. Adm. Code., unless noted in the instructions below. Personal information collected will be used for administrative purposes and may be provided to requesters to the extent required by Wisconsin's Open Records law [ss. 19.31 - 19.39, Wis. Stats.].

Definitions

"Property" refers to the subject Property that is perceived to have been or has been impacted by the discharge of hazardous substances.

"Liability Clarification" refers to a written determination by the Department provided in response to a request made on this form. The response clarifies whether a person is or may become liable for the environmental contamination of a Property, as provided in s. 292.55, Wis. Stats.

"Technical Assistance" refers to the Department's assistance or comments on the planning and implementation of an environmental investigation or environmental cleanup on a Property in response to a request made on this form as provided in s. 292.55, Wis. Stats.

"Post-closure modification" refers to changes to Property boundaries and/or continuing obligations for Properties or sites that received closure letters for which continuing obligations have been applied or where contamination remains. Many, but not all, of these sites are included on the GIS Registry layer of RR Sites Map to provide public notice of residual contamination and continuing obligations.

Select the Correct Form

This from should be used to request the following from the DNR:

- Technical Assistance
- Liability Clarification
- Post-Closure Modifications
- Specialized Agreements (tax cancellation, negotiated agreements, etc.)

Do not use this form if one of the following applies:

- Request for an **off-site liability exemption or clarification** for Property that has been or is perceived to be contaminated by one or more hazardous substances that originated on another Property containing the source of the contamination. Use DNR's Off-Site Liability Exemption and Liability Clarification Application Form 4400-201.
- Submittal of an Environmental Assessment for the **Lender Liability Exemption**, s 292.21, Wis. Stats., **if no response or review by DNR is requested**. Use the Lender Liability Exemption Environmental Assessment Tracking Form 4400-196.
- Request for an **exemption to develop on a historic fill site** or licensed landfill. Use DNR's Form 4400-226 or 4400-226A.
- **Request for closure** for Property where the investigation and cleanup actions are completed. Use DNR's Case Closure - GIS Registry Form 4400-202.

All forms, publications and additional information are available on the internet at: dnr.wi.gov/topic/Brownfields/Pubs.html.

Instructions

1. Complete sections 1, 2, 6 and 7 for all requests. Be sure to provide adequate and complete information.
2. Select the type of assistance requested: Section 3 for technical assistance or post-closure modifications, Section 4 for a written determination or clarification of environmental liabilities; or Section 5 for a specialized agreement.
3. Include the fee payment that is listed in Section 3, 4, or 5, unless you are a "Voluntary Party" enrolled in the Voluntary Party Liability Exemption Program **and** the questions in Section 2 direct otherwise. Information on to whom and where to send the fee is found in Section 8 of this form.
4. Send the completed request, supporting materials and the fee to the appropriate DNR regional office where the Property is located.

   See the map on the last page of this form. A paper copy of the signed form and all reports and supporting materials shall be sent with an electronic copy of the form and supporting materials on a compact disk. For electronic document submittal requirements see: http://dnr.wi.gov/files/PDF/pubs/rr/RR690.pdf"

The time required for DNR's determination varies depending on the complexity of the site, and the clarity and completeness of the request and supporting documentation.

Section 1. Contact and Recipient Information

Requester Information

This is the person requesting technical assistance or a post-closure modification review, that his or her liability be clarified or a specialized agreement and is identified as the requester in Section 7. DNR will address its response letter to this person.

Last Name	First	MI	Organization/ Business Name		
Wahl	Scott		Tyco Fire Products LP		
Mailing Address			City	State	ZIP Code
2700 Industrial Parkway South			Marinette	WI	54143
Phone # (include area code)	Fax # (include area code)		Email		

The requester listed above: (select all that apply)

- [x] Is currently the owner
- [ ] Is considering selling the Property
- [ ] Is renting or leasing the Property
- [ ] Is considering acquiring the Property
- [ ] Is a lender with a mortgagee interest in the Property
- [ ] Other. Explain the status of the Property with respect to the applicant:

Contact Information (to be contacted with questions about this request)

[ ] Select if same as requester

Contact Last Name	First	MI	Organization/ Business Name		
Milionis	Peter		Arcadis		
Mailing Address			City	State	ZIP Code
126 N Jefferson Street, Suite 400			Milwaukee	WI	53202
Phone # (include area code)	Fax # (include area code)		Email		
(267) 285-1815			peter.milionis@arcadis.com		

Environmental Consultant (if applicable)

Contact Last Name	First	MI	Organization/ Business Name		
Milionis	Peter		Arcadis		
Mailing Address			City	State	ZIP Code
126 N Jefferson Street, Suite 400			Milwaukee	WI	53202
Phone # (include area code)	Fax # (include area code)		Email		
(267) 285-1815			peter.milionis@arcadis.com		

Section 2. Property Information

Property Name			FID No. (if known)		
Tyco Fire Technology Center - PFCs			438005590		
BRRTS No. (if known)			Parcel Identification Number		
0238583856					
Street Address			City	State	ZIP Code
2700 Industrial Parkway South			Marinette	WI	54143
County	Municipality where the Property is located		Property is composed of:		Property Size Acres
Marinette	(•) City ( ) Town ( ) Village of Marinette		( ) Single tax parcel	( ) Multiple tax parcels	380

1. Is a response needed by a specific date? (e.g., Property closing date) Note: Most requests are completed within 60 days. Please plan accordingly.

◉ No ○ Yes

Date requested by: _____

Reason:

_____

2. Is the "Requester" enrolled as a Voluntary Party in the Voluntary Party Liability Exemption (VPLE) program?

◉ No. **Include the fee that is required for your request in Section 3, 4 or 5.**

○ Yes. **Do not include a separate fee.** This request will be billed separately through the VPLE Program.

Fill out the information in Section 3, 4 or 5 which corresponds with the type of request:
Section 3. Technical Assistance or Post-Closure Modifications;
Section 4. Liability Clarification; or Section 5. Specialized Agreement.

Section 3. Request for Technical Assistance or Post-Closure Modification

Select the type of technical assistance requested: [**Numbers in brackets are for WI DNR Use]**

☐ No Further Action Letter (NFA) (Immediate Actions) - NR 708.09, [183] - **Include a fee of $350.** Use for a written response to an immediate action after a discharge of a hazardous substance occurs. Generally, these are for a one-time spill event.

☒ Review of Site Investigation Work Plan - NR 716.09, [135] - **Include a fee of $700.**

☐ Review of Site Investigation Report - NR 716.15, [137] - **Include a fee of $1050.**

☐ Approval of a Site-Specific Soil Cleanup Standard - NR 720.10 or 12, [67] - **Include a fee of $1050.**

☐ Review of a Remedial Action Options Report - NR 722.13, [143] - **Include a fee of $1050.**

☐ Review of a Remedial Action Design Report - NR 724.09, [148] - **Include a fee of $1050.**

☐ Review of a Remedial Action Documentation Report - NR 724.15, [152] - **Include a fee of $350**

☐ Review of a Long-term Monitoring Plan - NR 724.17, [25] - **Include a fee of $425.**

☐ Review of an Operation and Maintenance Plan - NR 724.13, [192] - **Include a fee of $425.**

Other Technical Assistance - s. 292.55, Wis. Stats. [97] (For request to build on an abandoned landfill use Form 4400-226)

☐ Schedule a Technical Assistance Meeting - **Include a fee of $700.**

☐ Hazardous Waste Determination - **Include a fee of $700.**

☐ Other Technical Assistance - **Include a fee of $700.** Explain your request in an attachment.

Post-Closure Modifications - NR 727, [181]

☐ Post-Closure Modifications: Modification to Property boundaries and/or continuing obligations of a closed site or Property; sites may be on the GIS Registry. This also includes removal of a site or Property from the GIS Registry. **Include a fee of $1050, and:**

☐ Include a fee of $300 for sites with residual soil contamination; and

☐ Include a fee of $350 for sites with residual groundwater contamination, monitoring wells or for vapor intrusion continuing obligations.

Attach a description of the changes you are proposing, and documentation as to why the changes are needed (if the change to a Property, site or continuing obligation will result in revised maps, maintenance plans or photographs, those documents may be submitted later in the approval process, on a case-by-case basis).

Skip Sections 4 and 5 if the technical assistance you are requesting is listed above and complete Sections 6 and 7 of this fo

Section 6. Other Information Submitted

Identify all materials that are included with this request.

Send both a paper copy of the signed form and all reports and supporting materials, and an electronic copy of the form and all reports, including Environmental Site Assessment Reports, and supporting materials on a compact disk.

Include one copy of any document from any state agency files that you want the Department to review as part of this request. The person submitting this request is responsible for contacting other state agencies to obtain appropriate reports or information.

☐ Phase I Environmental Site Assessment Report - Date: _____

☐ Phase II Environmental Site Assessment Report - Date: _____

☐ Legal Description of Property (required for all liability requests and specialized agreements)
☐ Map of the Property (required for all liability requests and specialized agreements)
Analytical results of the following sampled media: Select all that apply and include date of collection.
☐ Groundwater ☐ Soil ☐ Sediment ☐ Other medium - Describe: _____
Date of Collection: _____
☐ A copy of the closure letter and submittal materials
☐ Draft tax cancellation agreement
☐ Draft agreement for assignment of tax foreclosure judgment
WDNR Fee Check No. 325560
☒ Other report(s) or information - Describe: Land Applied Biosolids Preliminary Assessment / Site Investigation Work Plan

For Property with newly identified discharges of hazardous substances only: Has a notification of a discharge of a hazardous substance been sent to the DNR as required by s. NR 706.05(1)(b), Wis. Adm. Code?

◯ Yes - Date (if known): _____
◯ No

Note: The Notification for Hazardous Substance Discharge (non-emergency) form is available at: dnr.wi.gov/files/PDF/forms/4400/4400-225.pdf.

Section 7. Certification by the Person who completed this form

☐ I am the person submitting this request (requester)
☒ I prepared this request for: Scott Wahl
Requester Name

I certify that I am familiar with the information submitted on this request, and that the information on and included with this request is true, accurate and complete to the best of my knowledge. I also certify I have the legal authority and the applicant's permission to make this request.

Signature

12/8/2021
Date Signed

Senior Environmental Specialist
Title

(312) 575-3732
Telephone Number (include area code)

Section 8. DNR Contacts and Addresses for Request Submittals

Send or deliver one paper copy and one electronic copy on a compact disk of the completed request, supporting materials, and fee to the region where the property is located to the address below. Contact a DNR regional brownfields specialist with any questions about this form or a specific situation involving a contaminated property. For electronic document submittal requirements see: http://dnr.wi.gov/files/PDF/pubs/rr/RR690.pdf.

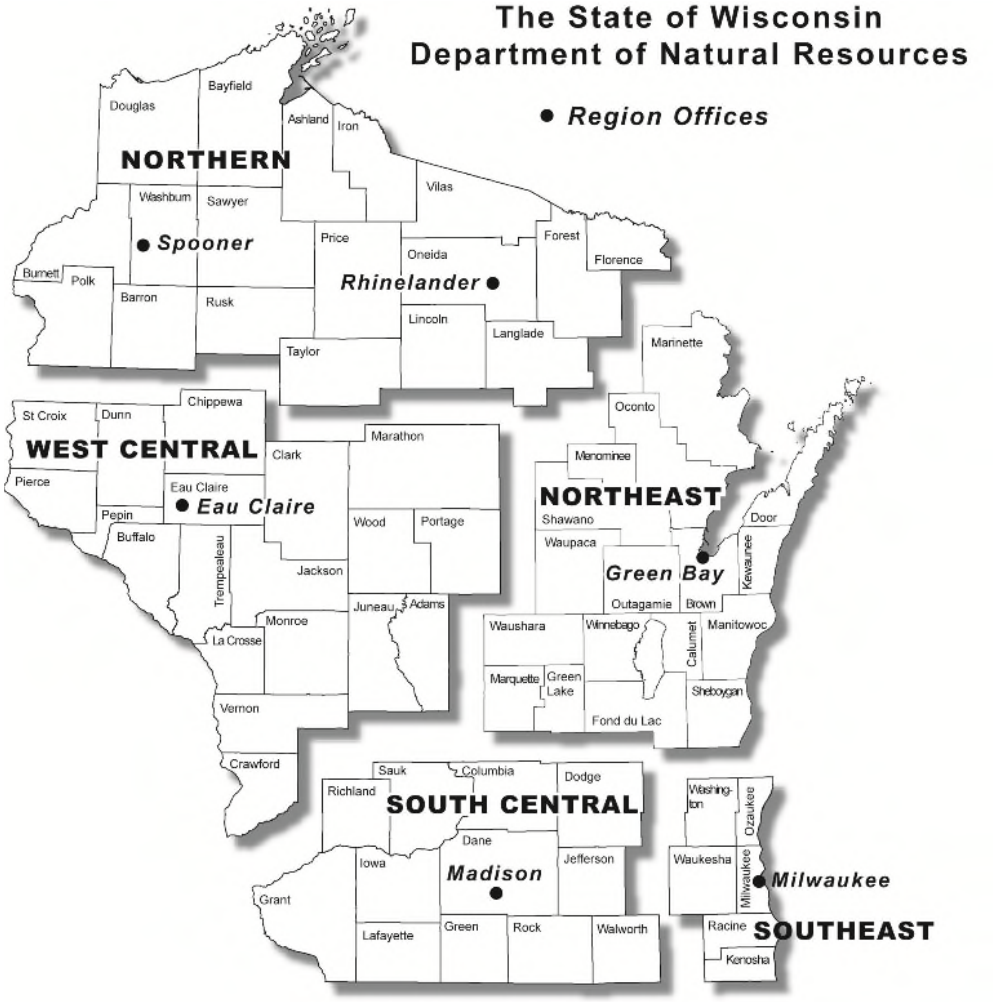
DNR NORTHERN REGION
Attn: RR Program Assistant
Department of Natural Resources
223 E Steinfest Rd Antigo, WI 54409

DNR NORTHEAST REGION
Attn: RR Program Assistant
Department of Natural Resources
2984 Shawano Avenue
Green Bay WI 54313

DNR SOUTH CENTRAL REGION
Attn: RR Program Assistant
Department of Natural Resources
3911 Fish Hatchery Road
Fitchburg WI 53711

DNR SOUTHEAST REGION
Attn: RR Program Assistant
Department of Natural Resources
2300 North Martin Luther King Drive
Milwaukee WI 53212

DNR WEST CENTRAL REGION
Attn: RR Program Assistant
Department of Natural Resources
1300 Clairemont Ave.
Eau Claire WI 54702



Note: These are the Remediation and Redevelopment Program's designated regions. Other DNR program regional boundaries may be different.

DNR Use Only			
Date Received	Date Assigned	BRRTS Activity Code	BRRTS No. (if used)
DNR Reviewer	Comments		
Fee Enclosed? ◯ Yes ◯ No	Fee Amount $	Date Additional Information Requested	Date Requested for DNR Response Letter
Date Approved	Final Determination		

Tyco Fire Product LP
One Stanton Street
Marinette, WI 54143

December 23, 2021

Via Email
alyssa.sellwood@wisconsin.gov

Ms. Alyssa Sellwood
Complex Sites Project Manager
Remediation & Redevelopment Program
Wisconsin Department of Natural Resources
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

Re: Notice of Non-Compliance and DNR Response to Drinking Water Well Sampling Summary Report – Land Applied Biosolids Area
BRRTS # 02-38-583856

Dear Ms. Sellwood:

We received your letters of September 14, 2021 and December 13, 2021 regarding the Land Applied Biosolids Area. In the September 14, 2021 letter, the WDNR requested three items:

1. a sampling plan for additional sampling of potable wells in the area where the City of Marinette publicly owned treatment works ("POTW"), and other parties, including the City of Peshtigo POTW, may have spread biosolids;

2. a proposed long-term sampling plan for these potable wells; and

3. an extensive proposed site investigation, including research to evaluate the potential environmental impacts from the spreading of biosolids by municipalities and other parties in this area.

For the first item, Tyco[1] responded to the request for a potable well sampling plan on November 22, 2021. In this response, Tyco agreed to extend its bottled water service to all of the homes identified in the September Notice, an extensive area encompassing an additional 147 homes

[1] The October 27, 2021 letter is addressed to Johnson Controls, Inc. and Tyco Fire Products LP. Tyco currently owns and operates the Fire Technology Center. Johnson Controls, Inc. is not the owner or operator of the business, is not the parent company of Tyco, and is not a liable party under any applicable law.

while performing investigative activities. On December 13, 2021, the WDNR approved of Tyco's plan to provide bottled water, but requested again the inclusion of testing of the potable wells.

As you know from working with us for several years now, Tyco has proactively addressed a wide range of environmental issues confronting the communities in Marinette and Peshtigo, including the permitted application of biosolids by the Marinette POTW. Tyco's discharge to the POTW was done under a WDNR approved permit, and this discharge was one of many PFAS containing inputs to the POTW. The POTW then, similarly under WDNR approved permits, produced and proceeded to apply the biosolids materials on farm fields. However, while having no authority or responsibility over the development or handling of biosolids, in the cooperative spirit that we have demonstrated throughout this process, Tyco will undertake a site investigation, as you requested. We believe a measured, scientific approach to this issue is warranted as this is a complicated issue. The proposed investigation will begin with a robust desktop study informed by data and information collected and held by WDNR as well as the cities of Marinette and Peshtigo, followed by collection of key physical data and informed by the extensive Michigan statewide study performed in 2020-2021 by the Michigan's Department of Environment, Great Lakes, and Energy (EGLE).

Regarding the December 13, 2021 request to sample potable water, along with the September 14, 2021 request to submit a long-term sampling plan request, Tyco will collect data about the nature and extent of the material spread on the fields, the environmental impact (if any) from those activities, and the source of the materials. During this time, we will provide bottled water to homes out of an abundance of caution to eliminate the potential drinking water exposure pathway. Because the possibility of an exposure pathway will be eliminated, sampling of the potable wells is not warranted at this time. Therefore, Tyco respectfully declines to submit such a long-term sampling plan or to undertake sampling at this time. Again, however, we intend to embark upon the site investigation requested by the WDNR. A high-level description of the work plan is provided below.

As in all of our work, the attached work plan adheres to industry best practice. We will begin with a thorough and comprehensive review to understand the application rates, nature, and PFAS sources that may have been in the biosolids applied by the cities of Marinette and Peshtigo. We have received information from the cities of Marinette and Peshtigo, and some information from the WDNR; however, some documentation we requested has not yet been provided. We understand the WDNR is providing a number of documents for our review, and if additional information is still needed, we will resubmit our Open Records Requests to all three entities and will let the WDNR know if assistance is warranted to obtain the data. Since the previously requested data is needed for the investigation to be properly designed, the information Tyco will re-request any remaining data that is needed before any investigation activities can be undertaken. We look forward to working with you and receiving data you hold relevant and essential to the work. Once we have all the requested data, we will proceed to undertake a thorough desk top analysis followed by selection of a representative number of sites and collection of key soil and groundwater data, informed by the 2021 state-wide in-depth EGLE study, as mentioned above. All of this is described in more detail in the attached work plan. Please note that the Review Fee for this work plan was previously sent to the WDNR (10/26/2021).

Last, the WDNR requested some additional data relating to prior submissions. We will separately provide all the well construction details and associated Site Map that we have for the wells included in the work that was summarized in the report titled *Drinking Water Well Sampling Summary Report – Land Applied Biosolids Area*.

We look forward to getting to work with you on this important matter.

Please feel free to contact me if you have any questions.

Sincerely,

Jeffrey H. Danko
Director – Remediation Programs

Tyco Fire Products LP

Land Applied Biosolids Preliminary Assessment / Site Investigation Work Plan

BRRTS No. 02-38-583856

December 2021

Land Applied Biosolids Preliminary Assessment / Site Investigation Work Plan

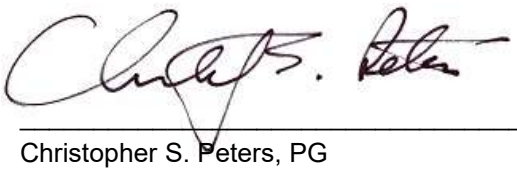
BRRTS No. 02-38-583856

December 23, 2021

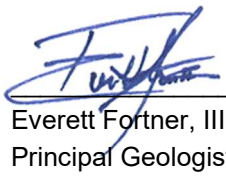
Prepared By:
Arcadis U.S., Inc.
123 North Third Street, Suite 705
Minneapolis
Minnesota 55401
Phone: 612 339 9434

Prepared For:
Tyco Fire Products LP
2700 Industrial Parkway South
Marinette
Wisconsin 54143

Our Ref:
30046162



Christopher S. Peters, PG
Principal Geologist



Everett Fortner, III
Principal Geologist

Tim Molitor
Staff Geologist

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Acronyms and Abbreviations

Arcadis	Arcadis U.S., Inc.
bgs	below ground surface
CSM	conceptual site model
EGLE	Michigan Department of Environment, Great Lakes, and Energy
IDM	investigation-derived materials
NTU	nephelometric turbidity unit
PdC	Prairie du Chien
PFAS	per- and polyfluoroalkyl substances
POTW	publicly owned treatment works
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
Tyco	Tyco Fire Products LP
USEPA	United States Environmental Protection Agency
WDNR	Wisconsin Department of Natural Resources

1 Introduction

On behalf of Tyco Fire Products LP (Tyco), Arcadis U.S., Inc. (Arcadis) has prepared this Land Applied Biosolids Preliminary Assessment / Site Investigation Work Plan (Work Plan) to describe the approach for biosolid permit application data review and initial field data screening of select fields within Marinette and Oconto Counties, Wisconsin. This Work Plan is being submitted pursuant to the Wisconsin Department of Natural Resources (WDNR) letter dated September 14, 2021, requesting submittal of a site investigation work plan that addresses media and migration pathways potentially impacted by land applied biosolids (WDNR 2021).

2 Background

Biosolids from the City of Marinette Publicly Owned Treatment Works (POTW) historically were applied on privately owned farm fields. The City of Marinette applied for approval to conduct these biosolid land application activities, which were permitted by WDNR in accordance with Wisconsin Administrative Code Chapter NR 214. City of Marinette biosolids were last applied to fields in 2017, and biosolids generated since that time have not been land applied. In June 2018, the City of Marinette notified WDNR of elevated per- and polyfluoroalkyl substance (PFAS) concentrations in influent wastewater received by the POTW. In July 2018, the City of Marinette identified PFAS concentrations in biosolids generated by the POTW. Also in July 2018, the City of Marinette tested sanitary sewer lines from five wastewater zones that discharge into its POTW and identified PFAS in all five zones. Tyco only discharges to two of these sanitary sewer zones. In September 2018, WDNR requested that the City of Marinette stop land application of biosolids. Using funding provided by Tyco, in 2019 the City of Marinette dewatered, treated, and disposed of the biosolids generated since the last land application in 2017.

Biosolids from the City of Peshtigo POTW also were applied historically on privately owned farm fields, some of which overlapped fields that received land applied biosolids from the City of Marinette POTW. These biosolid land applications also were permitted by WDNR in accordance with Wisconsin Administrative Code Chapter NR 214. In May 2019, the City of Peshtigo also identified elevated PFAS concentrations in biosolids generated by its POTW. In June 2019, WDNR requested that the City of Peshtigo also stop land application of biosolids. It is Tyco's understanding is that WDNR has since allowed the City of Peshtigo to resume land application of its biosolids.

The Marinette and Peshtigo communities have numerous industrial facilities that are contributing sources of PFAS to the POTWs. As a result, multiple sources may have contributed to the PFAS present in the biosolids historically applied to the privately owned farm fields by the City of Marinette and the City of Peshtigo POTWs. In addition, industries associated with the use of PFAS in their operations directly applied their own biosolids to fields in Marinette and Oconto Counties.

On July 3, 2019, WDNR requested that Tyco evaluate the impact of PFAS-containing land applied biosolids from the City of Marinette on private drinking water wells (WDNR 2019). WDNR identified 61 fields that received biosolids for land application from the City of Marinette between 1996 and 2018, some of which also received biosolids from the City of Peshtigo. The locations of these fields are shown on **Figure 1**.

Following receipt of WDNR correspondence dated February 18, 2020 (WDNR 2020a), in March 2020, Tyco agreed to conduct one-time sampling of certain wells in the vicinity of the 61 fields identified by WDNR where biosolids were land applied under WDNR permits from the City of Marinette. Tyco made multiple contacts to

345 property owners in this area for private well testing and ultimately identified 203 parcels that used well water as a drinking water source. In this initial sampling effort, 183 wells were sampled (Arcadis 2020). Following completion of the sampling program, WDNR and other private residents requested additional potable well sampling. Five additional owners requested sampling of their wells, all of which were sampled in 2021. In total, Tyco has sampled 188 potable wells in this study area to date. Of the 345 property owners contacted, 11 owners refused access to their property and nine were non-responsive after initially expressing interest in having their well sampled. Tyco offered bottled water to users of 27 of these wells that had potable well analytical results greater than the Wisconsin Department of Health Services recommended groundwater enforcement standard.

After receipt of WDNR correspondence dated September 14, 2021 (WDNR 2021), Tyco proposed to expand bottled water service to any property within a revised 1,200-foot buffer area with a potable drinking water well that was not sampled during the one-time sampling event (Tyco 2021). This provides a broadly applicable protective measure to residents of this expanded area while Tyco conducts further site investigation activities in coordination with WDNR.

3 Regional Geology

This discussion of geology is based on United States Geological Survey geological mapping (Oakes and Hamilton 1973). The geology in the Marinette County area where documented biosolid land application has occurred is mapped by the United States Geological Survey as stratified glacial outwash deposits and unstratified glacial ground moraine overlying early Paleozoic sedimentary bedrock. Bedrock found in this region includes the late Ordovician dolomite and middle Ordovician sandstone (central sampling region), early Ordovician dolomite (Lake Noquebay sampling region), and Cambrian sandstone (western sampling region) (Oakes and Hamilton 1973). The geologic regions are illustrated on **Figure 2**.

The majority of the region (central and Lake Noquebay) consists of unstratified ground moraine till that is typically very dense and a poorly sorted mixture of clay, silt, sand, and gravel above bedrock. The western region is overlain by stratified outwash that is well-sorted soil consisting mainly of sand and gravel with some silts and clay. The till has low permeability and is a poor source of groundwater, while the sandy outwash has high permeability and provides a better source of groundwater.

3.1 Central Region

The central region of the documented biosolid land applications (immediately west of the City of Marinette, near Porterfield) has more shallow overburden soil deposits present compared to the Lake Noquebay and western regions. The overlying soils are generally clay-rich glacial tills that are, on average, less than 50 feet thick. The bedrock that underlies the clay tills in the central region is the Sinnipee Group (Galena, Decorah, and Platteville formations). The area also crosses a thin bedrock unit, the Ancel Group, of the St. Peter Sandstone. The Prairie du Chien (PdC) Group is found in this region below the Sinnipee and Ancel Groups. Based on available well logs, potable wells in the central region have an average depth range from 60 to 262 feet below ground surface (bgs) and are commonly screened in the PdC aquifer.

3.2 Lake Noquebay Region

This region is situated immediately south of Lake Noquebay, and also incorporates an area to the north and northeast where biosolid land applications have been documented. The overlying soils are generally clay-based glacial tills that are, on average, less than 50 feet thick. The majority of this area is underlain by the shallower bedrock, the PdC Group, followed by Cambrian bedrock (the Jordan sandstone). Based on available well logs, potable wells in the Lake Noquebay region have an average depth range from 84 to 138 feet bgs and are commonly screened in the Jordan aquifer.

3.3 Western Region

This region is located in the far-western and southwestern corner of Marinette County, as well as in the eastern and northeastern portion of Oconto County. The majority of the overlying soils in this region are composed of glacial outwash, mainly sands, and the soils are noted at greater thicknesses (up to and greater than 200 feet bgs) compared to the other two regions. However, regionally, the glacial units often are interbedded with finer-grained sequences of fine sand, silt, clay, or a combination thereof to include glacial till units. The major bedrock unit in this area is Cambrian bedrock (the Jordan sandstone). This western region has a lower density of land applied biosolid fields compared to the other two regions. Based on available well logs, potable wells in the western region have an average depth range from 48 to 235 feet bgs and are commonly screened in either the unconsolidated glacial outwash or the Jordan aquifer.

4 Approach

The Work Plan process, as outlined in this approach, follows the United States Environmental Protection Agency (USEPA) preliminary site assessment/site investigation guidance (USEPA 1991 and 1992). This approach includes a data gathering portion (Phase 1 Desktop Document Review) and a site investigation (Phase 2 Initial Field Data Screening).

The data gathering portion of this approach includes a review of all available information to gain an understanding of the potential impacts to the 61 fields and the sources of these impacts, as well as any site-specific and regional hydrogeologic and/or geologic data. Tyco submitted multiple Open Records requests (February 2019 and March 2021) and information requests (October 15, 2021 and October 20, 2021) for data necessary to complete the investigation outlined in this Work Plan. The Open Records requests were denied. Tyco will resubmit those requests. Once Tyco receives the information requested, the site investigation can advance. The site investigation will be conducted to evaluate which substances, if any, are present at selected field sites and potential environmental release pathways. This phased, methodical approach complies with Wisconsin Administrative Code NR 716 requirements and permits the collection and analysis of foundational data necessary for further site investigation activities that may be warranted.

The work proposed in the two phases is described below:

- Phase 1 – Desktop Document Review
  - Receipt of data and documentation requested in Open Records and other requests of the WDNR. That assumes critical data are provided to effectively conduct an appropriate review.
  - Review available biosolid information, including potential sources, land application data, and applied volumes in Marinette and Oconto Counties, as provided by WDNR and the cities of Marinette and

Peshtigo. Tyco's ability to undertake the desktop review and other actions proposed in Phase 2 will be based on the data that is provided by WDNR.
  - Review available potable well construction data.
  - Develop individual field conceptual site models (CSMs).
  - Analyze biosolid land application data to identify criteria for selecting fields for Phase 2 investigation.
- Phase 2 – Initial Field Data Screening
  - Complete an initial field investigations at up to six selected fields and one background field that provide a statistically representative data set of the 61 fields in Marinette and Oconto Counties based on Phase 1 results.
    - Sampling will include soil and groundwater.
    - Data derived from sampling will be used to identify soil conditions and groundwater flow direction, which will allow for a more in-depth evaluation of local conditions, hydrogeology, and potential biosolid impacts, if any.
  - Update the respective individual field CSMs with initial field data and summarize findings in a report.

The summarized report findings are expected to provide a representative data set for further evaluation of potential receptors and potential expanded field investigations.

Phase 1 and Phase 2 activities are discussed in more detail in the following sections.

5 Phase 1 Desktop Document Review

A desktop review of documentation relating to the sources, characteristics, and volumes of the biosolids applied in Marinette and Oconto Counties will be completed to define the sources, application volume, and field locations of land applied biosolids within both counties. This phase includes review of the following documents for the fields in Marinette or Oconto County that received biosolids from either the Marinette POTW the Peshtigo POTW, or from any other source:

1. Land application approval forms submitted to WDNR pursuant to the discharge permits for the City of Marinette and the City of Peshtigo.
2. Land application approval forms submitted for landspreading under general permits WI-0057665, WI-0057657, and WI-0055867.
3. Annual and semiannual land application reports submitted to WDNR pursuant to the discharge permits for the City of Marinette and the City of Peshtigo, or by any other party, under general permits WI-0057665, WI-0057657, and WI-0055867.
4. Field forms or other documentation of dates and volumes of application maintained by the City of Marinette and the City of Peshtigo, or by any other party, under general permits WI-0057665, WI-0057657, and WI-0055867.
5. Contractor records to support the data submitted in the field forms maintained by the City of Marinette and the City of Peshtigo.
6. Contracts with landspreading contractors entered into by the City of Marinette or the City of Peshtigo.
7. Characteristic reports submitted to WDNR pursuant to the discharge permits for the City of Marinette and the City of Peshtigo, or by any other party, under general permits WI-0057665, WI-0057657, and WI-0055867.

8. Application forms filed with the City of Marinette or the City of Peshtigo, including Significant Industrial User application forms.
9. WDNR correspondence with the City of Marinette or the City of Peshtigo POTW, or with any Significant Industrial User, regarding landspreading activities in Marinette County, including any approval or disapproval of activity, or any comments, questions, or concerns regarding landspreading activities.
10. Records, including inspection reports and enforcement documents, containing sampling data for industrial dischargers to the City of Marinette and the City of Peshtigo.

Some of this information has already been provided by WDNR, the City of Marinette, or the City of Peshtigo. Tyco will follow up with these entities with respect to information that has not yet been made available, and may request WDNR's assistance with the document collection. Tyco's ability to complete an investigation at appropriate locations is dependent on critical data that can only be provided by WDNR, as described above.

In addition, a field owner questionnaire will be mailed to current owners of the 61 fields identified by WDNR to have historically received biosolids from the City of Marinette POTW. This questionnaire will be used to obtain additional details for each property. The information obtained from the questionnaire will also facilitate engagement for future potential property access.

Obtaining information from the document review and questionnaire responses is a critical first step toward informing individual field CSMs that will be used for the Phase 2 screening and field selection. The intent of the screening is to identify representative fields for initial evaluation. The information will be compared to other publicly available resources (property ownership, lot information, use code, well records, etc.) as well as previous data gathered on behalf of Tyco during previous evaluation work. Following the Phase 1 desktop document review, a status update report outlining the proposed path forward based on the information derived during Phase 1 will be provided to WDNR.

5.1 Government Documents and Data

In February 2020, Tyco submitted Open Records requests to the cities of Marinette and Peshtigo requesting the names of all parties that discharged to the POTWs and copies of sampling reports and other data. Both have since complied with the Open Records laws by providing documentation of other potential source contributors. Further follow-up to obtain additional data will occur as part of Phase 1 of this proposed Work Plan.

In February 2019, Tyco submitted an Open Records request to WDNR requesting various types of documents related to biosolid landspreading, to include documents related to any study by WDNR of the sanitary sewers in the City of Marinette and any information related to investigation of other potential sources in the City of Marinette. WDNR produced certain reports on biosolid application and records related to the City of Marinette's Wisconsin Pollutant Discharge Elimination System (WPDES) permit renewals. Information in response to these requests remains unproduced, including, for example, (1) permits and related documents for landspreading and (2) any WDNR investigation into other potential sources of biosolids. In March 2021, Tyco requested documentation and data regarding PFAS impacts within a 10-mile radius of Marinette or Peshtigo, including to wildlife, private wells, surface water, and air. To date, WDNR has not provided the requested documents or data.

The data and information requested are foundational to the desktop review being conducted in Phase 1; therefore, Tyco anticipates that WDNR will produce these remaining documents without necessity of further requests and as quickly as feasible. Tyco will provide resources to WDNR as necessary to help accomplish this

important step. Nevertheless, out of an abundance of caution, Tyco submitted information requests to WDNR on October 15, 2021, later updated on October 20, 2021, for available biosolid land application permit information and biosolid land application records for eight townships in Marinette and Oconto Counties. These townships (Beaver, Brazeau, Grover, Lake, Little River, Middle Inlet, Porterfield, and Wagner) have historical documentation of biosolid land application from the City of Marinette POTW and/or the City of Peshtigo POTW. These requests are also still pending, as not all records have been received.

Once received, the above government documents and data will be evaluated along with existing data and documents Tyco has collected in the course of its extensive site investigation activities throughout the Marinette area. Biosolid land application information, if made available to Tyco by WDNR, will be compiled into a table showing the source, frequency, amount, location, and application method of biosolid land application. Other relevant information will similarly be analyzed and compiled for use in informing the strategy for Phase 2 of the proposed Work Plan.

5.2 Field Owner Questionnaire

In preparation for field investigation work and based on the Phase 1 data review, the 61 field property owners will be provided with a questionnaire. The questionnaire will be designed to inquire about current and historical operations on the property (and primary residence), over at least the past 25 years, and may include the following:

- Field operations:
  - Tilling.
  - Fertilizers.
  - Manure and/or biosolid application.
  - Pesticides/herbicides.
  - Crops and cover crops.
- Nutrient management plans.
- Animal husbandry and management practices.
- General practices (equipment maintenance, chemical storage/management, documented fires, spills, etc.).
- Septic and drain field tile installation.
- Irrigation or other groundwater well installation and associated maintenance/use.

Questionnaires will be provided to the property owners with a request for return within 30 days of receipt. If questionnaires are not returned within the requested time frame, a follow-up communication will be conducted by telephone or a residence visit to confirm that the property owner has received the questionnaire and to determine the intent to reply or not reply. This communication effort may require assistance from WDNR.

5.3 Preliminary Individual Conceptual Site Model Development

Review of the permit application and biosolid land application records from the Open Records request, once received, questionnaire responses, and available public information sources will be used to construct a CSM for each of the 61 fields identified by WDNR in 2019 (WDNR 2019). The individual CSMs will include the following, if available:

- Location and property data.
- Biosolid mass loading assessment and application method.
- Source assessment.
- Proximal potable well sampling results.
- Summary of shallow geology from soil surveys or regional geologic data.

5.4 Initial Field Selection

Following the permit application data review, questionnaire review, and individual CSM development, a thorough assessment of available field information will be completed to select up to six fields to implement the Phase 2 initial field data screening. The assessment will include identifying fields with a range of application volume, sources, and proximal potable well data. For example, two ends of the spectrum may be (1) a field with either a small biosolid application volume or low to non-detected PFAS concentrations in potable wells, or (2) a field with either a large application volume or potable wells with relatively elevated PFAS concentrations. In addition to the fields selected for sampling, at least one background field will be included. The background field will be a field with no known biosolid land application in the vicinity. Background field selection will consider information from the preliminary CSMs. The objective of collecting a range of data is to evaluate potential correlations between biosolid application volumes and sources, PFAS concentrations in groundwater, and PFAS concentrations in soil. The presence or absence of correlation will facilitate potential future evaluations and/or data collection. The assessment selection criteria may change based on CSM development. The selected fields may change based on property owner questionnaire results and ability to obtain access to the field for sampling.

6 Phase 2 Initial Field Data Screening

The field investigation includes collecting shallow soil samples, shallow groundwater samples, and shallow groundwater level measurements at temporary wells. Soil and groundwater samples will be collected to evaluate the presence of PFAS in these media. Groundwater elevation data will be collected to evaluate shallow hydrogeology. The field investigation scope for media sampling, lithology observations, and groundwater flow direction determination follows the procedure used in other biosolid PFAS land application investigations and studies completed by the Michigan Department of Environment, Great Lakes, and Energy (EGLE 2021). Best practices and methodology for the field data collection are provided with the Arcadis Technical Guidance Instructions (**Appendix A**). Analyte selection and laboratory details are discussed in Section 8.2. Note that the information gathered from the field property owner questionnaires will provide guidance for Phase 2 activities.

6.1 Pre-Field Activities

Pre-field activities will be performed to obtain additional necessary information and facilitate property access. Preparation activities will include addressing health and safety and quality assurance considerations, securing access agreements, and conducting utility clearance.

6.1.1 Site Health and Safety Plan

As required by the Occupational Safety and Health Administration 29 Code of Federal Regulations 1910.120 (Hazardous Waste Operations and Emergency Responses), Arcadis will update the site-specific health and safety plan to address health and safety issues related to the anticipated field activities.

6.1.2 Quality Assurance Project Plan

The current version of the Tyco PFAS Revised Quality Assurance Project Plan (QAPP; Arcadis 2021) will be used. It is anticipated that the soil and groundwater sampling proposed for Phase 2 (as described in Section 7) is covered in the Revised QAPP. However, if necessary, an addendum to the Revised QAPP will be prepared to address additional methods or procedures and will be submitted for review prior to the Phase 2 initial field data screening.

6.1.3 Follow-up Questionnaire, Access, and Permitting

The selected field property owners will be provided with a second follow-up questionnaire and an access agreement explaining the field investigation scope of work, duration of work, and a tentative schedule. The access agreement will also include language to encompass the following assumptions:

- To minimize any disruption to a property or that property owner's livelihood, investigation activities will be scheduled to minimize disruption during the growing/cultivating seasons.
- Arcadis and subcontractors will be granted permission for access for the duration of the work.
- Properties will be restored to pre-investigation conditions.
- Investigation-derived materials (e.g., purge water) will be managed properly prior to disposal.

Additional access agreements may be needed if access to adjacent private property(ies) is required to access the respective selected field or if proposed sample locations fall outside of property boundaries. Access approval assistance from WDNR may be necessary. As noted above, alternate field selection may be necessary if access agreements cannot be obtained.

The required permits for borings and temporary wells will be submitted to WDNR prior to beginning intrusive work.

6.1.4 Utility Location

Utility location and clearance activities will be completed using multiple lines of evidence, including:

- Questionnaire information that includes locations of utilities such as drain tiles, if present.
- Public utility notification (Diggers Hotline) at least 48/72 hours in advance.
- Site inspection (following the Arcadis Utilities and Structures Clearance policy).
- Private utility clearance by a contractor using electromagnetic detector and ground-penetrating radar.
- Soft dig clearance (e.g., hand augering) to at least 5 feet bgs.

Boring locations will be marked using stakes, and representative utility clearance hand auger soil samples will be collected as described in Section 7.1.

6.2 Investigation Borings

Up to five borings will be installed using a direct push drill rig at each of the selected fields for the purposes of sampling shallow soil and first encountered groundwater, and collecting groundwater elevation data. Borings will be advanced to a depth of approximately 30 feet bgs. The initial boring will be placed near the center of the respective field contingent on logistics, owner communication, and/or utilities. The initial boring observations will be used to guide the installation depth of a temporary monitoring well at this location and will be used for advancement of soil borings, soil sample collection, and construction of monitoring wells at up to four field perimeter locations. The monitoring wells will be temporary to obtain representative groundwater elevations and samples for the first encountered groundwater zone. If groundwater does not appear to be present at a depth of approximately 30 feet bgs, the boring will be extended an additional 10 feet and the monitoring well installed for verification. First encountered groundwater may be discontinuous in nature, or another observed variation may be present in the shallow soils. This variation may result in a lack of groundwater in some of the temporary monitoring wells.

6.2.1 Soil Boring Descriptions and Sampling

Collected cores from the direct push drill rig fitted with a dual sleeve core sampler will be continuously logged. Down-hole tooling or equipment will be decontaminated prior to the start of drilling and between use at each borehole location. The color, grain-size lithology, sorting, moisture content, and other physical characteristics observed will be noted along with photoionization detector readings for every foot along the length of the sample. Field staff will document each core collected using a camera, measuring tape, and dry erase board.

At each of the five borings, a composite shallow sample that represents the uppermost soil of use from the utility clearance hand auger boring will be collected from 0 to 2 feet bgs. It should be noted that the fields likely will be plowed prior to sampling. However, if a location has vegetation present, the sample will be collected at a depth below the root system (assumed to be at 1 foot bgs), thereby altering the sample depth to be 1 to 3 feet bgs. The composite sample will be composed of soil from every 6-inch interval and homogenized prior to packaging. Additional sample volume may be collected and held at the laboratory to enable contingent analysis for the boring based on potential visual impact observations. A soil sample from 1 to 2 feet above the observed soil saturation (groundwater table) also will be collected.

6.2.2 Temporary Monitoring Well Installation

Following the advancement of each of the five soil borings, a temporary 1-inch-diameter monitoring well will be installed at each boring. The screened intervals will be guided by the initial boring and field observations (geology and depth to groundwater, if any). If saturated conditions are not observed during drilling, the respective boring will include well construction at a depth comparable to the other wells or observed boring saturation depth, and the well will be allowed to set overnight for potential groundwater accumulation.

Each monitoring well will be constructed as follows:

- Casing and screen will be 1-inch-diameter Schedule 40 polyvinyl chloride (PVC).
- Screens will be 10-slot and lengths will range from a minimum of 5 feet to a maximum of 10 feet.

- The well will consist of a primary filter pack appropriately sized for a 10-slot Schedule 40 PVC well screen extending 1 foot above the top of the screen, followed by a 1-foot finer-grained secondary filter pack, to have a minimum of 2 feet of filter pack material above the top of the screen.
- Above the finer-grained secondary filter pack, hydrated bentonite chips will be installed to properly seal the screen interval to grade.
- The temporary monitoring wells will be completed with risers extending approximately 3 feet above grade.

6.2.3 Temporary Monitoring Well Development

The temporary monitoring wells will be developed by surging and pumping following installation. During pumping, water quality parameters including pH, specific conductance, temperature, and turbidity will be monitored at an interval of every three to five minutes for evaluation of stabilization. If the turbidity is below 10 nephelometric turbidity units (NTUs) and other water quality parameters have stabilized, development will be deemed complete. If the turbidity is not stable and/or a sustainable flow rate cannot be maintained, additional rounds of development will be completed. Parameter stabilization will include pH ± 0.1, specific conductance ± 3%, temperature ± 1 degree Celsius, and turbidity ± 10% (when turbidity is greater than 10 NTUs).

If the well goes dry during development activities, surging and pumping will cease and the time that the well went dry will be noted. After the well is allowed to recover, surging and pumping will resume after sufficient groundwater has recharged in the well.

6.2.4 Groundwater Sampling and Water Levels

Prior to sampling, a comprehensive groundwater gauging event will be performed at each field. Water level and total depth measurements will be collected from the top of casing using an electronic water level probe attached to a tape graduated in hundredths of a foot.

After the comprehensive gauging event is complete, wells will be sampled via low-flow methodology. Field water quality parameters (dissolved oxygen, specific conductance, pH, temperature, oxidation-reduction potential, and turbidity) will be measured using a calibrated water quality meter and turbidity meter (or similar meter). If the monitoring is unable to sustain a flow rate of at least 100 milliliters per minute, the pumping rates will be reduced 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 not adequate to meet the above requirement, alternate purging techniques may be used, which will vary based on the well construction and screen position. In the case of a well pumped dry, sampling will commence as soon as the volume in the well has recovered sufficiently to permit collection of samples.

6.2.5 Abandonment

The temporary monitoring wells will be abandoned by using the drill rig to pull and/or over-drill the wells. Soils will be allowed to collapse, and the remaining borehole will be sealed with hydrated bentonite pellets to 2 feet bgs and then covered by native soil.

6.3 Surveying

A Wisconsin licensed land surveyor will survey the boring locations and monitoring wells. Vertical elevations and horizontal coordinates will be collected using North American Vertical Datum of 1988 (NAVD 88) and North American Datum of 1983 (NAD 83), respectively.

6.4 Investigation-Derived Materials

All investigation-derived materials (IDM) generated during field activities will be managed appropriately. A minimal volume of water is anticipated to be generated at each proposed field; as such, water IDM will be transported to the Fire Technology Center in Marinette, Wisconsin to be stored temporarily in clean, labeled United States Department of Transportation-approved 55-gallon drums pending waste characterization and disposal. Containerized waste will be disposed of either through an approved treatment facility or at an approved disposal facility. All soil IDM extracted during drilling activities will be thin-spread at the field in which it was removed.

7 Quality Assurance and Quality Control

The collection of samples as part of Phase 2 initial field data screening activities will follow procedures outlined in the Revised QAPP submitted to WDNR on March 16, 2021 (Arcadis 2021).

7.1 Special Considerations for PFAS Sampling

The detection of PFAS compounds at very low concentrations can be influenced by common PFAS-containing materials that may be present at a sampling location. To minimize the potential for cross-contamination, the sampling materials (i.e., tubing), decontamination procedures, and clothing and personal care products used by sampling personnel will be subject to specific requirements. The best practices and procedures that will be followed during investigation activities are outlined in the Revised QAPP (Arcadis 2021).

Quality assurance samples are specified in the Revised QAPP for each type of sampled media. Sampling for PFAS compounds will include the submission of one laboratory-supplied field reagent blank per day to detect the presence of ambient PFAS that may influence sampling results. Water that is PFAS-free will be used for the field reagent blank sample and will be brought to the field in a laboratory-supplied bottle. Field staff will transfer the laboratory-supplied PFAS-free water into an empty sample bottle. This field reagent blank will be placed in the same cooler as other samples intended for PFAS analyses.

All equipment will be decontaminated with PFAS-free water between use at each sampling location. Only Alconox, Liquinox, or methanol will be used as decontamination materials. To assess the adequacy of the decontamination process, an equipment rinsate blank will be collected every 20 samples or per day, whichever is more frequent. To prepare a rinsate blank, a sample of PFAS-free water will be poured over or through decontaminated field equipment before collection of environmental samples.

7.2 Laboratory Methods and Analysis

Details regarding the analytical methods to be used for each media are provided in the Revised QAPP (Arcadis 2021) and summarized in Table 1. Analysis for PFAS will include the 36 PFAS analytes required by WDNR per correspondence dated May 27, 2020 (WDNR 2020b).

Table 1. Laboratory Methods and Quality Assurance/Quality Control Frequency

Matrix	Parameter	Laboratory Method	Matrix Spike/ Matrix Spike Duplicate Frequency	Field Duplicate Frequency
Solids, Water	PFAS	Modified USEPA 537 (36 compounds)	1/20	1/10

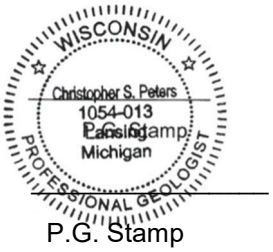
Other methods may be added to the sampling schedule based on the desktop review and results of property owner questionnaires.

8 Project Schedule and Reporting

Scheduling for the work described in this Work Plan will begin after Tyco receives approval from WDNR. Following approval, the Phase 1 desktop review will begin after the necessary information is obtained from WDNR and cities of Marinette and Peshtigo. Attempts will be made to complete the Phase 2 initial field data screening in the third to fourth quarter of 2022 pending access from each property owner, permit approval by any other necessary entities, and subcontractor availability. Within 60 days of completion of the site investigation, a report documenting field activities and investigation findings will be submitted to WDNR.

9 NR 712 Certification

I, Christopher S. Peters, hereby certify that I am a hydrogeologist as that term is defined in s. NR 712.03 (1), Wis. Adm. Code, am registered in accordance with the requirements of ch. GHSS 2, Wis. Adm. Code, or licensed in accordance with the requirements of ch. GHSS 3, Wis. Adm. Code, and that, to the best of my knowledge, all of the information contained in this document is correct and the document was prepared in compliance with the applicable requirements in chs. NR 700 to 726 Wis. Adm. Code.



WI PG 1054-013

Signature, title and P.G. number

P.G. Stamp

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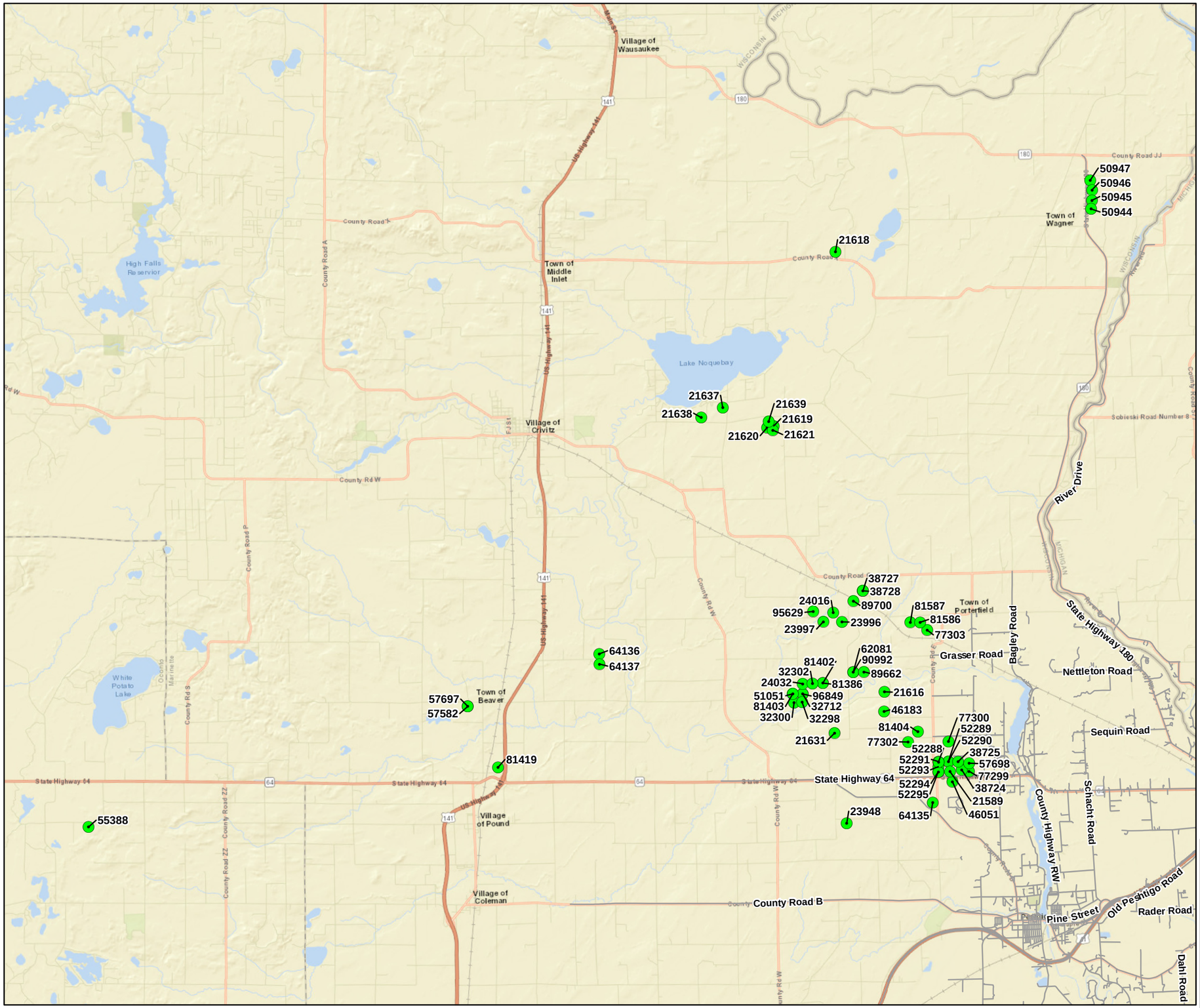
Figures



LEGEND:

- LAND APPLICATION SITE

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

0 1 2 Miles

GRAPHIC SCALE IN MILES

LAND APPLIED BIOSOLIDS IN
MARINETTE AND OCONTO COUNTIES

LAND APPLIED BIOSOLIDS SITE LOCATION

ARCADIS

FIGURE
1

City: Minneapolis/Citrix Div/Group: IMDVC Created By: Last Saved By: kkelley
TYCO Marinette, WI
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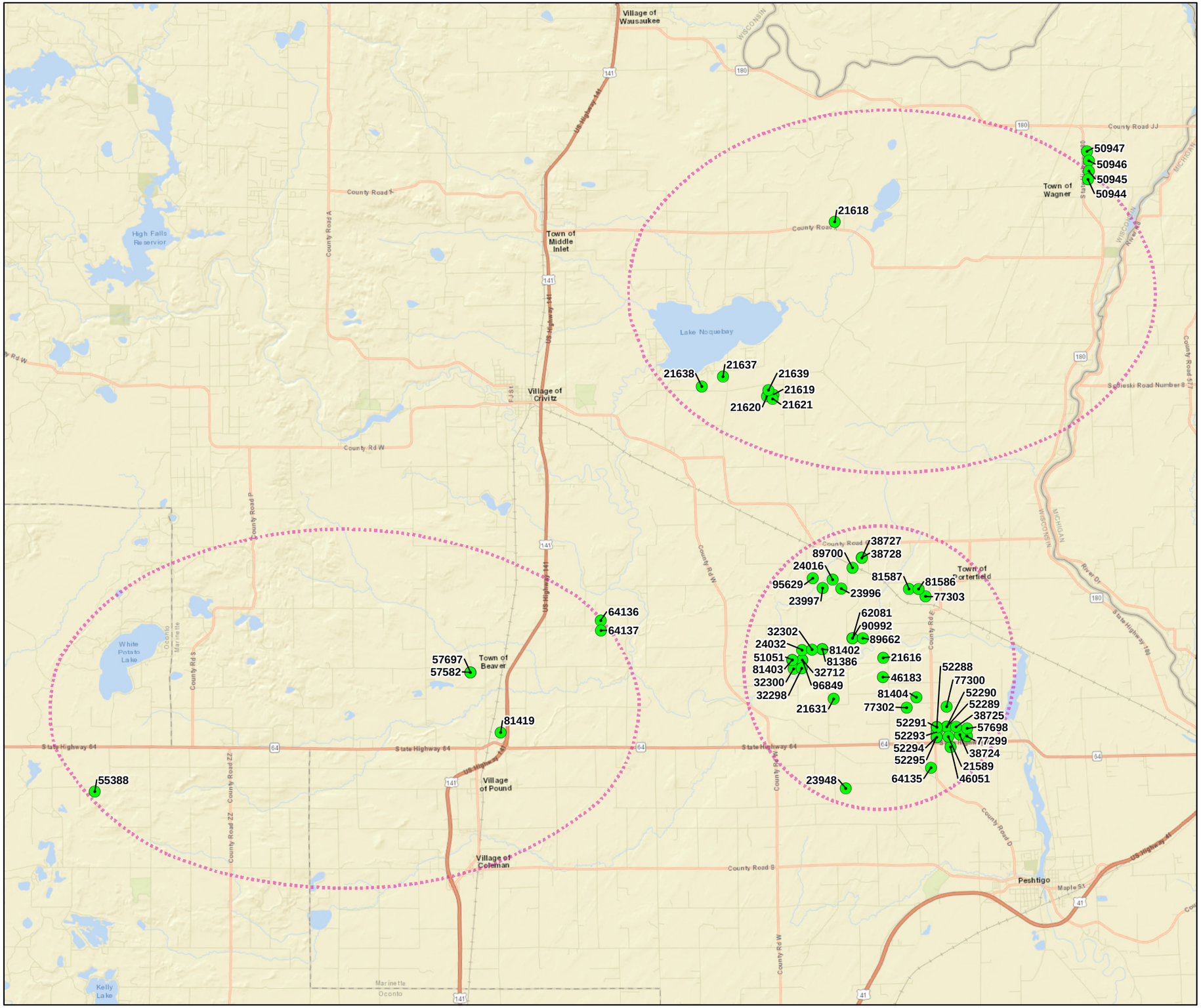

LEGEND:

- LAND APPLICATION SITE
- GEOLOGIC REGIONS

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

0 1 2 Miles

GRAPHIC SCALE IN MILES

LAND APPLIED BIOSOLIDS IN
MARINETTE AND OCONTO COUNTIES

GEOLOGIC REGIONS IN LAND APPLIED BIOSOLIDS AREA

ARCADIS

FIGURE
2

City: Minneapolis/Citrix Div/Group: IMDVC Created By: Last Saved By: kkelley
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Appendix A

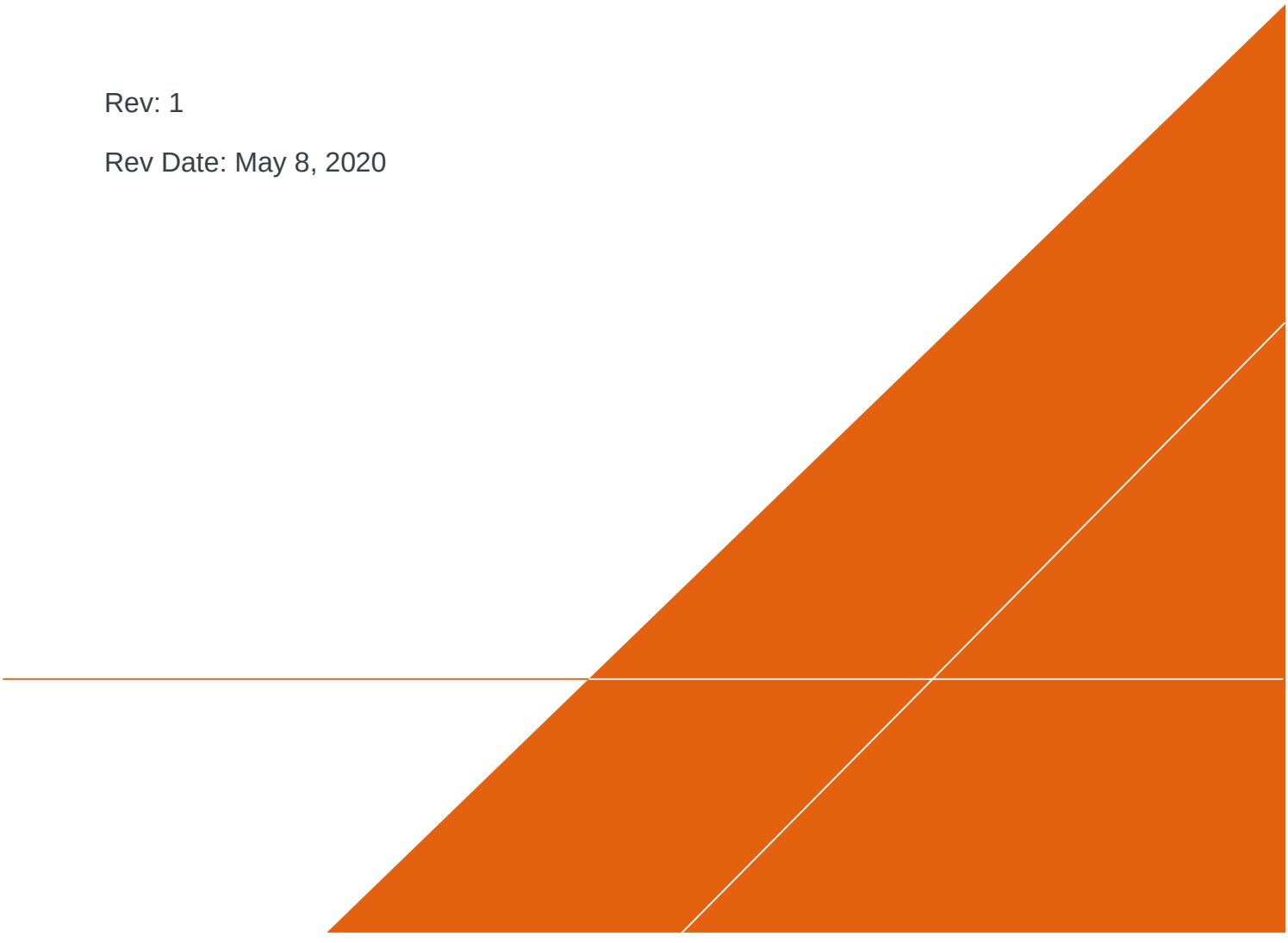
Standard Operating Procedures

ARCADIS Design & Consultancy for natural and built assets

TGI – GROUNDWATER AND SOIL SAMPLING EQUIPMENT DECONTAMINATION

Rev: 1

Rev Date: May 8, 2020



VERSION CONTROL

Revision No	Revision Date	Page No(s)	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

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APPROVAL SIGNATURES

Prepared by:  Date: 02/23/2017

Derrick Maurer

Technical Expert Reviewed by:  Date: May 8, 2020

Marc Killingstad (Technical Expert)

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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

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 includes: 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

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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.

3 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 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 health and safety plan (HASP) and other documents will identify other training requirements or access control requirements.

4 EQUIPMENT LIST

The equipment required for equipment decontamination is presented below:

- Health and safety equipment, including appropriate PPE, as required in the site Health and Safety Plan (HASP)
- Deionized water that meets that 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 VOCs, 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
- 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

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- (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

5 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 rinsate 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.

6 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.

7 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 should be handled by workers wearing clean gloves, properly changed to prevent cross-contamination.

Cleaning Sampling Equipment

1. Wash the equipment/pump with potable water.

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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 should not be used at sites where that may be a constituent of concern (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 should 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 should be placed on or in clean polyethylene sheeting to avoid contact with the ground surface.

8 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).

9 DATA RECORDING AND MANAGEMENT

Equipment cleaning and decontamination will be noted in the field notebook for 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.

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10 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 of the tools needed to collect a specific sample.

11 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.

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TGI - INVESTIGATION-DERIVED WASTE HANDLING AND STORAGE

Rev #: 1

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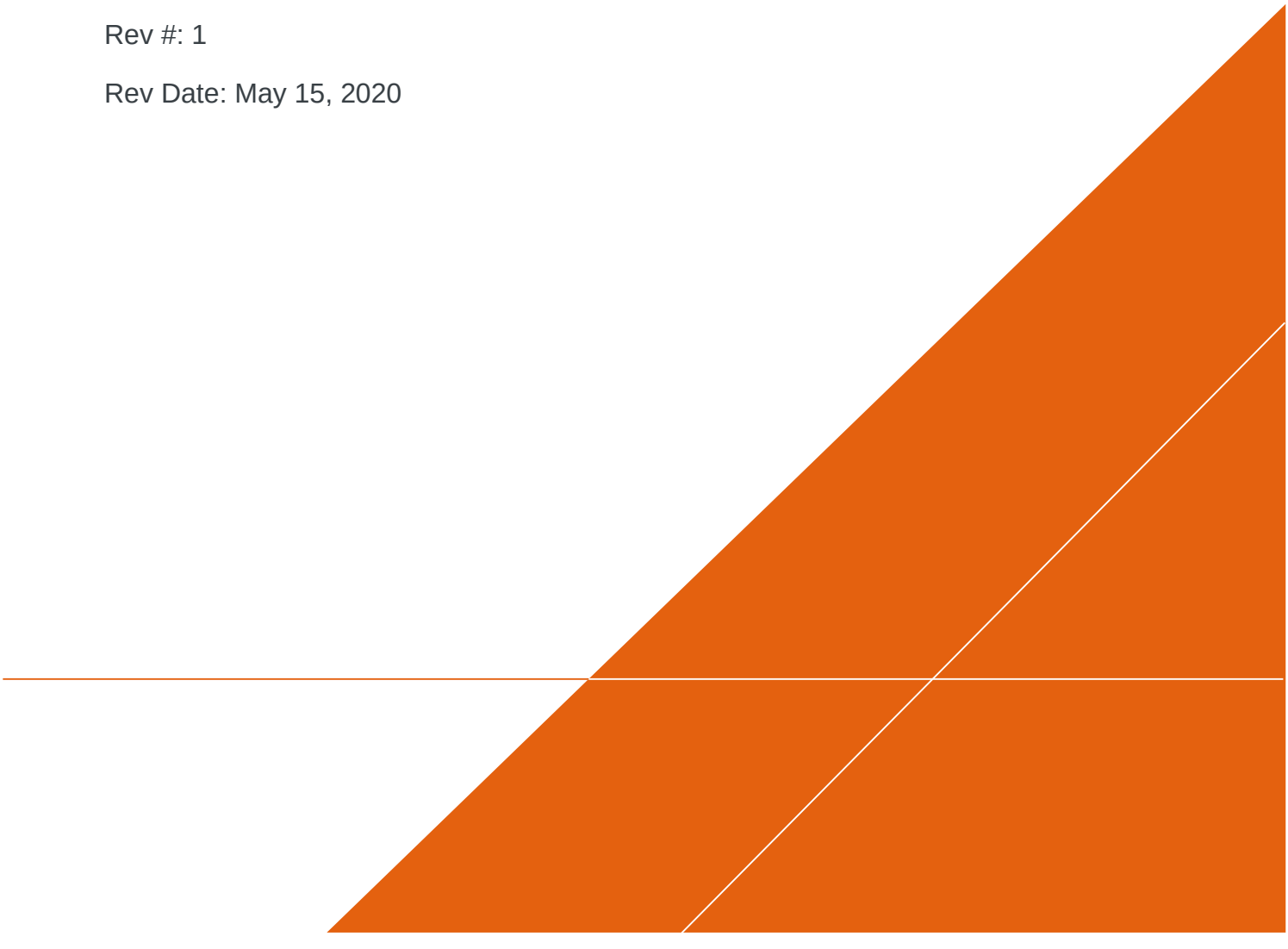

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	February 23, 2017	ALL	Conversion from SOP to TGI	Ryan Mattson / Peter Frederick
1	May 15, 2020	ALL	Updated to reflect regulatory changes	

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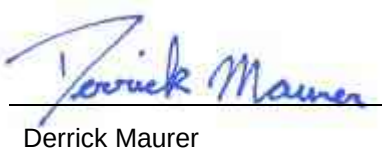
APPROVAL SIGNATURES

Prepared by:		02/23/2017
	Derrick Maurer	Date:
Technical Expert Reviewed by:		05/15/2020
	Ryan Mattson (Technical Expert)	Date:

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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 objective of this Technical Guidance Instruction (TGI) is to describe the procedures to manage investigation-derived wastes (IDW), both hazardous and nonhazardous, generated during site activities, which may include, but are not limited to: drilling, trenching/excavation, construction, demolition, monitoring well sampling, soil sampling, decontamination and remediation. For the purposes of this TGI, IDW is considered to be discarded materials which are defined as solid waste by United States Environmental Protection Agency (EPA) standard 40 CFR § 261.2 (which may include liquids, solids, or sludges). IDW may include soil, groundwater, drilling fluids, decontamination liquids, as well as contaminated personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials. Hazardous or uncharacterized IDW will be collected and staged at the point of generation. Quantities small enough to be containerized in 55-gallon drums will be taken to a designated temporary onsite storage area (discussed in further detail under Drum Storage) pending characterization and disposal. IDW materials will be characterized using process knowledge and appropriate laboratory analyses to determine the waste classification and evaluate proper safe handling and disposal methods.

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This TGI describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures necessary for proper handling and storage of IDW up to the time it is properly transported from the project site and disposed. The procedures included in this TGI for handling and temporary storage of IDW are based on the EPA's guidance document *Guide to Management of Investigation Derived Wastes* (USEPA, 1992). IDW is assumed to be contaminated with the site constituents of concern (COCs) until analytical evidence indicates otherwise. IDW will be managed to ensure the protection of human health and the environment and will comply with all applicable or relevant and appropriate requirements (ARAR). Although not comprehensive, the following laws and regulations on Hazardous Waste Management should be considered as potential ARAR. It is the Arcadis Certified Project Manager (CPM) and/or designated Technical Expert to determine which laws and regulations, at all levels of government, are applicable to each project site and activity falling under this TGI.

Federal Laws and Regulations

- Resource Conservation and Recovery Act (RCRA) 42 USC § 6901-6987.
- Federal Hazardous Waste Regulations 40 CFR § 260-265

Department of Transportation (DOT) Hazardous Materials Transportation 49 CFR

Occupational Safety and Health Administration (OSHA) Regulations 29 CFR

State Laws and Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Regional, County, Municipal, and Local Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Initial Storage

Pending characterization, IDW will be temporarily stored appropriately within each area of contamination (AOC). Under RCRA, "storage" is defined as the "holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed of, or stored elsewhere" (40 CFR § 260.10). The onsite waste staging area will be in a secure and controlled area. Uncharacterized wastes are considered potentially hazardous wastes and must be stored in DOT approved packaging. Liquid wastes must be stored in DOT approved closed head drums or other approved containers (e.g., portable tank containers) that are compatible with the type of material stored therein. Solid materials must be stored in DOT approved open head drums where practicable. Larger quantities of solid IDW can be containerized in bulk containers (such as in a roll-off box). Soil from large excavation projects may be managed in stockpiles with within the AOC and does not need to be containerized until exiting the AOC.

Characterization

Waste characterization can either be based on generator knowledge, such as using historical process knowledge and safety data sheets (SDS), or can be based upon characterization sampling analytical results. IDW typically is not characterized using SDS as it is a mixture of aged chemicals and environmental media. Historical process knowledge should be used to determine if the IDW is a listed hazardous waste (40 CFR § 261.31-33). If the IDW is not a listed hazardous waste, waste

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characterization can be completed by laboratory analysis of representative samples of the IDW. The laboratory used for waste characterization analysis must have the appropriate state and federal accreditations and may be required to be pre-approved by the Client. IDW will be classified as RCRA hazardous or non-regulated under RCRA based on the waste characterization determination.

If IDW is characterized as RCRA hazardous waste, RCRA and DOT requirements must be followed for packaging, labeling, transporting, storing, and record keeping as described in 40 CFR § 262 and 49 CFR § 171-178. Waste material classified as RCRA nonhazardous may be handled and disposed of as nonhazardous waste in accordance with applicable federal, state, and local regulations.

Storage Time Limitations

Containerized hazardous wastes can be temporarily stored for a maximum of 90 calendar days from the accumulation start date for a large quantity generator or a maximum of 180 calendar days from the accumulation start date for a small quantity generator. Wastes classified as nonhazardous may be handled and disposed of as nonhazardous waste and are not subject to storage time limitations.

This is TGI may be modified by the CPM and/or Technical Expert for a specific project or client program, as required, dependent upon client requirements, site conditions, equipment limitations, or limitations imposed by the procedure. The resulting procedure employed to execute the work will be documented in the project work plans or reports. If changes to the sampling procedures are required due to unanticipated field conditions, the changes will be discussed with the CPM and/or Technical Expert as soon as practicable, and if approved to be performed, be documented.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have current regulatory- and Arcadis-required health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and cardiopulmonary resuscitation (CPR), as needed. Personnel handling and packaging hazardous waste and performing hazardous waste characterizations must have RCRA hazardous waste management training per 40 CFR § 264.16. Additional state-specific hazardous waste management training is required in certain states (i.e., California).

Although not common practice, in certain situations Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an authorized representative of the generator. Arcadis personnel who sign waste profiles and/or waste manifests will have both current RCRA hazardous waste management training per 40 CFR § 264.16 and current DOT hazardous materials transportation training per 49 CFR § 172.704. Arcadis field personnel will also comply with client-specific training. 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 health and safety plan (HASP) and other documents will identify other training requirements or access control requirements.

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4 EQUIPMENT LIST

The Following Materials, as required, will be available for IDW handling and Storage:

- Appropriate personal protective equipment as specified in the Site Health and Safety Plan (HASP)
- DOT approved containers
- Hammer
- Leather gloves
- Drum dolly
- Appropriate drum labels (outdoor waterproof self-adhesive)
- Portable tank container
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as determined by the CPM and/or Technical Expert.
- Indelible ink and/or permanent marking pens
- Plastic sheeting
- Appropriate sample containers, labels, and forms
- Stainless-steel bucket auger
- Stainless steel spatula or knife
- Stainless steel hand spade
- Stainless steel scoop
- Digital camera
- Field logbook

5 CAUTIONS

Filled drums can be very heavy, become unbalanced, or spill its contents. Therefore, use appropriate moving techniques and equipment for safe handling. Similar media (e.g. soils with other soils; or liquids with other liquids) will be stored in the same drums to aid in sample analysis and disposal. Drum lids must be secured to prevent rainwater from entering the drums and leakage during movement. Drums containing solid material may not contain any free liquids. Waste containers stored for extended periods of time may be subject to deterioration. Drum Over Packs may be used as secondary containment. All drums must be visually inspected for condition to ensure that they are in good condition without visible evidence of rusting, holes, breakage, etc., to prevent potential leakage and facilitate subsequent disposal. All drum lids must be verified as having a properly functioning secured lid prior to use.

6 HEALTH AND SAFETY CONSIDERATIONS

As determined by the site's known and suspected hazards, appropriate PPE must be worn by all field personnel within the designated work area. Exposure air monitoring may be required during certain field activities as required in the Site Health and Safety Plan. If soil excavation in areas with potentially hazardous contaminants is possible, contingency plans will be developed to address the potential for encountering gross contamination or non-aqueous phase liquids. All excavation activities shall be in compliance with OSHA standard 29 CFR 1926.651 Excavations, and any other applicable regulations.

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Arcadis field personnel and subcontractors will be trained in and perform their work in compliance with all applicable federal, state, and local health and safety regulations as well as Arcadis' HASP and applicable Client health and safety requirements.

7 PROCEDURE

Specific waste temporary storage and handling procedures to be used are dependent upon the type of generated waste, including type of media (e.g. soils or free liquids) and constituents of concern. For this reason, IDW can be stored in a secure location onsite in separate 55-gallon storage drums, where solids can be stockpiled onsite (if nonhazardous) and purge water may be stored in portable tank containers. Waste materials such as broken sample bottles or equipment containers and wrappings will be stored in 55-gallon drums unless they were not in contact with sample media.

Management of IDW

Minimization of IDW should be considered by the project team during all phases of the project. Site managers may want to consider techniques such as replacing solvent based cleaners with aqueous-based cleaners for decontamination of equipment, reuse of equipment (where it can be properly decontaminated), limitation of traffic between exclusion and support zones, and drilling methods and sampling techniques that minimize the generation of waste. Alternative drilling and subsurface sampling methods may include the use of small diameter boreholes, as well as borehole testing methods such as a core penetrometer or direct push technique instead of coring.

Drum Storage

Drums containing hazardous waste will be stored in accordance with the requirements of 40 CFR 265 Subpart I (for containers) and 265 Subpart DD (for containment buildings). All 55-gallon drums will be stored at a secure, centralized onsite location that is readily accessible for vehicular pick-up. Drums confirmed as, or assumed to contain hazardous waste will be stored over an impervious surface provided with secondary spill containment. The storage location will, for drums containing liquid, have a containment system that can contain at least the larger of 10% of the aggregate volume of staged materials or 100% of the volume of the largest container. Drums will be closed during storage and be in good condition in accordance with the Guide to Management of Investigation-Derived Wastes (USEPA, 1992).

Hazardous Waste Determination

Waste material must be characterized to determine if it meets any of the federal definitions of hazardous waste as required by 40 CFR § 262.11. If the waste does not meet any of the federal definitions, it must then be established if any state-specific or local-specific hazardous waste criteria exist/apply.

Generator Status

Once hazardous waste determination has been made, the generator status will be determined. Large quantity generators (LQG) are generators who generate more than 1,000 kilograms of hazardous waste in a calendar month. Small quantity generators (SQG) of hazardous waste are generators who generate greater than 100 kilograms but less than 1,000 kilograms of hazardous waste in a calendar month. Very small quantity generators (VSQG) are generators who generate less than 100 kilograms of hazardous

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- Drum number of total drums as reconciled with the Drum Inventory maintained in the field log book.

IDW containers will remain closed except when adding or removing waste. Immediately upon beginning to place waste into the drum/container, a “Waste Container” or “Pending Analysis” label will be filled out to include the information specified above, and affixed to the container. Once the contents of the container are identified as either non-hazardous or hazardous, the following additional labels will be applied.

- Containers with waste determined to be non-hazardous will be labeled with a green and white "Nonhazardous Waste" label over the "Waste Container" label.
- Containers with waste determined to be hazardous will be stored in an onsite storage area and will be labeled with the "Hazardous Waste" label and affixed over the "Waste Container" label.

The ACCUMULATION DATE for the hazardous waste is the date the waste is first placed in the container and is the same date as the date on the "Waste Container" label. DOT hazardous class labels must be applied to all hazardous waste containers for shipment offsite to an approved disposal or recycling facility. In addition, a DOT proper shipping name will be included on the hazardous waste label. The transporter should be equipped with the appropriate DOT placards. However, placarding or offering placards to the initial transporter is the responsibility of the generator per 40 CFR § 262.33.

Inspections and Documentation

All IDW will be documented as generated on a Drum Inventory Log maintained in the field log book. The Drum Inventory will record the generation date, type, quantity, matrix and origin (e.g., Boring-1, Test Pit 3, etc.) of materials in every drum, as well as a unique identification number for each drum. The drum inventory will be used during drum pickup to assist with labeling of drums. The drum storage area and any other areas of temporarily staged waste, such as soil/debris piles, will be inspected weekly. The weekly inspections will be recorded in the field notebook or on a Weekly Inspection Log. Digital photographs will be taken upon the initial generation and drumming/staging of waste, and final labeling after characterization to document compliance with labeling and storage protocols, and condition of the container. Evidence of damage, tampering or other discrepancy should be documented photographically.

Emergency Response and Notifications

Specific procedures for responding to site emergencies will be detailed in the HASP. If the generator is designated as a LQG, a Contingency Plan will need to be prepared to include emergency response and notification procedures per 40 CFR § 265 Subpart D. In the event of a fire, explosion, or other release which could threaten human health outside of the site or when Client or Arcadis has knowledge of a spill that has reached surface water, Client or Arcadis must immediately notify the National Response Center (800-424-8802) in accordance with 40 CFR § 262.265. Other notifications to state and/or other local regulatory agencies may also be necessary.

Drilling Soil Cuttings and Muds

Soil cuttings are solid to semi-solid soils generated during trenching activities, subsurface soil sampling, or installation of monitoring wells. Depending on the drilling method, drilling fluids known as "muds" may be used to remove soil cuttings. Drilling fluids flushed from the borehole must be directed into a settling section of a mud pit. This allows reuse of the decanted fluids after removal of the settled sediments. Soil cuttings will be labeled and stored in 55-gallon drums with bolt-sealed lids.

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waste per month. Please note that a generator status may change from month to month and that a notice of this change is usually required by the generator's state agency.

Accumulation Time for Hazardous Waste

A LQG may accumulate hazardous waste on site for 90 calendar days or less without a permit and without having interim status, provided that such accumulation is in compliance with requirements in 40 CFR § 262.17. A SQG may accumulate hazardous waste on site for 180 calendar days or less without a permit or without having interim status, subject to the requirements of 40 CFR § 262.16. VSQG requirements are found in 40 CFR § 262.14. NOTE: The federal VSQG and SQG provisions may not be recognized by some states (e.g., California and Rhode Island). State-specific and local-specific regulations must be reviewed and understood prior to the generation of hazardous waste.

Satellite Accumulation of Hazardous Waste Satellite accumulation (SAA) will mean the accumulation of as much as fifty-five (55) gallons of hazardous waste, or the accumulation of as much as one quart of acutely hazardous waste, in containers at or near any point of generation where the waste initially accumulates, which is under the control of the operator of the process generating the waste, without a permit or interim status and without complying with the requirements of 40 CFR § 262.15 and without any storage time limit, provided that the generator complies with 40 CFR § 262.15.

Once more than 55 gallons of hazardous waste accumulates in SAA, the generator has three days to move this waste into storage.

Storage recommendations for hazardous waste include:

- Ignitable or reactive hazardous wastes must be >50 feet from the property line per 40 CFR § 265.176 (LQG generators only).
- Hazardous waste should be stored on a concrete slab (asphalt is acceptable if there are no free liquids in the waste).
- Drainage must be directed away from the accumulation area.
- Area must be properly vented.
- Area must be secure.

Drum/Container Labeling

Drums will be labeled on both the side and lid of the drum using a permanent marking pen. Old drum labels must be removed to the extent possible, descriptions crossed out should any information remain, and new labels affixed on top of the old labels. Other containers used to store various types of waste (e.g., polyethylene tanks, roll-off boxes, end-dump trailers, etc.) will be labeled with an appropriate "Waste Container" or "Testing in Progress" label pending characterization. Drums and containers will be labeled as follows:

- Appropriate waste characterization label (Pending Analysis, Hazardous, or Nonhazardous)
- Waste generator's name (e.g., client name)
- Project Name
- Name and telephone number of Arcadis project manager
- Composition of contents (e.g., used oil, acetone 40%, toluene 60%)
- Media (e.g., solid, liquid)
- Accumulation start date

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Excavated Solids

Excavated solids may include, but are not limited to: soil, fill, and construction and demolition debris. Prior to permitted treatment or offsite disposal, potentially hazardous excavated solids may be temporarily stockpiled onsite as long as the stockpile remains in the same AOC from where it was excavated. Potentially hazardous excavated solids removed from the AOC must be immediately containerized in labeled drums or closable top roll-offs lined with 9-mil polyvinyl chloride (PVC) sheeting and are subject to LQG storage time limits. Nonhazardous excavated solids can be stockpiled either inside or outside of the AOC, do not have to be containerized and are not subject to hazardous waste regulations. Potentially hazardous excavated solids must not be mixed with nonhazardous excavated solids. All classes of excavated solid stockpiles should be maintained in a secure area onsite. At a minimum, the floor of the stockpile area will be covered with a 20-mil high density polyethylene liner that is supported by a foundation or at least a 60-mil high density polyethylene liner that is not supported by a foundation. The excavated material will not contain free liquids. The owner/operator will provide controls for windblown dispersion, run-on control, and precipitation runoff. The run-on control system will prevent flow onto the active portion of the pile during peak discharge from at least a 25-year storm and the run-off management system will collect and control at least the water volume resulting from a 24-hour, 25-year storm (USEPA, 1992). Additionally, the stockpile area will be inspected on a weekly basis and after storm events. Individual states may require that the stockpile be inspected/certified by a licensed professional engineer. Stockpiled material will be covered with a 6-mil polyvinyl chloride (PVC) liner or sprayed dust control product. The stockpile cover will be secured in place with appropriate material (concrete blocks, weights, etc.) to prevent the movement of the cover.

Decontamination Solutions

Decontamination solutions are generated during the decontamination of personal protective equipment and sampling equipment. Decontamination solutions may range from detergents, organic solvents and acids used to decontaminate small field sampling equipment to steam cleaning rinsate used to wash heavy field equipment. These solutions are to be labeled and stored in closed head drums compatible with the decontamination solution. Decontamination procedures, including personnel and field sampling equipment, must comply with applicable Arcadis procedural documents.

Disposable Equipment

Disposable equipment includes personal protective equipment (e.g., tyvek coveralls, gloves, booties and APR cartridges) and disposable sampling equipment such as trowels or disposable bailers. If the media sampled exhibits hazardous characteristics per results of waste characterization sampling, contaminated disposable equipment will also be disposed of as a hazardous waste. If compatible with the original IDW waste stream (i.e., the IDW is a solid and the disposal equipment is a solid), the disposable equipment can be combined with the IDW. If these materials are not compatible (i.e., the IDW is a liquid and the disposal equipment is a solid), the disposable equipment will be stored onsite in separate labeled 55-gallon drums. Uncontaminated or decontaminated disposable equipment can be considered nonhazardous waste.

Purge Water

Purge water includes groundwater generated during well development, groundwater sampling, or aquifer testing. The volume of groundwater generated will dictate the appropriate storage procedure. Monitoring

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well development and groundwater sampling may generate three well volumes of groundwater or more. This volume will be stored in labeled 55-gallon drums. Aquifer tests may generate significantly greater volumes of groundwater depending on the well yield and the duration of the test. Therefore, large-volume portable polyethylene tanks will be considered for temporary storage pending groundwater-waste characterization.

Purged Water Storage Tank Decontamination and Removal

The following procedures will be used for inspection, cleaning, and offsite removal of storage tanks used for temporary storage of purge water. These procedures are intended to be used for rented portable tanks such as Baker Tanks or Rain for Rent containers. Storage tanks will be made of inert plastic materials. The major steps for preparing a rented tank for return to a vendor include characterizing the purge water, disposing of the purge water, decontaminating the tank, final tank inspection, and mobilization. Decontamination and inspection procedures are described in further detail below.

- Tank Cleaning: Most vendors require that tanks be free of any visible sediment and water before returning, a professional cleaning service may be required. Each specific vendor should be consulted concerning specific requirements for returning tanks.
- Tank Inspection: After emptying the tank, purged water storage tanks should be inspected for debris, chemical staining, and physical damage. The vendors require that tanks be returned in the original condition (i.e., free of sediment, staining and no physical damage).

8 WASTE MANAGEMENT

Soil/Solids Characterization

Waste characterization will be conducted in accordance with waste hauler, waste handling facility, and local/state/federal requirements. In general, RCRA hazardous wastes are those solid wastes determined by a Toxicity Characteristic Leaching Procedure (TCLP) test or to contain levels of certain toxic metals, pesticides, or other organic chemicals above specific applicable regulatory agency thresholds. If the one or more of 40 toxic compounds listed in Table I of 40 CFR § 261.24 are detected in the sample at levels above the maximum unregulated concentrations, the waste must be characterized as a toxic hazardous waste. Wastes can also be considered “listed” hazardous waste depending on site-specific processes.

Composite soil samples will be collected at a frequency of one sample per 250 cubic yard basis for stockpiled soil or one per 55-gallon drum per different waste stream for containerized. A four-point composite sample will be collected per 250 cubic yards of stockpiled material and for each drum waste stream. Sample and composite frequencies may be adjusted in accordance with the waste handling facility’s requirements and may be reduced for large volumes of waste with consistent properties. Waste characterization samples will be considered valid for consistent waste streams for a period of 1 year. Waste characterization samples may be analyzed for the TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls (PCBs), as well as reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional sampling. Please note that state- or local-specific regulations may require a different or additional sampling approaches.

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Wastewater Characterization

Waste characterization will be conducted in accordance with the requirements of the waste hauler, waste handling facility, and local/state/federal governments. In general, purge water should be analyzed by methods appropriate for the known contaminants, if any, that have been historically detected in the monitoring wells. Samples will be collected and analyzed in accordance with the requirements of the waste disposal facility. Wastewater characterization samples may be analyzed for TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls, as well as corrosivity (pH), reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional sampling. Please note that state- and/or local-specific regulations may require different or additional sampling approaches.

Sample Handling and Shipping

All samples will be appropriately labeled, packed, and shipped, and the chain-of-custody will be filled out in accordance with current Arcadis sample chain of custody, handling, packing, and shipping procedures and guidance instructions.

It should be noted that additional training is required for packaging and shipping of hazardous and/or dangerous materials. Please refer to the current Arcadis training requirements related to handling and shipping of samples, shipping determinations, and hazardous materials.

Preparing Waste Shipment Documentation (Hazardous and Nonhazardous)

Waste profiles will be prepared by the Arcadis CPM and forwarded, along with laboratory analytical data to the Client for approval/signature. The Client will then return the profile to Arcadis who will then forward to the waste removal contractor for preparation of a manifest. The manifest will be reviewed by Arcadis prior to forwarding to the Client for approval. Upon approval of the manifest, the Client will return the original signed manifest directly to the waste contractor or to the Arcadis CPM for forwarding to the waste contractor. Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an authorized representative of the generator.

Final drum labeling and pickup will be supervised by an Arcadis representative who is trained and experienced with applicable waste labeling procedures. The Arcadis representative will have a copy of the drum inventory maintained in the field book and will reconcile the drum inventory with the profile numbers on the labels and on the manifest. Different profile numbers will be generated for different matrices or materials in the drums. For example, the profile number for drill cuttings will be different than the profile number for purge water. When there are multiple profiles it is critical that the proper label, with the profile number appropriate to a specific material be affixed to the proper drums. A copy of the Arcadis drum inventory will be provided to the waste transporter during drum pickup and to the facility receiving the waste.

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9 DATA RECORDING AND MANAGEMENT

Waste characterization sample handling, packing, and shipping procedures will be documented in accordance with relevant Arcadis procedures and guidance instructions as well as applicable client and/or project requirements, such as a Quality Assurance Project Plan or Sampling and Analysis Plan. Copies of the chain-of-custody forms will be maintained in the project file. Arcadis should photograph or maintain a copy of any hazardous waste manifest signed on behalf of Client in the corresponding office DOT record file.

10 QUALITY ASSURANCE

The CPM or APM will review all field documentation once per week for errors or omissions as compared to applicable project requirements including but not limited to: the proposal/scope of work, QAPP, SAP, HASP, etc. Deficiencies will be noted, tracked, and resolved. Upon correction, they will be noted for project documentation.

11 REFERENCES

United States Environmental Protection Agency (USEPA). 1992. Guide to Management of Investigation-Derived Wastes. Office of Remedial and Emergency Response. Hazardous Site Control Division. January 1992.

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TGI: MONITORING WELL DECOMISSIONING

Rev: 0

Rev Date: March 16, 2021

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
	0	March 16, 2021	All	Updated and re-written at a TGI	Marc Killingstad

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Approval Signatures

Prepared by:		3/16/2021
	Name	Date:
Technical Expert Reviewed by:		3/16/2021
	Marc Killingstad	Date:

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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 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.

2 Scope and Application

This technical guidance instruction (TGI) describes the procedures for decommissioning groundwater monitoring wells. Monitoring wells may be decommissioned when (1) it is found they are no longer suitable for collection of groundwater data (i.e., groundwater quality or groundwater elevation) due to damage and/or questionable construction; (2) they must be removed to avoid interference to/from other construction activities in the area; or (3) groundwater monitoring is no longer required at the location. The purpose for decommissioning monitoring wells no longer in use is to:

- Eliminate physical hazards associated with an out-of-use monitoring well;
- Conserve the yield and hydrostatic head of confining aquifers;
- Prevent the intermingling of separate aquifers; and
- Remove a potential conduit for the vertical migration of constituents in groundwater along the well casing.

This TGI covers the decommissioning of single-cased overburden monitoring wells when a replacement well will not be installed within the same borehole. Three potential decommissioning methods—plugging -in-place, casing removal, and overdrilling—are described below. In addition, guidance for the abandonment of a soil boring when a monitoring well has not been installed, is also provided.

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Although these procedures are generally applicable for the decommissioning of double-cased monitoring wells or wells installed within bedrock, in most cases a decommissioning strategy will be developed on a well-by well basis. Additional information regarding potential methods to decommission these types of wells may be found in ASTM D5299-99 – *Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities* (ASTM 2012a). Furthermore, ASTM D6001 – *Standard Guide for Direct-Push Groundwater Sampling for Environmental Site Characterization* (ASTM 2012b) provides details on methods used to decommission boreholes or temporary monitoring wells installed via direct push technology (DPT).

3 Personnel Qualifications

Arcadis field 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 team will review and be thoroughly familiar with relevant 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 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 Arcadis 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.

The well decommissioning procedures described below will be carefully adhered to and conducted under the supervision of an experienced geologist, engineer, or other qualified individual. Ideally, Arcadis personnel directing, supervising, or leading well decommissioning activities will have a minimum of one (1) year of previous experience with decommissioning procedures. It is recommended that field employees with less than six (6) months of experience be accompanied by a supervisor (as described above) to ensure that decommissioning techniques are employed.

Drilling contractors involved in the decommissioning activities will provide their own, task-specific Health & Safety Plan but will be included in the Arcadis tailgate meetings where site-specific Health & Safety concerns will be outlined.

4 Equipment List

The following materials, as required, will be available during pre-decommissioning and decommissioning activities:

- Site Health and Safety Plan (HASP);
- Copy of Well Abandonment Permit, if required. If a grout inspection is required as specified in the Well Abandonment Permit, contact the appropriate agency prior to field activities.

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- Health and safety equipment, as required in the HASP (e.g., air monitoring equipment, personal protective equipment, exclusion zone barriers/caution tape);
- Field Implementation Plan (FIP)/work plan that includes site map, well construction records (table or logs), location of wells to be decommissioned, and decommissioning plan;
- Information concerning the construction of the well to be decommissioned;
- Appropriate field forms or field notebook (Note: Example forms including a Well Abandonment Checklist, a Well Abandonment Form, and a Well Abandonment Record are included with this TGI as Attachment A);
- Well keys;
- Water level probe;
- Cleaning materials;
- Drill rig with registered well driller (with copy of driller's registration) and experienced personnel if overdrilling is used as method for decommissioning;
- Tremie pipe;
- Sufficient quantity of predetermined type of cement specified (e.g., Type I Portland cement);
- Appropriate sealing material, such as bentonite;
- Identify appropriate water source for mixing cement (use potable water source if/when available);
- Containers for collecting spoils; and
- Any necessary specialized well drilling/decommissioning equipment.

5 Cautions

- Ensure that all state and local requirements for well abandonment are reviewed and followed and that any required permits are secured prior to mobilization.
- If necessary, access to the property where the monitoring well is located will be secured in advance.
- Utility clearance is required prior to well abandonment activities Utility clearance may or may not have been conducted prior to well installation or utilities could have been installed adjacent to the well casing.
- Avoid using drilling fluids or materials that could impact groundwater or soil quality or could be incompatible with the subsurface conditions.
- Water used for over drilling or grouting boreholes upon completion will be of a quality acceptable for project objectives. If the water quality is unknown, testing of water supply will be performed.
- Specifications of materials used for backfilling the bore hole will be obtained, reviewed, and approved to meet project quality objectives. Backfill material needs to be suitable for the geology at the well location.
- All sealing material including bentonite tablets, pellets, chips, or slurry grouts must be listed under American Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 60, for potable water contact.

6 Health and Safety Considerations

Health and safety protocols will be described in the site-specific HASP.

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

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

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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. If a JSA does not exist for the decommissioning work to be performed, field staff or team member will prepare a new, task-specific JSA.

If at any time during conduct of the work it becomes apparent that the proper tools to do the job safely are not available, stop work and contact the project manager and/or the health and safety manager.

7 Procedure

The plug-in place, casing removal, overdrilling, and borehole decommissioning/abandonment methods are briefly described below. Typical steps to complete monitoring well decommissioning and borehole abandonment are included in **Attachments A** through **D**.

The procedures are generally based on ASTM D5299, which allows for modifications to procedures, based on site-specific conditions. ASTM D5299 states

> *Decommissioning of boreholes and monitoring wells, and other devices requires that the specific characteristics of each site be considered. The wide variety of geological, biological, and physical conditions, construction practices, and chemical composition of the surrounding soil, rock, waste, and groundwater precludes the use of a single decommissioning practice. The procedures discussed in this guide are intended to aid the geologist or engineer in selecting the tasks required to plan, choose materials for, and carry out an effective permanent decommissioning operation. Each individual situation should be evaluated separately, and the appropriate technology applied to best meet site conditions. Considerations for selection of appropriate procedures are presented in this guide, but other considerations based on site specific conditions should also be taken into account.*

Plug-in Place Method

The plug-in place method is applicable at locations where available information indicates that the annular space contains an adequate seal and vertical migration of constituents across a confining layer is not a concern in the well casing and screen interval, or if other considerations (e.g., double-cased well construction) preclude removal of the well casing. Typical procedures used to decommission a monitoring well using the plug-in place method are presented in **Attachment B**.

Casing Removal Method

The casing removal method is generally applicable at shallow locations where vertical migration of constituents across a confining layer is not a concern and where the integrity of the borehole is reasonably expected to be maintained following removal of the well materials. Typical procedures used to decommission a monitoring well using the casing removal method are presented in **Attachment C.**

Overdrilling Method

The overdrilling method is the most conservative decommissioning procedure and is primarily utilized at locations where a well has penetrated a confining layer and there is no evidence that the annular space around the well casing was adequately sealed, or if attempts to remove the well casing are unsuccessful. Typical procedures used to decommission a monitoring well using the overdrilling method are presented in **Attachment D**.

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Abandoning a Soil Boring

The general steps for abandoning a soil boring are summarized in **Attachment E** and are based on ASTM D5299-99 as well as ASTM D6001.

8 Waste Management

Investigation-Derived Waste (IDW), including purge water, decontamination liquids, and disposable materials (plastic sheeting, PPE, etc.) will be stored on site in appropriately labeled containers (disposable materials will be contained separately) and disposed of properly. Containers must be labeled at the time of collection and will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, PPE). 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 notebook.

Waste management protocols will be described in the site-specific work plan.

9 Data Recording and Management

The process of decommissioning the well will be documented in the project-specific field book or on an appropriate field form in accordance with Arcadis QP306 – Field Activities Documentation.

Management of the original documents from the field will be completed in accordance with the site-specific QAPP. Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements.

To assure that a well is properly plugged and there has been no bridging of the plugging materials, verification calculations and measurements are required to determine whether the volume of material placed in the well/borehole equals or exceeds the volume of the void being filled. The calculations will be documented in the project-specific field notebook or the appropriate field form.

Some useful formulas for calculating well and material volumes are provided below.

- 7.481 gallons = 1 cubic foot
- 202.0 gallons = 1 cubic yard
- *Volume of Borehole [gal]= π x (borehole radius)^2[ft^2] x (length of borehole)[ft] x 7.481 [gallons per cubic ft]*

10 Quality Assurance

Records (original field documents) generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements as outlined in the FIP/work plan and/or QAPP

Field forms, logs/notes (including daily field and relevant calibration logs), and digital records will be maintained by the field team lead.

Records will be transmitted to the Arcadis Project Manager and/or Task Manager, as appropriate, at the end of each day or as specified in the FIP/work plan.

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Electronic data files will be sent to the project team and uploaded to the electronic project folder daily or as specified in the FIP/work plan.

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

11 References

ASTM. 2012a. D5299-99 – *Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.*

ASTM. 2012b. D6001 - *Standard Guide for Direct-Push Groundwater Sampling for Environmental Site Characterization.*

Lutenegger, A.J. and D.J. DeGroot. 1995. Techniques for sealing cone penetrometer holes. *Canadian Geotechnical Journal, Vol. 32, No. 5, pp. 880-891.*

U.S. EPA. 1997. *Expedited Site Assessment Tools for Underground Storage Tank Sites, A Guide for Regulators, EPA 510-B-97-001.* Office of Underground Storage Tanks, Washington, DC.

12 Attachments

Attachment A. Example Forms

Attachment B. Plug-in Place Procedures

Attachment C. Casing Removal Method

Attachment D. Overdrilling Method

Attachment E. Soil Boring Abandonment

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ATTACHMENT A
Example Forms

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Attachment A – Example Forms

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Well Abandonment Checklist

Project Name: ______________________ Project Number: ______________________

Page: ______ of ______
Date: ______________

	Photos		Measurements		Casing		Removal		Grout		Surface		
Well ID	Before Photo	After Photo	Depth to Water	Total Depth	Pulled	Cut	Cement Pad	Well Vault	Grouted	Grout Type	Covered Surface	Cover Type	Finished

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Well Abandonment Form

Project Name: _____ Page: _____ of _____
Project Number: _____ Date: _____
Conducted By: _____
Subcontractor: _____

Well ID	Dia. (in)	DTW (ft)	TD (ft)	Lengths Removed	Fully Removed?
				Riser:	
				Screen:	
				Riser:	
				Screen:	
				Riser:	
				Screen:	
				Riser:	
				Screen:	
				Riser:	
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ATTACHMENT B
Plug-in Place Procedures

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Attachment B – Plug-in Procedures

In this method the well screen is left in place and may be additionally perforated, along with the base of the well, to allow the grout seal to penetrate the surrounding filter pack. The decommissioning process consists of the following steps:

1. Perform a search of available records concerning the well to be decommissioned. The following activities will be completed to identify the location, construction, and condition of the well, and to determine the appropriate equipment to be utilized based on the depth, diameter, and access to the monitoring well:
   - Review the existing monitoring well log to identify construction characteristics (e.g., total depth, casing diameter, initial borehole diameter, type of casing, type of material(s) used);
   - Locate the monitoring well in the field;
   - Identify if the decommissioning equipment can access the monitoring well and/or if special considerations (e.g., construction of an access road) are necessary to gain access;
   - Conduct total depth measurements and water level measurements;
   - Calculate the volume of the well that will need to be filled utilizing field measurements and formulas provided in the main document;
   - Record all observations and measurements;
   - Conduct utility clearance.

2. Remove the protective casing and well casing to a depth of approximately 3 to 4 feet below ground surface (bgs), if possible.

3. Perforate the base of the well screen utilizing a length of drilling rod or other equipment.

4. Prepare a neat cement grout. (Note: A neat cement grout is preferred for application through an in-place well; whereas a bentonite grout or hydrated bentonite pellets may also be considered at locations where the well casing is removed, or the well is overdrilled. Bentonite will only be installed below the water table to ensure that the seal hydration is maintained. Neat cement grout is comprised of no more than 5.5 to 6 gallons of water per 94 lb. bag of cement).

5. Place the neat cement grout or other sealing material in the perforated well casing via the tremie method (i.e., the grout will be pumped from the bottom of the well upward). The grout will be added until the well is filled to above the top of the well casing remaining in place (i.e., typically approximately 3 to 4 feet bgs). Verify that the amount of grout added equals or exceeds the calculated volume of the void to be filled.

6. The grout will be allowed to set for a minimum of 24 hours and the remainder of the borehole will be filled with concrete and/or other surface finish materials (see Step 7).

7. The borehole shall be terminated with a minimum 1-foot-thick concrete plug above the grout and the remaining portion of the borehole shall be filled flush with grade with material(s) compatible with the surrounding land surface (e.g., asphalt, gravel, topsoil).

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8. A Well Abandonment Log will be completed. If required, a state-specific Well Abandonment Log will be used and submitted to the appropriate state agency.

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ATTACHMENT C
Casing Removal Method

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Attachment C - Casing Removal Method

The decommissioning process will consist of the following steps:

1. Perform a search of available records concerning the well to be decommissioned. The following activities will be completed to identify the location, construction, and condition of the well, and determine the appropriate equipment to be utilized based on the depth, diameter, and access to the monitoring well:
   - Review the existing monitoring well log to identify construction characteristics (e.g., total depth, casing diameter, initial borehole diameter, type of casing, type of material(s) used);
   - Locate the monitoring well in the field;
   - Identify if the decommissioning equipment can access the monitoring well and/or if special considerations (e.g., construction of an access road) are necessary to gain access;
   - Conduct total depth measurements and water level measurements;
   - Calculate volume of well that will need to be filled utilizing field measurements and formulas provided in the main document;
   - Record all observations and measurements; and
   - Conduct utility clearance.

2. Remove the protective casing, if possible.

3. Remove the well materials (riser and screen) using a method that keeps the borehole open to allow for proper seal placement.

4. Examine removed well materials to ensure that the entire section has been removed. Also ensure that the borehole has not collapsed and that the tremie pipe will be able to be inserted to the base of well depth. If the well casing is broken below grade and cannot be retrieved, or if the tremie pipe will not reach the base of the well, decommissioning will be completed by using the overdrilling method.

5. Prepare a neat cement grout or a bentonite grout that is compatible with the soil and groundwater conditions present at the monitoring well. (Note: A neat cement grout or a bentonite grout is preferred for this application. Hydrated bentonite pellets may also be considered if the entire well boring is overdrilled, using procedures similar to those for abandoning boreholes).

6. Place the cement grout in the borehole via tremie method (i.e., the grout will be pumped from the bottom of the borehole upward). The grout will be added until the borehole is filled to approximately 3 to 4 feet bgs. Verify that amount of grout added equals or exceeds the calculated volume of the void to be filled.

7. The grout will be allowed to set for a minimum of 24 hours and the remainder of the borehole will be filled with concrete and/or other surface finish materials (see Step 8 below).

8. The borehole shall be terminated with a minimum 1-foot-thick concrete plug above the grout and the remaining portion of the borehole shall be filled flush with grade with material(s) compatible with the surrounding land surface (e.g., asphalt, gravel, topsoil).

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9. A Well Abandonment Log will be completed. If required, a state-specific Well Abandonment Log will be used and submitted to the appropriate state agency.

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ATTACHMENT D
Overdrilling Method

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Attachment D - Overdrilling Method

The decommissioning process using the Overdrilling Method will consist of the following steps:

1. Perform a search of available records concerning the well to be decommissioned. The following activities will be performed to identify the location, construction, and condition of the well, and determine the appropriate equipment to be utilized based on the depth, diameter, and access to the monitoring well:
   - Review the existing monitoring well log to identify construction characteristics (e.g., total depth, casing diameter, initial borehole diameter, type of casing, type of material(s) used);
   - Locate the monitoring well in the field;
   - Identify if a drill rig can access the monitoring well and/or if special considerations (e.g., construction of an access road) are necessary to gain access;
   - Conduct total depth measurements and water level measurements;
   - Calculate the volume of the well/borehole that will need to be filled utilizing field measurements and formulas provided above; and
   - Record all observations and measurements.
   - Conduct utility clearance.

2. Remove the protective casing, if possible.

3. If the protective casing has been removed, advance a hollow-stem auger or other drill casing (with an outside diameter larger than the well diameter) over the well casing to the bottom of the original borehole.

4. Prepare a neat cement grout or a bentonite grout that is compatible with the soil and groundwater conditions present at the monitoring well. Alternatively, hydrated bentonite pellets may be used to plug the borehole, using procedures similar to those for abandoning boreholes. As described for the plug-in place method, bentonite will only be placed below the water table to ensure that the seal hydration is maintained.

5. Place the cement grout in the borehole via tremie method (i.e., the grout will be pumped from the bottom of the borehole upward) at the same time the hollow-stem augers or drill casing are removed from the borehole. Grout will be added until the borehole is filled to approximately 3 to 4 feet bgs. Verify that the amount of grout added equals or exceeds the calculated volume of the void to be filled. If hydrated bentonite pellets are utilized, measure deposition depth with a weighted tape as the hollow-stem augers or drill casing are removed from the borehole to ensure that bridging does not occur. At shallow well locations installed in competent formations, it may be possible to remove the hollow-stem augers or drill casing prior to installing the sealant. If this is attempted, confirmatory measurements must be taken to verify that borehole integrity was maintained prior to plugging the hole.

6. The grout will be allowed to set for a minimum of 24 hours and the remainder of the borehole will be filled with concrete and/or other surface finish materials (see Step 7 below).

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7. The borehole shall be terminated with a minimum 1-foot-thick concrete plug above the grout and the remaining portion of the borehole shall be filled flush with grade with material(s) compatible with the surrounding land surface (e.g., asphalt, gravel, topsoil).

8. A Well Abandonment Log will be completed. If required, a state-specific Well Abandonment Log will be used and submitted to the appropriate state agency.

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ATTACHMENT E
Soil Boring Abandonment

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Attachment E - Soil Boring Abandonment

The following steps for abandoning a soil boring are based on ASTM D 5299-99:

1. Prepare a neat cement grout using Type I Portland cement and potable water mixed according to the following ratio: one bag of Type I Portland cement (94 lbs.) mixed with 5.5 to 6 gallons potable water.

2. As soon as the borehole is completed, place a grout pipe (tremie pipe) to the bottom of the boring and pump sealing grout slowly through the pipe to displace material in the borehole. Inject grout starting from the bottom of the hole. Grout slowly to prevent channeling of the grout. As the grouting progresses, slowly raise the pipe. Complete the grouting in one continuous operation, continuing to pump grout until overflowing grout is seen at the surface. The overflowing grout will be similar in appearance and characteristics to the grout being pumped down the hole.

3. Grout may settle over a 24-hour period. After 24 hours, check the grout in the borehole for settlement. If settling has occurred, place additional grout to the surface. When grouting is complete, finish the surface in a manner appropriate for final use (e.g., concrete).

Boreholes and temporary monitoring wells installed via Direct-Push Technology (DPT) also need to be commissioned to avoid creating a conduit for vertical contaminant migration, either from the surface or between subsurface geologic units. Several methods are available, but the selected method will need to be capable of backfilling the hole completely (without gaps) with grout or a slurry. Applicable method will depend on factors such as, type and size of DPT equipment, subsurface conditions, and state and/or local regulations. The type of grout/slurry can also depend on the remedial action at the site (e.g., silica flour grout mixture may be selected for sites that may be treated with in-situ thermal technology).

The methods available for decommissioning DPT boreholes include:

- **Retraction grouting**: Involves pumping a high-solids bentonite and water mixture or a neat cement grout through the rod and tool string and out the bottom of the sampling tool as the tool is withdrawn from the hole ensuring that the borehole is sealed throughout its length. Considered to be most reliable method.

- **Re-entry grouting:** Involves pumping grout through a tremie pipe into the borehole immediately following withdrawal of the drill string or the drill string may be reinstalled in the borehole, without the sampling tool, so that grout may be pumped through the open rods. Grout is pumped continuously from the bottom to the top as the tremie pipe (or rod string) is withdrawn to avoid gaps and bridging of the grout. This method is effective if the hole remains open until tremie pipe or rods can be extended to the bottom of the borehole. If the borehole collapses, the tremie pipe or rods will not penetrate to the total depth of the hole, making it necessary to put an expendable tip on the end of the rod string, push the string to the total depth of the hole, knock out the tip, and pump grout through the rods as they are withdrawn.

- **Surface pouring:** Involves pouring either dry bentonite (granules, chips, or pellets), bentonite slurry, or neat cement grout from the surface down the open borehole after the rod string and tool are removed. The simplest method of borehole decommissioning, but it may not be as effective as the other methods in most situations. May be effective if the borehole does not collapse after the rods are removed, and if the borehole

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is relatively shallow (less than about 10 or 15 feet). If dry bentonite materials are proposed, it will only be effective if the bentonite is either hydrated from the surface immediately after installation or if it is installed beneath the water table and requires that the soil moisture content be sufficient to keep the bentonite hydrated after installation.

Additional details for these methods can be found in ASTM D6001 (ASTM, 2012b) as well as EPA (1997) and Lutenegger and DeGroot (1995).

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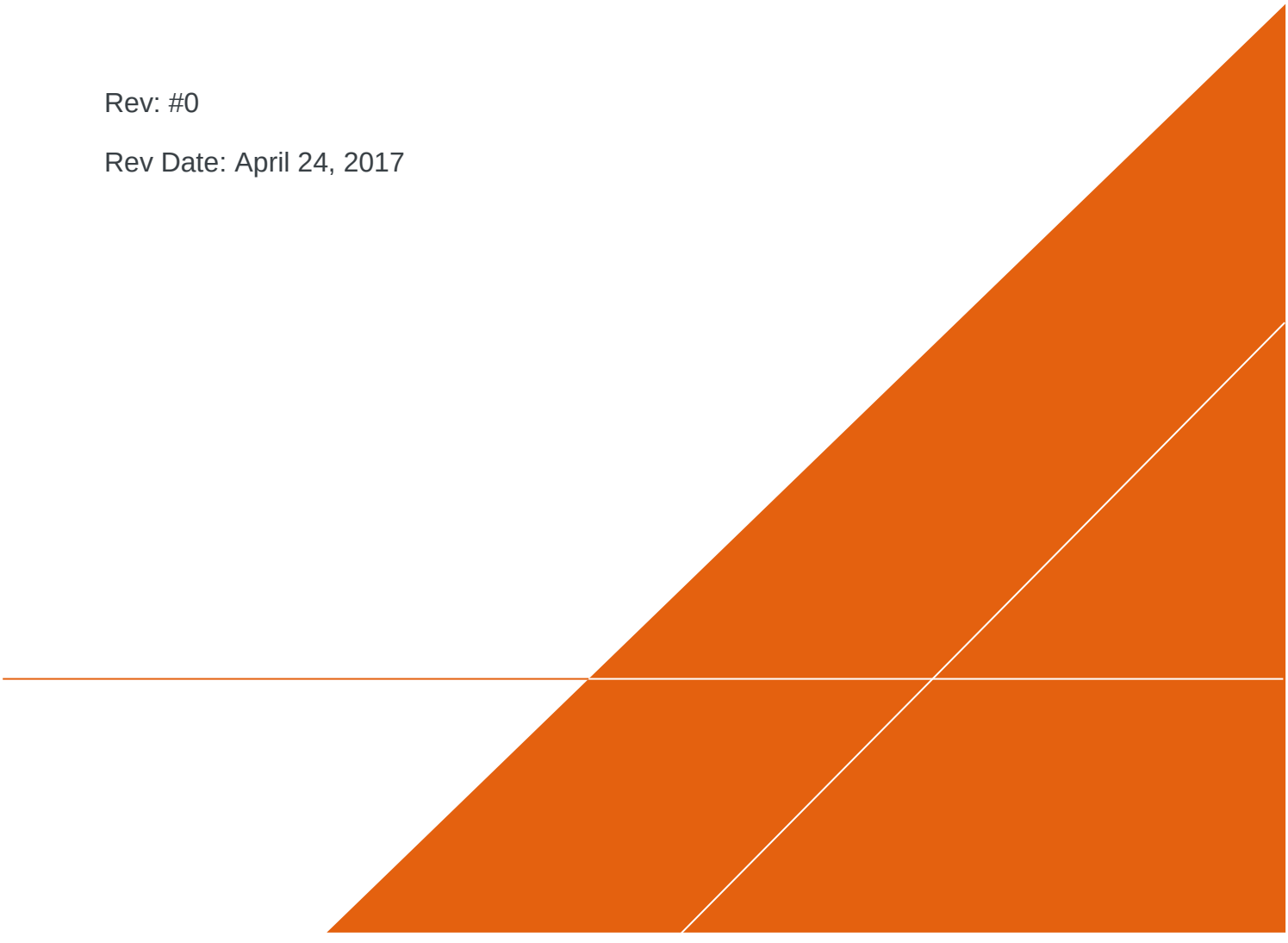
ARCADIS Design & Consultancy for natural and built assets

TECHNICAL GUIDANCE INSTRUCTION - MONITORING WELL DEVELOPMENT

Rev: #0

Rev Date: April 24, 2017



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	4/24/2017	All	Re-written as TGI	Marc Killingstad

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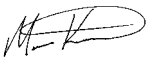
APPROVAL SIGNATURES

Prepared by:		4/24/2017
	Jay Erickson	Date:
Technical Expert Reviewed by:		4/24/2017
	Marc Killingstad	Date:

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1 INTRODUCTION

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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.

2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) covers the development of screened wells used for obtaining representative groundwater information and samples from granular aquifers (i.e., monitoring wells). Note that this TGI only applies to monitoring well development and not remediation (injection/extraction) well development.

The purposes of Monitoring Well Development are:

1. Repair damage to the borehole wall from drilling that can include clogging, smearing or compaction of aquifer materials;
2. Remove fine grained sediment from the formation and filter pack that may result in high turbidity levels in groundwater samples;
3. To re-sort formation and filter pack material adjacent to the well screen;

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4. To recover any drilling fluids (if used) that may affect the permeability of the formation and filter pack or alter the water quality around the well; and
5. To optimize the well efficiency and hydraulic communication between the well screen and the formation.

Successful monitoring well development is dependent on the following:

1. Hydrostratigraphy – Permeable formations containing primarily sand and gravel are more easily developed due to lower percentages of silt and clay material. Water in permeable formations can be moved in and out of the screen and/or through the formation easier than in less permeable deposits
2. Well Diameter – Development tooling including brushes, surge blocks, pumps and jetting tools are more readily available for wells 4 inches in diameter and greater.
3. Well Design – Wells with filter packs and screens designed to match the formation through the analysis of formation sieve samples are easier to develop. An important aspect to well design is to minimize the size of the annular space between the formation and well screen. Adequate room must be allowed for the proper installation of well materials, but not too large as to prevent/reduce communication with the surrounding formation.
4. Drilling Methods – Different drilling methods result in varying amount of borehole damage and, therefore, impact the degree to which development will be successful.

Well development methods for monitoring wells include the following:

1. Bailing – use of a bailer to remove water and sediment from the well casing. This technique does little to remove fines from the filter pack and may lead to bridging of sediment since the flow in only in one direction, toward the well screen.
2. Pumping/overpumping – use of a pump to remove water and sediment from the well casing, overpumping involves pumping the well at a rate that exceeds the design capacity of the well. Similar to bailing, this technique does little to remove fines from the filter pack and may lead to bridging of sediment since the flow in only in one direction, toward the well screen. Small diameter monitoring wells have the additional constraint on pump size and flow rates.
3. Backwashing (rawhiding) – consists of starting and stopping a pump intermittently to produce rapid pressure changes in a well. This method can produce better results than pumping alone since the procedure involves movement of the water in and out of the screen and formation. However, in many cases the surging action is not rigorous enough to fully develop the well.
4. Surging/swabbing – use of a mechanical surge block or swabbing tool to operate like a piston with an up and down motion. The downstroke causes a backwash action that breaks up bridged sediment and the upstroke pulls the dislodged sediment into the well. This method works well for small and large diameter wells. Care should be taken on the downstroke so as not to force fines back into the formation, frequent pumping/purging during surging help to keep fines out of the well. Double surge blocks are recommended.
5. Jetting – use of a tool fitted with nozzles that direct streams of water horizontally into well screens at high velocity. Due to the size of the tooling, this method is better suited for wells 4 inch in diameter and larger. The method is also more effective with wire-wrapped/continuous slot screens due to the

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increased open area. Jetting requires specialized equipment and concurrent pumping to prevent reintroducing fines into the filter pack. Additionally, jetting requires subsequent surging to remove fines dislodged in the filter pack and formation.

For most situations, gentle surging coupled with bailing or pumping to remove dislodged materials is recommended.

Well development for properly designed and constructed monitoring wells may begin after the annular seal materials have been installed and allowed to cure, since these wells are designed to retain 90-99% of the filter pack material. This cure time is typically at least 24 to 48 hours after the sealing materials have been installed.

This TGI is meant to provide a general guide for proper monitoring well development. A site-specific field implementation plan for well installation and development detailing the specific methods and tools should be developed to provide site-specific instruction and guidance.

3 PERSONNEL QUALIFICATIONS

Monitoring well development activities will be performed by persons who have been trained in proper well development procedures under the guidance of an experienced field geologist, engineer, or technician.

4 EQUIPMENT LIST

Required equipment depends on the selected method and should be detailed in the site-specific field implementation plan. However, the following are typically required.

- Health and safety equipment, as required by the site Health and Safety Plan (HASP):
- Cleaning equipment
- Field notebook and/or personal digital assistant (PDA)
- Monitoring well keys
- Water level indicator
- Field parameter meter (YSI)
- Well Development Logs
- Well construction logs/diagrams
- Weighted tape (measure depth)
- Turbidity meter
- Camera
- Watch/timing device.

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5 CAUTIONS

Where surging is performed to assist in removing fine-grained material from the sand pack, surging must be performed in a gentle manner. Excessive suction could promote fine-grained sediment entry into the outside of the sand pack from the formation.

Avoid using development fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

In some cases, it may be necessary to add potable water to a well to allow surging and development, especially for new monitoring wells installed in low permeability formations. Before adding potable water to a well, the Certified Project Manager (CPM) and/or Project Hydrogeologist must be notified and the CPM shall make the decision regarding the appropriateness and applicability of adding potable water to a well during well development procedures. If potable water is to be added to a well as part of development, the potable water source should be sampled and analyzed for constituents of concern, and the results evaluated by the CPM prior to adding the potable water to the well. If potable water is added to a well for development purposes, at the end of development the well will be purged dry to remove the potable water, or if the well no longer goes dry then the well will be purged to remove at least three times the volume of potable water that was added.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with monitoring well development will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

7 PROCEDURE

As indicated above, for most monitoring wells, gentle surging coupled with bailing or pumping to remove dislodged sediment is recommended.

1 Ensure sufficient time has passed to allow for proper curing of the well seal.

2 Don appropriate PPE (as required by the site-specific HASP).

3 Place plastic sheeting around the well.

4 Clean all equipment entering each monitoring well, except for new, disposable materials that have not been previously used.

5 Open the well cover while standing upwind of the well, remove well cap. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field notebook. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the PID reading in the breathing zone is below 5 PID units, proceed. If the PID reading is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don the appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

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6 Obtain an initial measurement of the depth to water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book. It is recommended to use a weighted tape for the total well depth measurement.

7 The depth to the bottom of the well should be sounded and then compared to the completion form or construction diagram for the well. Any discrepancies should be reported immediately to the CPM and/or Project Hydrogeologist. If sand or sediment is present inside the well, it should first be removed by bailing. Do not insert bailers, pumps, or surge blocks into the well if obstructions, parting of the casing, or other damage to the well is suspected. Instead report the conditions to the CPM and/or Project Hydrogeologist and obtain approval to continue or cease well development activities.

8 Lower a double surge block into the screened portion of the well. Starting from the bottom of the screen using 2 foot throws, gently raise and lower the surge block to force water in and out of the screen slots and sand pack. Continue surging for 15 to 30 minutes.

9 Lower a bottom-loading bailer, submersible pump, or inertia pump tubing with check valve to the bottom of the well and gently bounce on the bottom of the well to collect/remove accumulated sediment, if any. Remove and empty the bailer, if used. Repeat until the bailed/pumped water is free of excessive sediment and contact at the bottom of the well feels solid. Alternatively, measurement of the well depth with a weighted tape can be used to verify that sediment and/or silt has been removed to the extent practicable, based on a comparison with the well installation log or previous measurement of total well depth.

10 After surging the well for a minimum of two cycles and removing excess accumulated sediment from the bottom of the well, re-measure the depth-to-water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

11 Remove formation water by pumping/bailing. Where pumping is used, measure and record the pre-pumping water level. Operate the pump at a relatively constant rate. Measure the pumping rate using a calibrated container and stop watch, and record the pumping rate in the field log book. Measure and record the water level in the well at least once every 5 minutes during pumping. Note any relevant observations in terms of water color, visual level of turbidity, sheen, odors, etc. Pump or bail until termination criteria specified in the Site-Specific Field Implementation plan are reached. Note: the project-specific field implementation plan may also specify a maximum turbidity requirement for completion of development. Unless otherwise specified the maximum turbidity should be 50 NTUs or less. Record the total volume of water purged from the well.

12 While developing, take periodic water level measurements (at least one every five minutes) to determine if drawdown is occurring and record the measurements on the Well Development Log.

13 While developing, calculate the rate at which water is being removed from the well. Record the volume on the Well Development Log.

14 While developing, water is also periodically collected directly from the well or bailer discharge and readings taken of the indicator parameters: pH, specific conductance, and temperature. Development is considered complete when the indicator parameters have stabilized (i.e., three consecutive pH, specific conductance, and temperature readings are within tolerances specified in the project work plans or within 10% if not otherwise specified), the extracted water is clear and free

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of fine sediment and most importantly, when acceptable volume of water has been removed and/or a sufficient amount of surging has been performed.

15 In certain instances, for slow recharging wells, the parameters may not stabilize. In this case, well development is considered complete when minimal amounts of fine-grained sediments are recovered and acceptable volume of water has been removed.

16 If the well goes dry, stop pumping or bailing. Note the time that the well went dry. After allowing the well to recover, note the time and depth to water. Resume pumping or bailing when sufficient water has recharged the well.

17 Contain all development water in appropriate containers.

18 When complete, secure the lid back on the well.

19 Place disposable materials in plastic bags for appropriate disposal and decontaminate reusable, downhole pump components and/or bailer

8 WASTE MANAGEMENT

Materials generated during monitoring well installation and development will be placed in appropriate labeled containers and disposed of as described in the Work Plan/Field Implementation Plan or Field Sampling Plan.

9 DATA RECORDING AND MANAGEMENT

All well development activities should be documented on appropriate log forms as well as in a proper field notebook and/or PDA. Additionally, all documents (and photographs) should be scanned and electronically filed in the appropriate project directory for easy access. Pertinent information will include personnel present on site; times of arrival and departure; significant weather conditions; timing of well development activities; development method(s); observations of purge water color, turbidity, odor, sheen, etc.; purge rate; and water levels before, during, and after pumping.

10 QUALITY ASSURANCE

All reused, non-disposable, downhole well development equipment should be cleaned in accordance with the procedures outlined in the project documents.

11 REFERENCES

American Society for Testing Materials (ASTM), Designation D5521-05. *Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers*. American Society for Testing Materials. West Conshohocken, Pennsylvania.

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PFAS-SPECIFIC DRILLING AND MONITORING WELL INSTALLATION TECHNICAL GUIDANCE INSTRUCTION

Rev: #0

Rev Date: 10/12/2018

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	10/12/2018	All	Generated from generic Well Installation TGI (Rev 0, April 24, 2017). Revised to be PFAS-specific, provide more instruction on soil sample collection, and only include DPT and Sonic methods	Ankit Gupta

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APPROVAL SIGNATURES

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Technical Expert Reviewed by:

Date: 10/12/2018

Ankit Gupta

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Senior Environmental Engineer

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2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) describes methods used to advance soil borings via direct push technology (DPT) or rotosonic drilling techniques, collect single or multiple depth-discrete dry and/or saturated soil samples, and install groundwater monitoring wells in unconsolidated aquifers (as necessary) at sites impacted by per- and polyfluoroalkyl substances (PFASs). It covers specific considerations relevant for PFASs due to their unique chemical and physical properties, low detection limits, and low regulatory standards. A more detailed discussion of general PFAS sampling procedures is provided in PFAS Field Sampling Guidance TGI (Arcadis 2018a).

If monitoring wells are to be installed upon completion of borehole drilling and soil sampling, it is assumed that the monitoring well has been designed consistent with the approach and methods presented in the American Society of Testing and Materials (ASTM) D5092 – *Standard Practice for Design and Installation of Groundwater Monitoring Wells* (ASTM D5092). This includes sizing of the filter pack and screen slot size, the length of the screen, total depth of the well, material strength and compatibility and surface completion. Typical monitoring wells are constructed of manufactured screen and engineered filter pack

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and are generally suitable for formations with granular materials having a grain size distribution with up to 50% passing a #200 sieve and up to 20% clay-sized material. Monitoring wells installed in formations finer than this may not be able to produce turbidity free water.

The procedures set out herein are designed to produce standard groundwater monitoring wells suitable for: (1) groundwater sampling; (2) water level measurement; and (3) hydraulic conductivity testing of formation sediments immediately adjacent to the open interval of the well (e.g., slug testing).

This TGI will focus specifically on two drilling methods most likely to be utilized during drilling and soil sampling activities: DPT and rotosonic techniques. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling depths, site or regional geologic knowledge, type of sampling to be conducted, project objectives, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No polyvinyl chloride (PVC) glue/cement will be used in constructing or retrofitting monitoring wells that will be used for water-quality monitoring. No coated bentonite pellets will be used in the well drilling or construction process. Specifications of materials to be installed in the borehole will be obtained prior to mobilizing onsite; these materials generally include:

- Well casing (length, material, and diameter);
- Well screen (length, material, diameter, and slot size);
- Bentonite (type, as applicable, chips, non-coated and granular bentonite are acceptable);
- Filter pack (filter pack type and fine sand seal type, as applicable); and
- Grout (type, as applicable).

Well materials will be inspected and, if needed, cleaned or replaced prior to installation.

3 PERSONNEL QUALIFICATIONS

Drilling and soil sampling activities will be performed by persons who have been trained in proper procedures under the guidance of an experienced field geologist, engineer, or technician, with particular emphasis on PFAS sampling procedures outlined in PFAS Field Sampling Guidance TGI (Arcadis 2018a). Field personnel will have undergone in-field training in soil description methods, as described in Soil Description TGI (Arcadis 2018b).

4 EQUIPMENT LIST

The following materials will be available during soil boring and monitoring well installation activities, as required:

- Site Plan with proposed soil boring/well locations;
- Work Plan (or equivalent) and Site Safety and Health Plan (SSHP);

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- Personal protective equipment (PPE), as required by the SSHP;
- Traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if not provided by drillers;
- Drilling/Sampling
    - Stainless-steel spatulas, spoons, and trowels
    - Stainless-steel hand auger with at least 10-ft of extension rods
    - PVC piping of larger diameter than hand auger, if necessary, to keep hand auger borings open
    - Soil logging equipment as specified in the appropriate project documents;
    - Dedicated low-density polyethylene (LDPE) plastic sheeting to prevent sample contact with the ground.
    - Photoionization detector (PID) or flame ionization detector (FID) with calibration gas;
    - 4-gas meter with calibration gas
    - Water level meter with fluorine-free materials (Geotech ET 3/8" with Delrin tip and Buna-N O-ring);
    - Laboratory provided PFAS-free water for field and equipment blank QC samples
- Appropriate sample containers and labels:
    - Laboratory-supplied sample bottles: see the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a) for PFAS-specific considerations;
    - 1-qt and 1-gal polyethylene bags (Ziploc® brand only) to hold ice and samples;
    - Appropriate blanks (field reagent blanks supplied by the laboratory);
    - Packing and shipping materials;
    - Chain-of-Custody (COC) Forms; see the Sample Chain of Custody Standard Operating Procedure (SOP) for reference (Arcadis 2017a);
    - Appropriate transport containers (coolers) with ice and appropriate labeling, no blue ice;
- Decontamination/Waste Management:
    - PFAS-free decontamination fluids and equipment
        - HDPE or PVC brushes and squirt bottles, stainless steel bowl
        - HDPE buckets to hold decontamination fluids
        - Alconox or Liquinox (other detergents prohibited)
        - Methanol or isopropyl alcohol, if necessary
        - Distilled or laboratory-supplied deionized water
        - Laboratory provided PFAS-free water

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    - See the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a) or the Groundwater and Soil Sampling Equipment Decontamination TGI (Arcadis 2017b) for additional guidance;
    - Portable field hand washing setup;
    - Non-hazardous drum labels as required for investigation-derived waste handling: see the Investigation-Derived Waste Handling and Storage TGI for details (Arcadis 2017c).
- Field Notes:
    - Pens, pencils, and/or Sharpies® for writing;
    - Appropriate field forms; consider including a photo of the well head and a Google Earth map showing the well location.
    - Clipboards, field binders, field notebook, and field note pages that are not waterproof;
    - Digital camera.
- Other:
    - Field clothing made of cotton or other natural fibers that is well laundered (i.e., washed at least 6 times)
    - Well laundered cotton blankets for covering field vehicle seats
    - PFAS-free sunscreen and insect repellant
    - Garbage bags;
    - Paper towels;
- Locks and keys for securing the well after installation;
- Engineer's tape/measuring wheel;

Prior to mobilizing to the site, ARCADIS personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary by project, and so communication with the driller is necessary to ensure that the materials provided will meet the project objectives. Equipment/materials typically provided by the driller could include:

- Disposable acetate (or Lexan ™) liners (when drilling with direct-push equipment);
- Drums for investigation derived waste;
- Drilling and sampling equipment decontamination materials;
- Decontamination pad materials;
- Well construction materials.

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5 CAUTIONS

5.1 Utility Clearance

The appropriate drilling authorities will be contacted and a site visit for public utility line clearance at the proposed boring locations will be conducted at least 72 hours prior to work commencing. As applicable, utility maps will be reviewed during field reconnaissance of the proposed inspection locations to determine if any are co-located with public utility lines. Arcadis will also contract an independent geophysical survey company to verify that proposed boring locations are not co-located with existing underground utility/substructure features, as necessary. Arcadis will clear locations with soft dig methods to assess the presence of underground utilities as necessary. See the Utility Location and Clearance Arcadis Health and Safety Standard (Arcadis 2017d) for reference.

5.2 General Drilling and Well Construction Considerations

Prior to beginning field work, contact the project technical team to ensure that all field logistics (e.g., access issues, health and safety issues, communication network, schedules, etc.) and task objectives are clearly understood by all team members.

Some regulatory agencies require a minimum annular space between the well or permanent casing and the borehole wall. When specified, the minimum clearance is typically 2 inches on all sides (e.g., a 2-inch diameter well requires a 6-inch diameter borehole). In addition, some regulatory agencies have specific requirements regarding grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling and well installation plan.

If dense non-aqueous phase liquids (DNAPL) are known or expected to exist at the site, refer to the project specific documents for additional details regarding drilling and well installation to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquids (LNAPLs) are known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Consider the compatibility between the well materials and the surrounding environment. For example, PVC well materials are not preferred when DNAPL is present. In addition, some groundwater conditions leach metals from stainless steel or are corrosive to metal well materials. If questions arise, contact the CPM and/or project technical lead to discuss.

Specifications of materials used for backfilling the borehole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPLs are likely to be present or in groundwater with high salinity. In these situations, neat cement grout is preferred.

As noted above, coated bentonite pellets will not be used in monitoring well construction, as the coating could impact the water quality in the completed well.

Heat of hydration during neat cement grout curing must be considered to avoid damage to PVC well materials. The annular space for a typical monitoring well is small enough that heat of hydration should

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not create excessive temperature increases which may damage PVC well material. However, washouts in the borehole can lead to thick accumulations of grout which can produce enough heat during curing to weaken and potentially damage PVC casing. If heat of hydration is a concern, contact the project technical lead to address the issue.

5.3 PFAS-Specific General Sampling Considerations

This section provides a summary of methods and procedures applicable to the collection of environmental samples for field screening or laboratory analysis during PFAS site characterization activities. 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. For example, Teflon™ and other fluoropolymer containing materials are found in pumps, tubing, and sample storage containers and therefore should be avoided (Department of Environment Regulation [DER], Western Australia 2016; New Hampshire Department of Environmental Services [NHDES] 2016). Certain field documentation materials such as waterproof paper or field books, adhesive paper products, and some writing utensils (grouped as non-Sharpie® markers) are also prohibited items during PFAS sampling (DER 2016; NHDES 2016).

New nitrile gloves should be donned before any of the following activities:

- Decontamination of re-usable sampling equipment;
- Contact with sample bottles or PFAS-free water bottles;
- Handling clean sample tubing/down-well equipment or connecting tubing;
- Handling QC samples including field blanks and equipment blanks.

Additionally, new nitrile gloves should also 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.**

Prior to initiating field activities, water sources to be used during drilling activities (e.g., rotosonic drilling, should be sampled to verify those sources are PFAS-free. While not part of the PQAPP, this is considered best practice and should be completed to the extent possible.

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:

- Keep field notes, writing implements, and electronic data collection tablets away from samples and sampling materials; and,
- Do not write on sampling bottles unless they are closed.

Tables 1 and **2** in **Attachment 1** provide recommendations for PFAS Site Inspection equipment. **Table 1** provides a summary of materials that have been approved for site inspection; this list is expected to grow longer as industry experience increases. **Table 2** 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 PFASs and/or retaining PFASs, these recommendations are considered preliminary and subject to change.

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Given the extremely low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFASs, field personnel are typically advised to err on the side of caution by strictly following field wear guidelines and decontamination procedures as specified in the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a). **The most important consideration during PFAS related drilling and soil sampling is to prevent contact between sample media and suspect PFAS sources.**

5.4 PFAS-Specific Soil Sampling

Equipment that contacts soil cuttings during sampling activities should be carefully considered and selected. PFAS-containing materials are potentially present in some of the equipment typically used for soil sampling. This includes any lubricants, connections, fittings, etc. used on the cutting shoe on the head of a direct push drill string. Additionally, no materials that pose a cross-contamination risk should be introduced to the bucket of a hand auger. **To minimize the risk of cross-contamination, all hand augering activities (i.e. augering, sample collection, decontamination) should be performed by Arcadis personnel (as opposed to drilling subcontractor) when surface soil samples will be collected**. Each piece of reusable drilling/sampling equipment that comes into direct contact with soil cuttings or groundwater must be inspected before use to confirm that PFAS-containing materials are not present, which could be a source of cross-contamination and cause false positives, and that PFASs will not adhere to the material, which has the potential to cause low bias sample results. If equipment cannot be verified as being PFAS-free and there is a concern that it could potentially introduce contamination, a conservative number of equipment blanks should be collected to confirm that materials in the sample equipment do not cause false positives by introducing PFASs. Other quality assurance methods may be implemented to avoid materials that could result in potential losses associated with PFASs adhering to surfaces. For example, collecting soil samples for laboratory analysis from an “undisturbed” portion of a large diameter soil core is a good practice.

The following additional notes are provided regarding soil sampling materials:

- Where drilling or decontamination water is needed, a sample of the source water must be collected and analyzed for PFAS before drilling begins to ensure that background PFASs will not be introduced. Some water systems may be constructed with PFAS-containing thread and gasket sealants; therefore, an inspection of the source water distribution system may provide an additional level of assurance for identifying a source of PFAS-free water for site inspections.
- It is often standard practice to cover the ends of sample sleeves and protect the sample from potential cross-contamination from the plastic end caps with Teflon™ or other PTFE tape (Geotechnical Services, Inc. 2018); this practice is prohibited for PFAS sample collection (DER 2016).
- Lexan™ liner sleeves are made of polycarbonate and they are not expected to contain PFASs based on review of the Safety Data Sheet (Sabic 2016).
- Acetate (i.e., cellulose acetate butyrate) liners are commonly used as sleeves and are not expected to contain PFASs.

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- Studies evaluating the use of stainless steel indicate that PFASs do not strongly sorb to stainless-steel (Obal et al. 2012). Therefore, stainless-steel sleeves and equipment should be acceptable for collection of soil samples for PFAS analysis.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with drilling, soil sampling, and monitoring well installation will be performed in accordance with the SSHP, a copy of which will be present on site during such activities.

7 PROCEDURE

The procedures for drilling, soil sampling, and installing groundwater monitoring wells (if necessary), are presented below. All field sampling should be completed by a two-person team, with one collecting the samples, and the other handling documentation and providing support. This will help to limit the potential for accidental cross-contamination of the sample media.

7.1 Direct Push Technology (DPT) Method

Direct-push drilling may be used to complete soil borings and install monitoring wells. Examples of this technique include the Diedrich ESP vibratory probe system, GeoProbe®, or AMS Power Probe® dual-tube system. Environmental probe systems typically use a hydraulically operated percussion hammer. Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff to medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual-tube liner for sampling soil. The outside diameter (OD) of the outer casing ranges from 1.75 to 2.4 inches and the OD of the inner sampling tube ranges from 1.1 to 1.8 inches. The outer casing isolates shallow layers and permits the unit to continue to probe at depth. The double-rod system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, the inside diameter (ID) of the steel casing provides clearance for the installation of small-diameter (e.g., 0.75- to 1-inch ID) micro-wells. The procedures for drilling, soil sampling, and installing monitoring wells (if necessary) in soil using the direct-push method are described below.

1. Place LDPE plastic sheeting over core/sampling processing area to create a clean working surface, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
2. Clear the ground surface of brush, root mat, grass, leaves, or other debris prior to sampling.
3. Decontaminate all non-disposable sampling equipment/tooling that will or may to come into direct contact with soil prior to first use. Disposable sampling equipment must be kept in sealed PFAS-free packaging until it is used.
4. Use stainless-steel hand auger to collect samples from 0 - 5 ft bgs surface interval, if applicable. All hand auguring to collect soil samples will be completed by Arcadis personnel, not the drilling subcontractor. These samples can be collected either during other Utility Clearance activities (e.g., third party clearance) or immediately prior to drilling.
    a. The sample should be collected manually directly from the hand auger bucket (using stainless steel scoop, spatula, or trowel as necessary) and placed directly into the sample

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jar, following Steps 7 – 15 below. The sample should not contact the ground or LDPE sheeting.

b. If collecting multiple samples from the same boring, after collecting sample from the surface or shallowest depth interval examine the stability of the soil in the boring sidewalls. If sidewalls appear to be at risk of collapsing into the borehole insert a length of polyvinyl chloride (PVC) pipe into the boring to maintain the opening and prevent collapse prior to augering to the next deeper sampling interval.

5. If using direct push drilling method, use dual tube rod system and collect soil cores in acetate or Lexan™ liners. The cutting shoe and core extractor must be stainless steel with no PFAS-containing materials present (e.g., gaskets, coatings).
6. After each drilling run, drillers extract and cut open liners and provide to Arcadis personnel for characterization and sampling. Drillers must not touch soil inside of liners during this process. Arcadis personnel decontaminate cutter between uses (see below).
7. Don a new set of nitrile gloves prior to handling sample core, then characterize soils in accordance with P-04 TGI - Soil Description (Arcadis 2018b). Record descriptions in the field notes, boring logs, and/or personal digital assistant (PDA). It is also beneficial to photo document the samples. It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data.
8. Don a new set of nitrile gloves prior collecting soil samples for analysis. Do not use gloved hands to handle papers, pens, clothes, etc., before collecting samples. Do not touch outside of sample liner with gloved hands.
9. Collect field samples and any required QC samples from recovered soil cores using a clean stainless-steel trowel and place in clean, labeled bottles supplied by the laboratory for the required analyses. If collecting samples for multiple analyses, collect PFAS samples first. Make sure caps remain on PFAS sample bottles until immediately prior to filling. Caps must remain in the hand of the sampler until replacing on the bottle.
10. Once the sample has been placed in the bottle, and the bottle cap has been completely tightened, label the sample with sample identification number, date, and time of collection. Labels must be completed only after the caps have been placed back on each bottle. (See P-01 QP#3.06 Field Activities documentation for sample label information).
11. Place soil sample bottles in a sealed Ziploc© bag, and then into sample coolers. Store PFAS samples in separate cooler from other samples.
12. Record the label information and time of sampling in the field notes and sampling forms.
13. Fill out laboratory COC and check against the labels on the sample bottles progressively after each sample is collected.
14. Decontaminate all reusable sampling equipment between sample intervals and borings as described in Section 10.
15. Repeat Steps 7 – 14 until all samples have been collected from the boring location.
16. Abandon soil boring to grade in accordance with the site-specific work plan upon completion and before moving to the next boring location. **If well is to be installed, see Section 7.1.1 for well construction procedure**.
17. Mark boring location with wooden stake that identifies boring ID for subsequent surveying, as necessary.

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18. Manage investigation-derived-waste (IDW) as specified in Section 8 and in accordance with the site-specific work plan.
19. If samples are not shipped the same day as collected, add fresh ice to sample coolers at the end of the day to maintain the temperature between 0 and 6°C. Place ice in sealed Ziplock® bags. Do not use blue ice. Sample coolers must remain in the possession of the sampling team at all times or secured under lock and key until shipment to the laboratory.

7.1.1 DPT Monitoring-Well Construction

1. Upon advancing the borehole to the desired depth, install the well through the inner drill casing. The well will consist of 2-inch ID PVC or stainless-steel slotted screen and blank riser. Screen length and construction will be specified in the Work Plan or discussed with the Arcadis PM.

2. When the monitoring well assembly has been set in place, place a washed silica filter pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen (following specifications in the Work Plan) using a tremie pipe. The filter pack is placed, and drilling equipment (i.e., rods) extracted in increments until the top of the sand pack is at the appropriate depth. Verify that the expected volume of filter pack matches with the actual amount installed. There can be differences due to irregularities in the borehole. Washout of the borehole will result in the need for greater than calculated well materials. If a difference of more than 10% is noted, consult with the project technical team. The filter pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan. The well should be gently surged to prevent filter pack material bridging and to settle the filter pack prior to well seal installation.

    a. Alternately, a monitoring well assembly with a pre-packed screen can be installed. The monitoring well assembly (i.e., regular PVC or pre-packed) should be discussed and decided prior to beginning field work and specified in the QAPP addendum. Pre-packed filters should be verified as PFAS-free prior to use.

3. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack (alternatively, in some cases a fine sand seal may be installed instead of bentonite—follow the specifications in the Work Plan). Use of a tremie pipe is not required for placement of the bentonite seal (though may be required if a well is very deep and borehole bridging is reasonably anticipated). However, bentonite should be poured into the annular space slowly enough to ensure borehole bridging does not occur. If non-hydrated bentonite is used, the bentonite should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. *No coated bentonite pellets will be used in monitoring well drilling or construction*. PFAS-free water (verified by laboratory analysis of source water) should be added to hydrate the bentonite if the seal is above the water table. Continuously monitor the placement of the sand pack and bentonite with a weighted tape measure.

4. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 ft bgs or as

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specified in the Work Plan. As with the filter pack, it is recommended that seal material be placed with a tremie pipe. Ensure that seal materials are mixed at the proper ratios with PFAS-free water (verified by laboratory analysis of source water) following manufacturer's recommendations.

5. Install the monitoring well completion as specified in the Work Plan. Typical completions are a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing set within a neat cement pad at grade. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing set within a neat cement pad. In either case, the cement pad will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing and should slope gently away to promote drainage away from the well.

6. During well installation, record construction details and tabulate materials used in field notebook as well as appropriate field forms.

7. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section 8 below.

7.2 Rotosonic Drilling Methods

Rotosonic drilling produces soil cores that, for the most part, are relatively undisturbed, but note that when drilling in consolidated or finer-grained sediment the vibratory action during core barrel advancement may create secondary fractures or breaks.

1. Place LDPE plastic sheeting over core/sampling processing area to create a clean working surface, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
2. Clear the ground surface of brush, root mat, grass, leaves, or other debris prior to sampling.
3. Decontaminate all non-disposable sampling equipment/tooling that will or may to come into direct contact with soil prior to first use. Disposable sampling equipment must be kept in sealed PFAS-free packaging until it is used.
4. Use stainless-steel hand auger to collect samples from 0 - 5 ft bgs surface interval, if applicable. All hand augering to collect soil samples will be completed by Arcadis personnel, not the drilling subcontractor. These samples can be collected either during other Utility Clearance activities (e.g., third party clearance) or immediately prior to drilling.
    a. Hand auger soil sample should be collected manually from the hand auger bucket (using stainless steel scoop, spatula, or trowel as necessary) and placed directly into the sample jar. The sample should not contact the ground or LDPE sheeting.
    b. If sampling by hand auger, after collecting sample from the surface or shallowest depth interval examine the stability of the soil in the boring sidewalls. If sidewalls appear to be at risk of collapsing into the borehole insert a length of polyvinyl chloride (PVC) pipe into the boring to maintain the opening and prevent collapse prior to augering to the next deeper sampling interval.

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5. During rotosonic drilling, drillers extract soil core bags after each drilling run, place the core bag onto LDPE sheeting, and cut open bags so Arcadis personnel can perform characterization and sampling. Arcadis personnel should confirm with drilling subcontractor that core bags are constructed of PFAS-free material. Drillers must not touch soil inside of bags during this process. Arcadis personnel decontaminate cutter between uses (see below).
6. Don a new set of nitrile gloves prior to collecting each sample. Do not use gloved hands to handle papers, pens, clothes, etc., before collecting samples. Do not touch outside of sample bag with gloved hands.
7. During sampling, characterize soils in accordance with P-04 TGI - Soil Description (Arcadis 2018b). Record descriptions in the field notes, boring logs, and/or personal digital assistant (PDA). It is also beneficial to photo document the samples. It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data.
8. Collect sample volumes from recovered soil cores using a clean stainless-steel trowel and place in clean, labeled bottles supplied by the laboratory for the required analyses (see sample container list in PQAPP Worksheets #19&30). Make sure caps remain on PFAS sample bottles until immediately prior to filling. Caps must remain in the hand of the sampler until replacing on the bottle.
9. Once the sample has been placed in the bottle, and the bottle cap has been completely tightened, label the sample with sample identification number, date, and time of collection. Labels must be completed only after the caps have been placed back on each bottle. (See P-01 QP#3.06 Field Activities documentation for sample label information).
10. Collect QC samples at frequency specified in PQAPP Worksheet #20. QC sample locations to be selected based on consultation with Arcadis RL.
11. Place soil sample bottles in a sealed Ziploc© bag, and then into sample coolers. Store PFAS samples in separate cooler from other samples.
12. Record the label information and time of sampling in the field notes and sampling forms.
13. Fill out laboratory COC and check against the labels on the sample bottles progressively after each sample is collected.
14. Abandon all soil borings to grade as specified in the QAPP Addendum upon completion and before moving to the next boring location. **If well is to be installed, see Section 7.2.1 for well construction procedure**.
15. Mark boring location with wooden stake that identifies boring ID for subsequent surveying, as necessary.
16. Manage investigation-derived-waste (IDW) as specified in site-specific work plan.
17. If samples are not shipped the same day as collected, add fresh ice to sample coolers at the end of the day to maintain the temperature between 0 and 6°C. Place ice in sealed polyethylene bags (Ziplock). Do not use blue ice. See QAPP worksheet #19 and 30 for sample containers, preservation and hold times. Sample coolers must remain in the possession of the sampling team at all times or secured under lock and key until shipment to the laboratory.

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7.2.1 Monitoring Well Construction

1. If it is necessary to install a monitor well into a permeable zone below a confining layer, particularly if the deeper zone is believed to have water quality that differs significantly from the zone above the confining layer, then a telescopic well construction will be considered. In this case, the borehole is advanced approximately 3 to 5 feet into the top of the confining layer, and a permanent casing (typically PVC, black steel or stainless steel) is installed into the socket drilled into the top of the confining layer. The casing is then grouted in place. Grout should be mixed with PFAS-free water (verified by laboratory analysis of source water). The preferred methods of grouting telescoping casings include: pressure-injection grouting using an inflatable packer installed temporarily into the base of the casing, such that grout is injected out the bottom of the casing until it is observed at ground surface outside the casing; displacement-method grouting (also known as the Halliburton method), which entails filling the casing with grout and displacing the grout out the bottom of the casing by pushing a drillable plug, typically made of wood to the bottom of the casing, following by tremie grouting the remainder of the annulus outside the casing; or tremie grouting the annulus surrounding the casing using a tremie pipe installed to the base of the borehole. In all three cases, the casing is grouted to the ground surface, and the grout is allowed to set prior to drilling deeper through the casing. Site-specific criteria and work plans should be created for the completion of non-standard monitoring wells, including telescopic wells.

2. Before installing a screened well, it is important to confirm that the borehole has been advanced into the targeted saturated zone. This is particularly important for wells installed to monitor the water table and/or the shallow saturated zone, as the capillary fringe may cause soils above the water table to appear saturated. If one or more previously installed monitoring wells exist nearby, use the depth to water at such well(s) to estimate the water-table depth at the new borehole location.

   To verify that the borehole has been advanced into the saturated zone, it is necessary to measure the water level in the borehole. For boreholes drilled using water (e.g., Rotosonic), monitor the water level in the borehole as it re-equilibrates to the static level. In low-permeability units like clay, fine-grained glacial tills, shale and other bedrock formations, it may be necessary to wait overnight to allow the water level to equilibrate. Document depth to water in the borehole on the appropriate field forms and field notebook. If there are questions concerning the depth of the well/screen interval, consult with the project technical lead or PM prior to finalizing well depth/screen interval. To the extent practicable, ensure that the depth of the well below the apparent water table is deep enough so that the installed well can monitor groundwater year-round, accounting for seasonal water-table fluctuations. When in doubt, err on the side of slightly deeper well installation.

3. Upon completing the borehole to the desired depth, if a screened well construction is desired, install the monitoring well by lowering the screen and solid PVC risers through the augers or casing. Monitoring wells typically will be constructed of 2-inch-diameter (although sometimes 4-inch), flush-threaded PVC or stainless steel slotted or wire wrapped well screen and blank riser

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casing. Smaller diameters may be used if multiple wells are to be installed in a single borehole. The screen length will be specified in the Work Plan (or equivalent) based on regulatory requirements and specific monitoring objectives. Monitoring well screens should be limited to 5 to 10 feet long. The screen length will depend on the purpose for the well and the objectives of the groundwater investigation and will (in most cases) be determined prior to the field mobilization.

The slot size and filter pack gradation should be predetermined in the Work Plan (or equivalent) based on site-specific grain-size analysis (sieve analysis) or other geologic considerations or monitoring objectives. Typically, slot sizes for monitoring wells will range from 0.010 inches to 0.020 inches while the filter pack will be 20-40, Morie No. 0, or equivalent. In very fine-grained formations where sample turbidity needs to be minimized, it may be preferred to use a 0.006-inch slot size and 30-65, Morie No. 00, or equivalent filter pack. Alternatively, where monitoring wells are installed in coarse-grained deposits and higher well yield is required, a 0.020-inch slot size and 10-20, Morie No. 1, or equivalent filter pack may be preferred. If the screen slot size and filter pack have not been based on site-specific grain-size analysis, consider collecting soil samples during well installation so future wells can be properly designed.

Alternately, a monitoring well assembly with a pre-packed screen can be installed. The monitoring well assembly (i.e., regular PVC or pre-packed) should be discussed and decided prior to beginning field work and specified in the QAPP addendum. Pre-packed filters should be verified as PFAS-free prior to use.

A blank riser will extend from the top of the screen to approximately 2.5 feet above grade or, if necessary, just below grade where conditions warrant a flush-mounted monitoring well. For wells greater than 50 feet deep, centralizers may be desired to assist in centering the monitoring well in the borehole during construction.

4. When the monitoring well assembly has been set in place, place a washed silica filter pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen (following specifications in the Work Plan) using a tremie. The filter pack is placed, and drilling equipment extracted in increments until the top of the sand pack is at the appropriate depth. Verify that the expected volume of filter pack matches with the actual amount installed. There can be differences due to irregularities in the borehole. Washout of the borehole will result in the need for greater than calculated well materials. If a difference of more than 10% is noted, consult with the project technical team. The filter pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan (or equivalent). The well should be gently surged to prevent filter pack material bridging and to settle the filter pack prior to well seal installation.

5. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack (alternatively, in some cases a fine sand seal may be installed instead of bentonite—follow the specifications in the Work Plan). Use of a tremie pipe is not required for placement of the bentonite seal (though may be required if a well is very deep and borehole

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bridging is reasonably anticipated). However, bentonite should be poured into the annular space slowly enough to ensure borehole bridging does not occur. If non-hydrated bentonite is used, the bentonite should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. *No coated bentonite pellets will be used in monitoring well drilling or construction*. PFAS-free water (verified by laboratory analysis of source water) should be added to hydrate the bentonite if the seal is above the water table. Continuously monitor the placement of the sand pack and bentonite with a weighted tape measure.

6. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 ft bgs or as specified in the Work Plan (or equivalent). As with the filter pack, it is recommended that seal material be placed with a tremie pipe. Ensure that seal materials are mixed at the proper ratios with PFAS-free water (verified by laboratory analysis of source water) following manufacturer's recommendations.

7. Install the monitoring well completion as specified Work Plan (or equivalent). Typical completions are a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing and secure with a neat cement seal. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing and secure with a neat cement seal. In either case, the cement seal will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing and should slope gently away to promote drainage away from the well.

8. Monitoring wells should be labeled using indelible ink or paint with the appropriate designation on both the inner and outer well casings or inside of the curb box lid. Use caution when labeling the well as paint or indelible ink could potentially contain PFAS materials.

9. When an above-grade completion is used, the riser will be sealed using an expandable locking plug and the top of the well will be vented by drilling a small-diameter (1/8 inch) hole near the top of the well casing or through the locking plug, or by cutting a vertical slot in the top of the well casing. When a flush-mount installation is used, the riser will be sealed using an unvented, expandable locking plug.

10. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook as well as appropriate field forms.

11. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section 8 below.

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8 WASTE MANAGEMENT

Investigation-derived waste (IDW) including soil cuttings, purge water, and decontamination water generated during cleaning procedures will be collected and placed in Department of Transportation approved containers, segregated by waste streams: see the Investigation-Derived Waste Handling and Storage TGI for details (Arcadis 2017c). All containers will be labeled as non-hazardous unless otherwise instructed by the project manager. 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 (QAPP addendum) and will be consistent with applicable Army policies and Army post requirements. Personal protective equipment (e.g., gloves, disposable clothing, disposable equipment) resulting from personnel cleaning procedures and soil sampling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

9 DATA RECORDING AND MANAGEMENT

The supervising field lead will be responsible for documenting drilling events to record all relevant information in a clear and concise format. The record of drilling events should include:

- Start and finish drilling dates;
- Project name and location;
- Project number, client, and site location;
- Boring number and depths;
- Soil descriptions;
- Depth to water;
- Well construction specifications, if applicable (screen and riser material and diameter, sump length, screen length and slot size, riser length, sand pack type);
- Quantities of materials used (e.g., bentonite, grout);
- Type of drilling tools used (e.g., rig type);
- Core barrel size;
- Names of contractor's drillers, inspectors, or other people onsite; and,
- Weather conditions.

Field staff should ensure COC Forms are properly completed, and verify which PFAS analytes (e.g., just PFOS and PFOA, some or all of the modified method 537 target analyte list) are required for analysis and note on the COC.

All documents (and photographs) should be scanned and electronically filed in the appropriate project directory for easy access. In addition, the locations of newly-installed wells will be documented

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photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

The well location, ground surface elevation, and inner and outer casing elevations will be surveyed using the method specified in the site Work Plan. Generally, a local baseline control will be set up. This local baseline control can then be tied into the appropriate vertical and horizontal datum, such as the National Geodetic Vertical Datum of 1929 or 1988 and the State Plane Coordinate System. At a minimum, the elevation of the top of the inner casing used for water-level measurements should be measured to the nearest 0.01 foot. Elevations will be established in relation to the National Geodetic Vertical Datum of 1929. A permanent mark will be placed on top of the inner casing to mark the point for water-level measurements.

10 DECONTAMINATION

To avoid cross-contamination during drilling and sampling, all reusable groundwater sampling equipment that has or is suspected to have come into contact with groundwater or soil will be decontaminated between each sample using the following steps. If Class B firefighting foam is a suspected PFAS source at any sampling location, then these steps should be performed twice.

- Don new pair of Nitrile gloves prior to decontamination
- Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox) and plastic brush;
- Double-rinse in potable deionized or distilled water;
- Rinse once with methanol or isopropyl alcohol;
- Rinse once with laboratory-certified PFAS-free water;
- Collect all rinsate in a sealed pail for disposal
- Allow time for equipment to air dry prior to re-use.

While strongly recommended, the use of solvents may be excluded for project-specific H&S concerns. If solvents are prohibited after DQO development, 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.

Additionally, the following decontamination procedure could be utilized when organic solvent use is not possible.

- Don new pair of Nitrile gloves prior to decontamination
- Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox) and plastic brush;
- Single-rinse in potable deionized or distilled water;
- Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox) and plastic brush;

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- Rinse twice with deionized water and once with PFAS-free water;
- Collect all rinsate in a sealed pail for disposal
- Allow time for equipment to air dry prior to re-use.

Drive casings and other drilling tooling will be steam cleaned or replaced with new equipment between boreholes. Steam cleaning will be performed by the drillers within a temporary decontamination or other containment area designated by the supervising engineer or geologist that is located outside of the work zone. All decontamination water will be collected and containerized for disposal.

See additional specifics in P-04, TGI - Groundwater and Soil Sampling Equipment Decontamination in PQAPP Appendix A.

11QUALITY ASSURANCE

In general, the following quality assurance and quality control (QA/QC) samples should be collected:

- Equipment blanks
- Field (i.e., reagent) blanks
- Field duplicates
- Matrix spike/matrix spike duplicate

Details on QC sampling requirements (e.g., frequency of collection, types of QA/QC samples) are provided in the PQAPP and will be outlined in various Site-specific sampling scopes of work in the QAPP Addendum. Additionally, detailed procedures related to equipment and field (i.e., reagent) blank sample collection are outlined in the Equipment and Reagent Blank Sample Collection TGI (Arcadis 2018c). In general, equipment blanks should be collected from every piece of downhole equipment that could come in contact with soil or groundwater during sample collection. This includes all downhole tooling (e.g., drill bits, drill rods).

Prior to initiating field activities, water sources to be used during drilling and well construction activities should be sampled to verify those sources are PFAS-free. While not part of the PQAPP, this is considered best practice and should be completed to the extent possible.

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 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.**

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12 REFERENCES

American Society for Testing Materials (ASTM), Designation D5092-04. *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. American Society for Testing Materials. West Conshohocken, Pennsylvania.

American Society of Testing and Materials (ASTM) D 1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*. American Society for Testing Materials. West Conshohocken, Pennsylvania.

Arcadis. 2018a. TGI – Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance. Rev. 2. October 15.

Arcadis. 2018b. TGI – Soil Description. Rev. #2. February 16.

Arcadis. 2018c. TGI – Equipment and Reagent Blank Sample Collection for PFAS Analysis. Rev. #0. October 2.

Arcadis. 2017a. SOP – Sample Chain of Custody, Rev. #1. May 23.

Arcadis. 2017b. TGI – Groundwater and Soil Sampling Equipment Decontamination, Rev. #0. February 23.

Arcadis. 2017c. TGI – Investigation-Derived Waste Handling and Storage, Rev. #0. February 23.

Arcadis. 2017d. Utility Location and Clearance, Rev. #16. March 17.

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Department of Environment Regulation (DER). Government of Western Australia. 2016. Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS). Contaminated Sites Guidelines. February.

Massachusetts Department of Environmental Protection (MassDEP). 2017. DRAFT Fact Sheet, Guidance on Sampling and Analysis for PFAS at Disposal Sites Regulated under the Massachusetts Contingency Plan. January.

New Hampshire Department of Environmental Services (NHDES). 2016. Perfluorinated Compound (PFC) Sample Collection Guidance. November.

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ATTACHMENT 1

Table 1 and Table 2: PFAS Inspection Material Recommendations

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

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™	Low density polyethylene (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 inspections	--
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		
Sharpie®	--	NHDES 2016; USACE 2016; MassDEP 2017
Ball point pens	--	MassDEP 2017
Standard paper and paper labels	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Decontamination		
Water-only decontamination	Confirm PFAS-free water source via laboratory analysis prior to inspections	DER 2016
Alconox®, Liquinox® or Citranox® followed by deionized water or PFAS-free water rinse	Alconox® known to contain trace levels of 1,4-dioxane	NHDES 2016; USACE 2016; MassDEP 2017
Methanol, isopropanol, or acetone	Special health and safety precautions are necessary	UNEP 2015; USACE 2016

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 2: Summary of Equipment and Materials Not Recommended for PFAS Site Inspections

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFASs	References
Water Sampling Materials				
Teflon® or polytetrafluoroethylene (PTFE)-containing or coated field equipment (e.g., tubing, bailers, tape, plumbing paste)	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				
Aluminum foil			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Drilling fluid containing PFASs	x	x		DER 2016
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
Non-Sharpie® markers		x		NHDES 2016
Decontamination				
Some detergents and decontamination solutions (e.g., Decon 90® Decontamination Solution)	x	x		DER 2016; NHDES 2016; MassDEP 2017

N**ote**: For materials that are suspected of containing PFASs, or have the potential to retain PFASs, 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.

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

Rev: 9

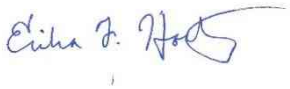
Rev Date: October 22, 2021

Version Control

Issue	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

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
	9	October 20, 2021	Most pages have been updated.	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 California State Water Board PFAS Sampling Guidance. TGI formatted to comply with new QMS TGI template and Arcadis brand compliance.	Kevin Engle, Erika Houtz

Approval Signatures

Prepared by:		10/22/2021
	Kevin Engle, PG Geologist (Preparer)	Date
Reviewed by:		10/22/2021
	Erika F. Houtz, PhD, PE (Subject Matter Expert)	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 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.

2 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.

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™	Low density polyethylene (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		
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
Methanol, isopropanol, or acetone	Special health and safety precautions are necessary	UNEP 2015; USACE 2016
Sun and Biological Protection		

Sampling Materials	Additional Considerations	References
OFF Deep Woods, Sawyer Permethrin	Apply >10 m away from sampling area	MDEQ 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				
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				
Aluminum foil			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Drilling fluid containing PFAS	x	x		DER 2016
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

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

3 Personnel Qualifications

3.1 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.

3.2 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.**

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 fine/ultra-fine point 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 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;
- Methanol, isopropanol, or acetone if able to be brought safely to field site; especially important for decontamination during soil sampling;
- Alconox or Liquinox®;
- Packing and shipping materials;
- Groundwater and/or 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 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.
- 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. If at all possible, Gore-Tex footwear should not be worn and 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. 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 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.

5.4 Visitors

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

6 Health and Safety Considerations

6.1 Biological and Environmental Hazard Controls

6.1.1 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

- OFF Deep Woods
- Sawyer Permethrin

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:

- Insect repellents and sunscreen should be applied away from the work area prior to initiating sampling.
- When re-applying, stay at least 10 m away from the sampling locations and equipment.
- Wash hands after application and don new nitrile gloves.

6.1.2 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.

6.1.3 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.

7 Procedure

7.1 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 two times with distilled water or deionized water;
- Rinse one time with “PFAS-free” water or once with methanol/isopropanol/acetone, if it is available, and once with “PFAS-free” water; organic solvents are especially useful for decontaminating soil sampling equipment. If organic cleaning solvents cannot be brought to site, scrub equipment a second time after a single distilled or deionized water rinse, then rinse two times with distilled or deionized water and once 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.

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 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.

7.3.2 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 labeled 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.

7.3.3 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 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 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. 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.
- 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.

7.3.4 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.

7.3.5 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.

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.

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

9 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.

9.1 Field Notes

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.

9.2 Other Project Documentation

- Complete groundwater and/or soil 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 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.**

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). 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.

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 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.

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

- 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 should be used for quantification with isotope-labeled surrogate standards, as available, according to the guidelines of QSM 5.3 Table B-15. The USEPA has two drinking water methods (USEPA Method 537.1 and USEPA Method 533). Method 537.1 does not allow for isotope dilution but USEPA Method 533 requires isotope dilution.
- 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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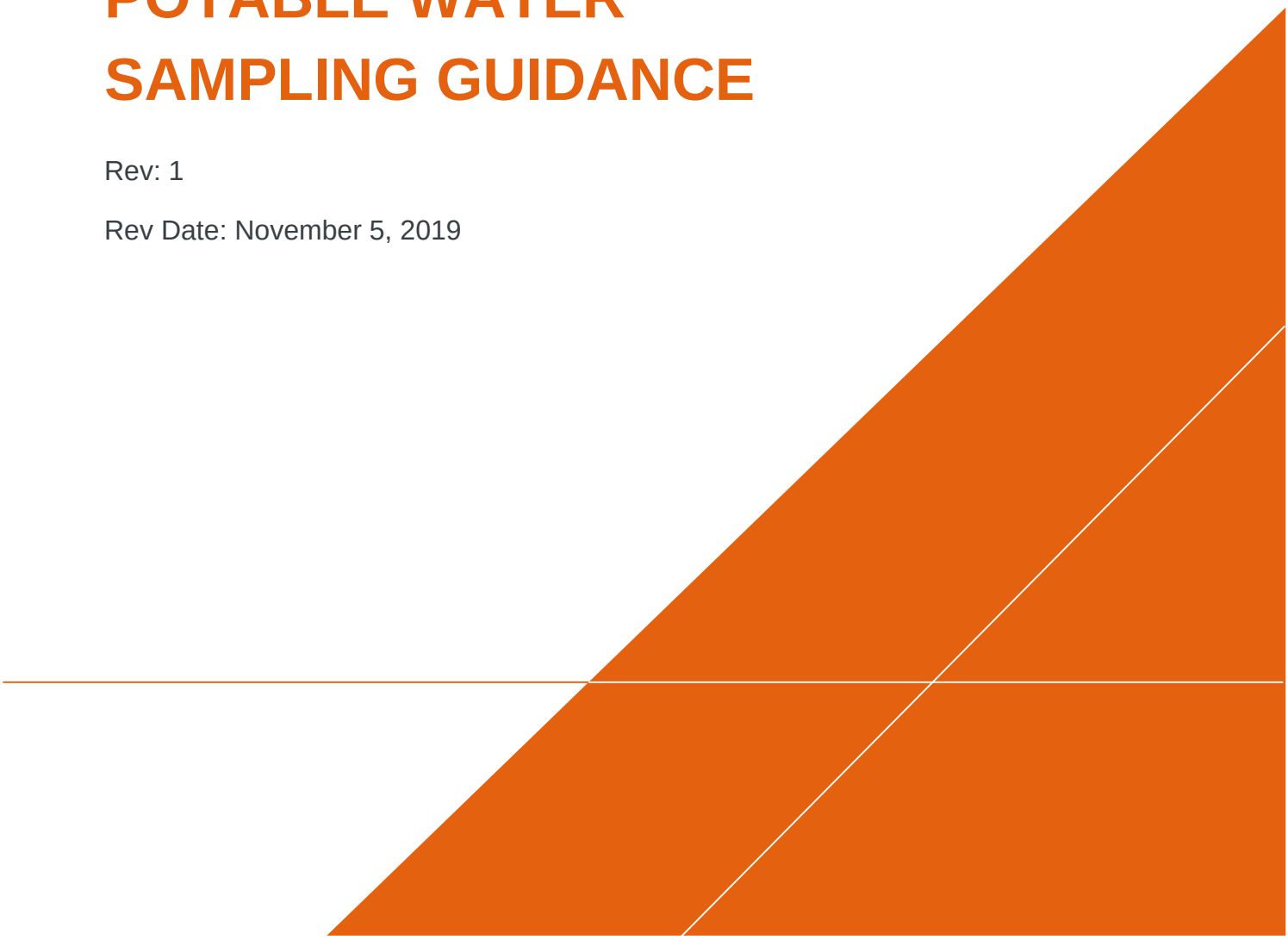
ARCADIS Design & Consultancy for natural and built assets

POLY- AND PERFLUORINATED ALKYL SUBSTANCES (PFAS) POTABLE WATER SAMPLING GUIDANCE

Rev: 1

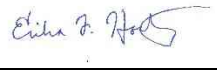
Rev Date: November 5, 2019



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	November 16, 2017	All	Initial Release	Erica Kalve Erika Houtz
1	November 5, 2019	All	General Updates to Sampling TGI, including references to USEPA Method 537.1 Version 1	Lisa Rutkoswki

APPROVAL SIGNATURES

Prepared by:		11/5/2019
	Erika F. Houtz, PhD, PE Environmental Engineer and PFAS Analytical Lead	Date
Reviewed by:		11/16/2017
	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 document is to provide guidance on sampling for poly-and perfluorinated alkyl substances (PFASs) from potable water supplies. This protocol was adapted from various sources including the United States (US) Department of Defense, US Army Corp of Engineers (USACE) Omaha, Transport Canada, US Environmental Protection Agency (US EPA), and Michigan Department of Environment, Great Lakes, and Energy.

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 to mitigate the potential for false detections of PFASs. Specific items related to field sampling for PFASs are discussed in the sections below.

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 must 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

As of this writing, the preferred method to analyze PFAS in drinking water is USEPA Method 537.1 Version 1.0, issued in November 2018. A laboratory accredited by the relevant federal or state accreditation agency for USEPA Method 537.1 Version 1.0 should be used to conduct the PFAS analysis.

These laboratories are examples of laboratories that may be used to analyze potable water for PFASs:

- TestAmerica Eurofins
- SGS
- Vista
- Shealy

Other laboratories may be selected for analysis if they have the appropriate accreditation.

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 guidance document;
- Appropriate health and safety equipment, as specified in the site Healthy and Safety Plan (HASP);
- Pens, pencils, and/or Sharpies® for writing;
- Clipboards, field binders, and field note pages that are not waterproof;
- High-density polyethylene (HDPE) sample bottles fitted with polypropylene or HDPE screw cap only;
- Sample labels;
- Ziploc® bags to hold wet ice and samples;
- Laboratory-supplied PFAS-free water;
- Stainless steel or PVC bailer for samples that cannot be collected out of a tap
- Coolers;
- Wet ice;
- Methanol for cleaning reusable sampling equipment (if available);
- Packing and shipping materials; 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 on site, and eat snacks and meals off site.
- 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 PFASs for stain and water resistance, in particular outdoor performance wear under brand names such as Gore-Tex® or eVent™. 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.
- 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/or 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 increase durability, and may represent a source of trace PFAS. For the health and safety of field personnel, protective footwear must be worn at all times. To avoid potential PFAS contamination:

- Do not touch your safety footwear in the immediate vicinity of the sampling port (i.e., within 2 feet).
- Do not allow gloves used for sampling to come in contact with safety footwear.

Nitrile Gloves

Wear disposable, powderless nitrile gloves at all times. Don a new pair of nitrile gloves **before** the following activities at each sample location:

- Contact with sample bottles or “PFAS-free” water bottles;
- 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:

- Contacting contaminated surfaces; or
- When judged necessary by field personnel.

5.3 Personal Hygiene

Some personal care products may contain PFASs. To minimize potential for cross-contamination from personal care products:

- 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 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 30 feet away). Wash hands after application.

5.4 Visitors

If possible, visitors to the site are to remain at least 30 feet from sampling areas.

6 HEALTH AND SAFETY CONSIDERATIONS

- Field activities must be performed in accordance with the site HASP, a copy of which will be present on site during such activities.
- Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.

7 PROCEDURE

7.1 Sample Collection

Different laboratories may supply sample collection bottles of varying sizes, however all sample bottles should be made of HDPE plastic with polypropylene or HDPE plastic, unlined lids. The laboratory should specify the amount of sample required for the analysis given the anticipated detection levels.

7.1.1 Sample Containers

- Collect samples in HDPE bottles fitted with an unlined (no Teflon™), polypropylene or HDPE screw cap.
- Sample bottles must contain Trizma® preservative if samples are being collected from a chlorinated water source. The laboratory should specify the amount added to the sample container.
- Complete bottle labels after sample collection, once the caps have been placed back on each bottle.
- Do not use glass bottles due to potential loss of analyte through adsorption to glass.

7.1.2 Potable Water Sampling

Before Sample Collection

- Don a new set of powderless 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. Samples bottle caps must remain on the bottle until immediately prior to sample collection, and the bottle must be sealed immediately after sample collection. This will minimize the potential for contamination of the sample. The bottle cap must remain in the other hand of the sampler, until replaced on the bottle. Sample bottles will not be rinsed during sampling.
- Inspect the tap prior to sampling as potable water outfalls and taps are likely to vary.
    - Avoid sampling from any taps fitted with Teflon tape or other PFAS-containing materials. If a sample can only be taken from a tap fitted with PFAS-containing materials, remove these materials prior to sampling if possible. Annotate the presence of these materials in the field notes.
    - Sample from a cold water line only.
    - Whenever possible, remove any attachments from the taps, including aerators, screens, washers, hoses, and water filters. Annotate the presence of these materials in the field notes.
    - Stainless steel and PVC are tap materials that are not expected to bias PFAS results.

During Sample Collection

- If sampling from a tap or port, in accordance with US EPA Method 537.1 sample collection procedures, begin flow from the water source and allow the system to flush for at least 3 minutes. Then, collect the sample under the still running tap.
- If a port or tap is not available to collect the water sample, use a stainless steel or HDPE bailer that has been pre-rinsed with methanol (if available) and PFAS-free water. A pump may be used if needed, but new silicone and/or HDPE outflow tubing should be used for each sample and any wetted pump parts should be decontaminated with methanol (if available) and PFAS-free water.
- Collect the sample into the HDPE bottle until the sample bottle is full to the neck of the bottle. Do not filter and do not overflow the bottle, as the preservative used for chlorinated samples may be lost. Tightly screw on the polypropylene or HDPE cap.

After Sample Collection

- Place each sample bottle in two sealed Ziploc® bags. Another brand of LDPE bag is acceptable.
- Record the sample name and time of sampling on the sample bottle label, in the field notes, and on the COC form. Record notes about the tap, including any attachments, or the conditions of how the sample was collected in the field notes.
- Place samples in coolers that are durable in transportation and keep the temperature between 0 and 4ºC with wet ice until transported to the laboratory. The temperature should not exceed 10ºC during the first 48 hours after sample collection, per USEPA Method 537.1.
- Treat all disposable sampling materials as single use and dispose of them appropriately after sampling at each location.

7.2 Shipping

- If samples cannot be received at the laboratory the next day (e.g., Friday sample collection), delay shipment until samples can be assured to be received. Note that samples must be extracted within 14 days of sample collection, per USEPA Method 537.1. The laboratory has an additional 28 days before the sample extract must be analyzed.
- If samples cannot be shipped the same day as collected, arrange an appropriate means of keeping the samples cool overnight (e.g., a refrigerated room or extra wet ice) and maintain the temperature

between 0 and 4°C. The temperature should not exceed 10ºC during the first 48 hours after sample collection, per USEPA Method 537.1.

- For shipping, store labeled samples in coolers suitable with wet ice stored in Ziploc® bags.
- 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.
- Ship samples via FedEx using priority overnight delivery. Tracking numbers for all shipments should be provided and recorded to ensure their timely delivery.

8 DATA RECORDING AND MANAGEMENT

8.1 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.
- 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.

8.2 Quality Control

Refer to quality control requirements for the project to ensure that appropriate 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.

8.3 Field Duplicates

Project requirements may include the collection of one or more duplicate samples. If required, one field duplicate for every 20 samples collected or one per day, whichever is more frequent, is a typical collection frequency. 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 form and given a sample name such as “duplicate”).

8.4 Field Blanks

QA/QC sampling for PFASs typically includes the submission of one laboratory supplied reagent field blank per day or per site. The PFAS-free water used for the reagent field blank sample is brought to the site in a laboratory-supplied bottle. Field staff should transfer the laboratory-supplied PFAS-free water into an empty sample bottle. This reagent field blank should be placed in the same cooler as other PFAS samples.

If a sampling bailer is used to collect the sample, PFAS-free water may be used to take an equipment blank through the sampler and then collected into a new sampling container.

Trip blanks are not needed, as the PFAS to be analyzed are not volatile.

8.5 Matrix Spike/ Matrix Spike Duplicate

Project requirements may include the collection of one or more matrix spikes or matrix spike duplicates. If required, one matrix spike and matrix spike duplicate for every 20 samples collected or one per day, whichever is more frequent, is a typical collection frequency. Each matrix spike sample will be collected immediately after the unspiked sample into a separate laboratory-provided sample bottle; the matrix spike and its duplicate will each require their own containers. The matrix spike and matrix spike duplicate should be clearly indicated on the laboratory COC, however their location should remain blind. The laboratory will add the appropriate chemical spike once the sample returns to the laboratory.

8.6 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 QA/QC procedures. For potable water, the laboratory should follow the methodology and be accredited for analysis according to US EPA Method 537.1 Version 1. Updated potable water analytical procedures may become available and should be considered at that time.
- 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, typically 20% RPD.

9 REFERENCES

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ARCADIS Design & Consultancy for natural and built assets

PFAS SAMPLING PROCEDURES AND LOW-FLOW GROUNDWATER PURGING FOR MONITORING WELLS

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PFAS SAMPLING PROCEDURES AND LOW-FLOW GROUNDWATER PURGING FOR MONITORING WELLS

REV. # 0

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CONTENTS

1 SCOPE AND APPLICATION

The protocol presented in this methods and procedures document describes the procedures recommended to purge monitoring wells and collect groundwater samples for per- and polyfluoroalkyl substances (PFASs) using low flow sampling with a peristaltic pump. Samples will be analyzed for a specified list of PFASs using a modified version of United States (U.S.) Environmental Protection Agency (USEPA) method 537 following the U.S. Department of Defense and U.S. Department of Energy Quality Systems Manual 5.1 methods and procedures set forth in Table B-15.

This protocol has been developed in accordance with the 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). PFAS sampling guidelines are incorporated from various guidance documents including the United States Army Corps of Engineers (2016), Department of Environment Regulation, Western Australia (2016), New Hampshire Department of Environmental Services (2016), and Massachusetts Department of Environmental Protection (2017). Staff should also review the Arcadis Technical Guidance Instruction (TGI) titled, Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018).

The project team should determine the last time the wells were developed and if additional development is necessary prior to sample collection. Groundwater samples should not be collected within one week following well development.

2 PERSONNEL QUALIFICATIONS

Arcadis personnel providing assistance to groundwater sample collection and associated activities should have a minimum of six months of related experience or an advanced degree in environmental sciences, engineering, hydrogeology, or geology. The supervisor of the groundwater sampling team should have at least one year of previous supervised groundwater sampling experience, preferably with PFAS related experience. Prior to mobilizing to the field, the groundwater sampling team should review and be thoroughly familiar with relevant site-specific documents including but not limited to the site work plan, field sampling plan, Health and Safety Plan (HASP), historical information, and site relevant documents. Additionally, the groundwater sampling team should review and be thoroughly familiar with documentation provided by equipment manufacturers for all equipment that will be used in the field prior to mobilization, in particular to confirm the sample materials that will be in contact with the water sample are compatibile with PFAS sample collection**.**

3 EQUIPMENT LIST

Specific to this activity, the following materials (or equivalent) should be available:

- Health and safety documents and equipment (as identified in the Programmatic Accident Prevention Plan and Site Safety and Health Plan)
- Site Plan, well construction records, prior groundwater sampling records (if available)

- Peristaltic pump (e.g., ISCO Model 150) or bladder pump (e.g., Geotech PFC-Free Portable Bladder Pumps)
- A power supply for the peristaltic pump; peristaltic pumps require electric power from either a generator or a deep cell battery.
- High Density Polyethylene (HDPE) tubing and/or silicon tubing of an appropriate size for the pump being used. When collecting samples for PFASs, Teflon® or polytetrafluoroethylene-containing or coated components or tubing are prohibited.
- HDPE bailers (if necessary)
- Water-level probe with fluorine-free materials (e.g., Geotech ET 3/8" with Delrin tip and Buna-N O-ring)
- Water-quality (temperature/pH/specific conductivity/oxidation reduction potential [ORP]/turbidity/dissolved oxygen [DO]) meter, flow-through measurement cell, and appropriate calibration standards. Several brands may be used, including:
    - YSI 6-Series Multi-Parameter Instrument
    - Horiba U-22 Multi-Parameter Instrument
    - Hydrolab Series 3 or Series 4a Multiprobe and Display
- Supplemental turbidity meter (e.g., Horiba U-10, Hach 2100P, LaMotte 2020). Turbidity measurements collected with multi-parameter meters have sometimes been shown to be unreliable due to fouling of the optic lens of the turbidity meter within the flow-through cell. A supplemental turbidity meter should be used to verify turbidity data during purging if such fouling is suspected. An in-line tee and valve should allow for collection of water for turbidity measurements before the pump discharge enters the flow-through cell. Note that industry improvements may eliminate the need for these supplemental measurements in the future.
- HDPE water sample containers (supplied by the laboratory) fitted with an unlined (no Teflon™), polypropylene screw cap. Sample bottles for standard groundwater sampling should not contain Trizma® preservative. If sample bottles with Trizma® are provided by the laboratory, request new sample bottles prior to sample collection.
- Appropriate blanks (field reagent blanks supplied by the laboratory)
- Fluorine-free cleaning equipment
- Groundwater sampling log
- Dedicated plastic sheeting (preferably HDPE) or other clean surface to prevent sample contact with the ground
- Clipboards, field binders, and field note pages that are not waterproof and are fluorine-free
- 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 containers (coolers) with ice and appropriate labeling, no blue ice should be used
- "PFAS-free" water provided by the laboratory for decontamination rinsing
- Alconox® or Liquinox®; note that Alconox® is known to contain trace levels of 1,4-dioxane
- Packing and shipping materials
- Chain-of-Custody (COC) Forms

Note the specific make/model of the equipment used during each sampling event on the groundwater sampling log. The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, calibration, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment should be serviced by a qualified technician.

4 CAUTIONS

- 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 sample location. Ensure that the canopy will not leak into the sampling area prior to use.
- Do not wear any outdoor performance wear that is water or stain resistant or appears to be. Performance wear such as Gore-Tex® or eVent™ are examples of clothing brands to avoid. 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. Avoid contacting clothing with sampling equipment, bottles, and samples.
- Waterproof field books must not be used for field notes. Use loose paper on Masonite, plastic, or aluminum clip boards. Pens, pencils, and Sharpies may be used but should be kept away from sampling materials. One person should conduct the sampling while another records the field notes.
- To avoid potential food packaging-related PFAS contact, do not bring any food outside of the field vehicles onsite. Wash your hands after eating and remove any field garments or outer layers prior to eating.
- Safety footwear is often 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 location and do not allow gloves used for sampling to come in contact with safety footwear.

- 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 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.
- 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 meters away). Wash hands after application. Don a new pair of gloves as noted above.
- Visitors are asked to remain at least 30 feet from sampling areas.

5 HEALTH AND SAFETY CONSIDERATIONS

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. The HASP and JSA documents should be present onsite during all field activities. Generators and cord and plug equipment should employ an overcurrent protection device such as an integrated ground fault circuit interrupter cord. 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 the well may be under pressure and the cap can dislodge forcefully and cause injury.

6 PROCEDURE

If a round of water level measurements for all site monitoring wells are planned as part of the project scope, the site-wide water level measurements should be collected in such a manner to avoid potential cross-contamination between the wells. Follow appropriate decontamination procedures for collection of water level measurements.

Peristaltic pumps are preferred when sampling for PFASs to minimize potential cross-contamination. If the depth to water is below the sampling range of a peristaltic pump (approximately 25 feet), a PFAS-free bladder pump is acceptable. Purge water should be collected and containerized according to the direction of the project team.

1. Calibrate field instruments according to manufacturer procedures for calibration and document.
2. 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.
3. If required in the HASP, use a photoionization detector (PID) to measure the headspace before sampling. Open the well cover while standing upwind of the well. Remove the well cap and place it on the plastic sheeting. Insert the 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.
4. Measure the initial depth to groundwater prior to placing the HDPE tubing.
5. Prepare and install the pump in the well: when using a peristaltic pump, slowly lower the HDPE sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Any dedicated tubing in the well should be replaced with new HDPE tubing. The sampling tube must be kept at least 2 feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well. If using a weight on the tubing ensure the material is PFAS free and has been deconned according to the procedures described in this document.
6. Measure the water level again with the pump in the well before starting the pump to ensure that it has stabilized. Start pumping the well at 200 to 500 milliliters (mL) per minute (or at a lower site-specific rate if specified). Adjust the pump rate to cause little or no water level drawdown in the well (less than 0.3 foot below the initial static depth to water measurement), and the water level should stabilize; however, this is not always possible. If the recovery rate is less than 50 mL per minute, or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. Contact the project manager or other appropriate personnel to discuss.

   The water level should be monitored every 3 to 5 minutes (or as appropriate, lower flow rates may require longer time between readings) during pumping if the well diameter is of sufficient size to allow such monitoring. Do not break pump suction or cause entrainment of air in the sample. 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. Maintain a steady flow rate to the extent practicable. Review groundwater sampling records from previous sampling events (if available) prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for the well in order to more efficiently reach a stabilized pumping condition.

   If the recharge rate of the well is very low, use approved 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 foot) 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. Sampling may

commence after one well volume has been removed and the well has recovered sufficiently to permit collection of samples.

During purging, monitor the field indicator parameters (e.g., turbidity, temperature, specific conductance, pH, ORP, and DO) every 3 to 5 minutes (or after each volume of the flow-through cell has been purged). Measure field indicator parameters using a flow-through analytical cell or a clean container such as a glass beaker. Record field indicator parameters on the groundwater sampling log. The well is considered stabilized and ready for sample collection when turbidity values remain within 10% (or within 1 nephelometric turbidity unit [NTU] if the turbidity reading is less than 5 NTU), the specific conductance and temperature values remain within 3%, ORP readings remain within ± 10 mV, DO values remain within 10%, and pH remains within 0.1 unit for three consecutive readings collected at 3- to 5-minute intervals (or other appropriate interval, alternate stabilization goals may exist in different geographic regions, consult the site-specific Work Plan for stabilization criteria). If the field indicator parameters do not stabilize within 1 hour of the start of purging, but the groundwater turbidity is below the goal of 10 NTU and the values for all other parameters are within 10%, the well can be sampled. If the parameters have stabilized but the turbidity is not in the range of the 5 NTU goal, the pump flow rate may be decreased to a minimum rate of 100 mL/min to reduce turbidity levels as low as possible.

DO is extremely susceptible to various external influences (including temperature or the presence of bubbles on the DO meter); care should 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 then again check for and remove air bubbles on the probe before re-measuring. If the DO value is 0.00 or less, then the meter should be serviced and re-calibrated. If the DO values are above possible results, then the meter should be serviced and re-calibrated.

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) should be documented in the field notes. If other field conditions preclude stabilization of certain parameters, an explanation of why the parameters did not stabilize should also be documented on the groundwater sampling log.

7. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection. Under no circumstances should analytical samples be collected from the discharge of the flow-through cell.
8. Make sure the sample bottle caps have remained on the bottle until immediately prior to sample collection.
9. Don a new set of nitrile gloves prior to sample collection. While collecting the sample, make sure the bottle cap remains in the other hand of the sampler until replaced on the bottle. When the container is full (fill to the neck of the bottle, some headspace is acceptable), firmly screw on the cap (snug but

not too tight so that the screw cap is stripped). Do not use gloved hands to subsequently handle papers, pens, clothes, etc. before collecting the sample.

10. 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.
11. Do not rinse PFAS sample bottles during sampling. Do not filter samples.
12. Complete and attach the sample label(s) after sample collection and after the caps have been placed back on each container. Pre-printed labels are preferred, but pens and Sharpies® may be used.
13. Place sample bottles in a sealed Ziploc® bag. Place samples in coolers that are durable in transportation and keep the temperature between 0 and 4ºC until transported to the laboratory.
14. Record the sample name and time of sampling on the sample bottle label, in the field notes and note observations (e.g., physical appearance and the presence or lack of odors or sheens), and record on the COC form.
15. 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. Therefore, note ‘shake test’ results on the COC form if appropriate.
16. Turn off the pump. Slowly remove the tubing from the well. If the tubing will be dedicated, store the tubing in an appropriate storage container. Do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them.
17. Complete the procedures for packaging, shipping, and handling with the associated COC.
18. Between uses, complete decontamination procedures for flow-through analytical cell and water level meter, and any equipment that comes into contact with well water (see decontamination procedures described in Section 9 below).
19. At the end of the day, perform a calibration check of field instruments.
20. The general procedures listed in this document can be used for collection of samples from groundwater treatment systems or other similar sampling of water. In order to collect samples from a sampling port on a groundwater treatment system or for a similar situation follow the safety and quality procedures listed in this document. As a general note on sampling ports, ensure that there is no indication of Teflon™ tape or other Teflon™ containing material.

7 WASTE MANAGEMENT

Materials generated during groundwater sampling activities, including disposable equipment, should be placed in appropriate containers. PFAS containing waste requires special considerations and containerized waste will be stored onsite for future management by the responsible party.

8 DATA RECORDING AND MANAGEMENT

Initial field logs and COC records should be transmitted to the Arcadis Project Manager at the end of each day unless otherwise directed. The groundwater team leader retains copies of the groundwater sampling logs until they are relinquished to the project file.

9 QUALITY ASSURANCE

In addition to the quality control samples to be collected in accordance with these methods and procedures, the following quality control procedures should 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. If no analytical data are available, collect samples in order of upgradient, then furthest downgradient to source area locations.
- 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.
- Equipment blanks should be collected from various sampling equipment including the pump, water level meter (following decontamination procedures), disposable tubing, and nitrile gloves.
- Collect equipment blanks using laboratory supplied “PFAS-free” water after wells with higher concentrations (if known) have been sampled.
- Field duplicates, matrix spike, and matrix spike duplicates will be collected at a frequency in accordance with the QAPP and applicable QAPP Addenda.
- Samples must be stored in appropriate transport containers (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. Samples should be maintained at temperatures between 0 and 4^{o}C until transported to the laboratory.
- Operate all monitoring instrumentation in accordance with manufacturer’s instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities on calibration log sheets.
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well following the procedure for PFAS equipment decontamination noted below. 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 below steps repeated twice.
- The steps for PFAS equipment decontamination are as follows:
    - 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; and
- Collect all rinsate in a sealed pail for disposal. Do not reuse decontamination solutions between sampling locations

10 REFERENCES

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TGI - INVESTIGATION-DERIVED WASTE HANDLING AND STORAGE

Rev #: 0

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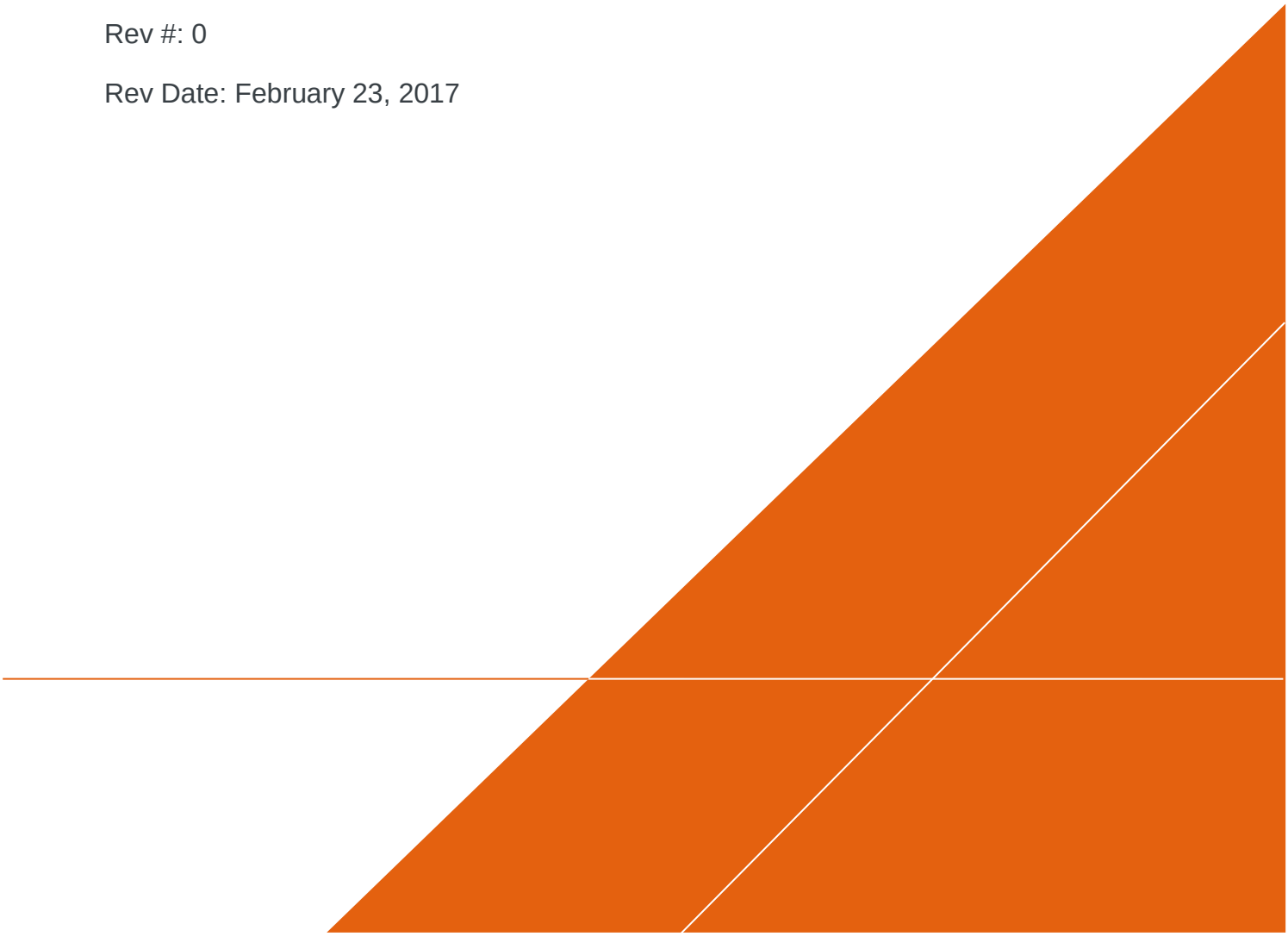

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	February 23, 2017	ALL	Conversion from SOP to TGI	Ryan Mattson / Peter Frederick

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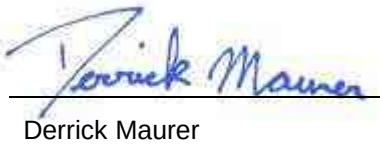
APPROVAL SIGNATURES

Prepared by:		02/23/2017
	Derrick Maurer	Date:
Technical Expert Reviewed by:		02/23/2017
	Ryan Mattson (Technical Expert)	Date:

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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 objective of this Technical Guidance Instruction (TGI) is to describe the procedures to manage investigation-derived wastes (IDW), both hazardous and nonhazardous, generated during site activities, which may include, but are not limited to: drilling, trenching/excavation, construction, demolition, monitoring well sampling, soil sampling, decontamination and remediation. For the purposes of this TGI, IDW is considered to be discarded materials which are defined as solid waste by United States Environmental Protection Agency (EPA) standard 40 CFR § 261.2 (which may include liquids, solids, or sludges). IDW may include soil, groundwater, drilling fluids, decontamination liquids, as well as contaminated personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials. Hazardous or uncharacterized IDW will be collected and staged at the point of generation. Quantities small enough to be containerized in 55-gallon drums will be taken to a designated temporary onsite storage area (discussed in further detail under Drum Storage) pending characterization and disposal. IDW materials will be characterized using process knowledge and appropriate laboratory analyses to determine the waste classification and evaluate proper safe handling and disposal methods.

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This TGI describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures necessary for proper handling and storage of IDW up to the time it is properly transported from the project site and disposed. The procedures included in this TGI for handling and temporary storage of IDW are based on the EPA's guidance document *Guide to Management of Investigation Derived Wastes* (USEPA, 1992). IDW is assumed to be contaminated with the site constituents of concern (COCs) until analytical evidence indicates otherwise. IDW will be managed to ensure the protection of human health and the environment and will comply with all applicable or relevant and appropriate requirements (ARAR). Although not comprehensive, the following laws and regulations on Hazardous Waste Management should be considered as potential ARAR. It is the Arcadis Certified Project Manager (CPM) and/or designated Technical Expert to determine which laws and regulations, at all levels of government, are applicable to each project site and activity falling under this TGI.

Federal Laws and Regulations

- Resource Conservation and Recovery Act (RCRA) 42 USC § 6901-6987.
- Federal Hazardous Waste Regulations 40 CFR § 260-265

Department of Transportation (DOT) Hazardous Materials Transportation 49 CFR

Occupational Safety and Health Administration (OSHA) Regulations 29 CFR

State Laws and Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Regional, County, Municipal, and Local Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Initial Storage

Pending characterization, IDW will be temporarily stored appropriately within each area of contamination (AOC). Under RCRA, "storage" is defined as the "holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed of, or stored elsewhere" (40 CFR § 260.10). The onsite waste staging area will be in a secure and controlled area. Uncharacterized wastes are considered potentially hazardous wastes and must be stored in DOT approved packaging. Liquid wastes must be stored in DOT approved closed head drums or other approved containers (e.g., portable tank containers) that are compatible with the type of material stored therein. Solid materials must be stored in DOT approved open head drums where practicable. Larger quantities of solid IDW can be containerized in bulk containers (such as in a roll-off box). Soil from large excavation projects may be managed in stockpiles with within the AOC and does not need to be containerized until exiting the AOC.

Characterization

Waste characterization can either be based on generator knowledge, such as using historical process knowledge and safety data sheets (SDS), or can be based upon characterization sampling analytical results. IDW typically is not characterized using SDS as it is a mixture of aged chemicals and environmental media. Historical process knowledge should be used to determine if the IDW is a listed hazardous waste (40 CFR § 261.31-33). If the IDW is not a listed hazardous waste, waste

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characterization can be completed by laboratory analysis of representative samples of the IDW. The laboratory used for waste characterization analysis must have the appropriate state and federal accreditations and may be required to be pre-approved by the Client. IDW will be classified as RCRA hazardous or non-regulated under RCRA based on the waste characterization determination.

If IDW is characterized as RCRA hazardous waste, RCRA and DOT requirements must be followed for packaging, labeling, transporting, storing, and record keeping as described in 40 CFR § 262 and 49 CFR § 171-178. Waste material classified as RCRA nonhazardous may be handled and disposed of as nonhazardous waste in accordance with applicable federal, state, and local regulations.

Storage Time Limitations

Containerized hazardous wastes can be temporarily stored for a maximum of 90 calendar days from the accumulation start date for a large quantity generator or a maximum of 180 calendar days from the accumulation start date for a small quantity generator. Wastes classified as nonhazardous may be handled and disposed of as nonhazardous waste and are not subject to storage time limitations.

This is TGI may be modified by the CPM and/or Technical Expert for a specific project or client program, as required, dependent upon client requirements, site conditions, equipment limitations, or limitations imposed by the procedure. The resulting procedure employed to execute the work will be documented in the project work plans or reports. If changes to the sampling procedures are required due to unanticipated field conditions, the changes will be discussed with the CPM and/or Technical Expert as soon as practicable, and if approved to be performed, be documented.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have current regulatory- and Arcadis-required health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and cardiopulmonary resuscitation (CPR), as needed. Personnel handling and packaging hazardous waste and performing hazardous waste characterizations must have RCRA hazardous waste management training per 40 CFR § 264.16.

Although not common practice, in certain situations Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an authorized representative of the generator. Arcadis personnel who sign waste profiles and/or waste manifests will have both current RCRA hazardous waste management training per 40 CFR § 264.16 and current DOT hazardous materials transportation training per 49 CFR § 172.704. Arcadis field personnel will also comply with client-specific training. 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 health and safety plan (HASP) and other documents will identify other training requirements or access control requirements.

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4 EQUIPMENT LIST

The Following Materials, as required, will be available for IDW handling and Storage:

- Appropriate personal protective equipment as specified in the Site Health and Safety Plan (HASP)
- DOT approved containers
- Hammer
- Leather gloves
- Drum dolly
- Appropriate drum labels (outdoor waterproof self-adhesive)
- Portable tank container
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as determined by the CPM and/or Technical Expert.
- Indelible ink and/or permanent marking pens
- Plastic sheeting
- Appropriate sample containers, labels, and forms
- Stainless-steel bucket auger
- Stainless steel spatula or knife
- Stainless steel hand spade
- Stainless steel scoop
- Digital camera
- Field logbook

5 CAUTIONS

Filled drums can be very heavy, become unbalanced, or spill its contents. Therefore, use appropriate moving techniques and equipment for safe handling. Similar media (e.g. soils with other soils; or liquids with other liquids) will be stored in the same drums to aid in sample analysis and disposal. Drum lids must be secured to prevent rainwater from entering the drums and leakage during movement. Drums containing solid material may not contain any free liquids. Waste containers stored for extended periods of time may be subject to deterioration. Drum Over Packs may be used as secondary containment. All drums must be visually inspected for condition to ensure that they are in good condition without visible evidence of rusting, holes, breakage, etc., to prevent potential leakage and facilitate subsequent disposal. All drum lids must be verified as having a properly functioning secured lid prior to use.

6 HEALTH AND SAFETY CONSIDERATIONS

Click here and enter text] As determined by the site's known and suspected hazards, appropriate PPE must be worn by all field personnel within the designated work area. Exposure air monitoring may be required during certain field activities as required in the Site Health and Safety Plan. If soil excavation in areas with potentially hazardous contaminants is possible, contingency plans will be developed to address the potential for encountering gross contamination or non-aqueous phase liquids. All excavation

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activities shall be in compliance with OSHA standard 29 CFR 1926.651 Excavations, and any other applicable regulations.

Arcadis field personnel and subcontractors will be trained in and perform their work in compliance with all applicable federal, state, and local health and safety regulations as well as Arcadis' HASP and applicable Client health and safety requirements.

7 PROCEDURE

Specific waste temporary storage and handling procedures to be used are dependent upon the type of generated waste, including type of media (e.g. soils or free liquids) and constituents of concern. For this reason, IDW can be stored in a secure location onsite in separate 55-gallon storage drums, where solids can be stockpiled onsite (if nonhazardous) and purge water may be stored in portable tank containers. Waste materials such as broken sample bottles or equipment containers and wrappings will be stored in 55-gallon drums unless they were not in contact with sample media.

Management of IDW

Minimization of IDW should be considered by the project team during all phases of the project. Site managers may want to consider techniques such as replacing solvent based cleaners with aqueous-based cleaners for decontamination of equipment, reuse of equipment (where it can be properly decontaminated), limitation of traffic between exclusion and support zones, and drilling methods and sampling techniques that minimize the generation of waste. Alternative drilling and subsurface sampling methods may include the use of small diameter boreholes, as well as borehole testing methods such as a core penetrometer or direct push technique instead of coring.

Drum Storage

Drums containing hazardous waste will be stored in accordance with the requirements of 40 CFR 265 Subpart I (for containers) and 265 Subpart DD (for containment buildings). All 55-gallon drums will be stored at a secure, centralized onsite location that is readily accessible for vehicular pick-up. Drums confirmed as, or assumed to contain hazardous waste will be stored over an impervious surface provided with secondary spill containment. The storage location will, for drums containing liquid, have a containment system that can contain at least the larger of 10% of the aggregate volume of staged materials or 100% of the volume of the largest container. Drums will be closed during storage and be in good condition in accordance with the Guide to Management of Investigation-Derived Wastes (USEPA, 1992).

Hazardous Waste Determination

Waste material must be characterized to determine if it meets any of the federal definitions of hazardous waste as required by 40 CFR § 262.11. If the waste does not meet any of the federal definitions, it must then be established if any state-specific or local-specific hazardous waste criteria exist/apply.

Generator Status

Once hazardous waste determination has been made, the generator status will be determined. Large quantity generators (LQG) are generators who generate more than 1,000 kilograms of hazardous waste in a calendar month. Small quantity generators (SQG) of hazardous waste are generators who generate

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greater than 100 kilograms but less than 1,000 kilograms of hazardous waste in a calendar month. Conditionally exempt small quantity generators (CESQG) are generators who generate less than 100 kilograms of hazardous waste per month. Please note that a generator status may change from month to month and that a notice of this change is usually required by the generator's state agency.

Accumulation Time for Hazardous Waste

A LQG may accumulate hazardous waste on site for 90 calendar days or less without a permit and without having interim status, provided that such accumulation is in compliance with requirements in 40 CFR § 262.34. A SQG may accumulate hazardous waste on site for 180 calendar days or less without a permit or without having interim status, subject to the requirements of 40 CFR § 262.34(d). CESQG requirements are found in 40 CFR § 261.5. NOTE: The CESQG and SQG provisions of 40 CFR § 261.5, 262.20(e), 262.42(b) and 262.44 may not be recognized by some states (e.g., California and Rhode Island). State-specific and local-specific regulations must be reviewed and understood prior to the generation of hazardous waste.

Satellite Accumulation of Hazardous Waste Satellite accumulation (SAA) will mean the accumulation of as much as fifty-five (55) gallons of hazardous waste, or the accumulation of as much as one quart of acutely hazardous waste, in containers at or near any point of generation where the waste initially accumulates, which is under the control of the operator of the process generating the waste, without a permit or interim status and without complying with the requirements of 40 CFR § 262.34(a) and without any storage time limit, provided that the generator complies with 40 CFR § 262.34(c)(1)(i).

Once more than 55 gallons of hazardous waste accumulates in SAA, the generator has three days to move this waste into storage.

Storage recommendations for hazardous waste include:

- Ignitable Hazardous wastes must be >50 feet from the property line per 40 CFR § 265.176 (LQG generators only).
- Hazardous waste must be stored on a concrete slab (asphalt is acceptable if there are no free liquids in the waste) per 40 CFR § 265.176.
- Drainage must be directed away from the accumulation area.
- Area must be properly vented.
- Area must be secure.

Drum/Container Labeling

Drums will be labeled on both the side and lid of the drum using a permanent marking pen. Old drum labels must be removed to the extent possible, descriptions crossed out should any information remain, and new labels affixed on top of the old labels. Other containers used to store various types of waste (e.g., polyethylene tanks, roll-off boxes, end-dump trailers, etc.) will be labeled with an appropriate "Waste Container" or "Testing in Progress" label pending characterization. Drums and containers will be labeled as follows:

- Appropriate waste characterization label (Pending Analysis, Hazardous, or Nonhazardous)
- Waste generator's name (e.g., client name)
- Project Name
- Name and telephone number of Arcadis project manager

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- Composition of contents (e.g., used oil, acetone 40%, toluene 60%)
- Media (e.g., solid, liquid)
- Accumulation start date
- Drum number of total drums as reconciled with the Drum Inventory maintained in the field log book.

IDW containers will remain closed except when adding or removing waste. Immediately upon beginning to place waste into the drum/container, a “Waste Container” or “Pending Analysis” label will be filled out to include the information specified above, and affixed to the container. Once the contents of the container are identified as either non-hazardous or hazardous, the following additional labels will be applied.

- Containers with waste determined to be non-hazardous will be labeled with a green and white "Nonhazardous Waste" label over the "Waste Container" label.
- Containers with waste determined to be hazardous will be stored in an onsite storage area and will be labeled with the "Hazardous Waste" label and affixed over the "Waste Container" label.

The ACCUMULATION DATE for the hazardous waste is the date the waste is first placed in the container and is the same date as the date on the "Waste Container" label. DOT hazardous class labels must be applied to all hazardous waste containers for shipment offsite to an approved disposal or recycling facility. In addition, a DOT proper shipping name will be included on the hazardous waste label. The transporter should be equipped with the appropriate DOT placards. However, placarding or offering placards to the initial transporter is the responsibility of the generator per 40 CFR § 262.33.

Inspections and Documentation

All IDW will be documented as generated on a Drum Inventory Log maintained in the field log book. The Drum Inventory will record the generation date, type, quantity, matrix and origin (e.g., Boring-1, Test Pit 3, etc.) of materials in every drum, as well as a unique identification number for each drum. The drum inventory will be used during drum pickup to assist with labeling of drums. The drum storage area and any other areas of temporarily staged waste, such as soil/debris piles, will be inspected weekly. The weekly inspections will be recorded in the field notebook or on a Weekly Inspection Log. Digital photographs will be taken upon the initial generation and drumming/staging of waste, and final labeling after characterization to document compliance with labeling and storage protocols, and condition of the container. Evidence of damage, tampering or other discrepancy should be documented photographically.

Emergency Response and Notifications

Specific procedures for responding to site emergencies will be detailed in the HASP. If the generator is designated as a LQG, a Contingency Plan will need to be prepared to include emergency response and notification procedures per 40 CFR § 265 Subpart D. In the event of a fire, explosion, or other release which could threaten human health outside of the site or when Client or ARCADIS has knowledge of a spill that has reached surface water, Client or ARCADIS must immediately notify the National Response Center (800-424-8802) in accordance with 40 CFR § 262.34. Other notifications to state and/or other local regulatory agencies may also be necessary.

Drilling Soil Cuttings and Muds

Soil cuttings are solid to semi-solid soils generated during trenching activities, subsurface soil sampling, or installation of monitoring wells. Depending on the drilling method, drilling fluids known as "muds" may

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be used to remove soil cuttings. Drilling fluids flushed from the borehole must be directed into a settling section of a mud pit. This allows reuse of the decanted fluids after removal of the settled sediments. Soil cuttings will be labeled and stored in 55-gallon drums with bolt-sealed lids.

Excavated Solids

Excavated solids may include, but are not limited to: soil, fill, and construction and demolition debris. Prior to permitted treatment or offsite disposal, potentially hazardous excavated solids may be temporarily stockpiled onsite as long as the stockpile remains in the same AOC from where it was excavated. Potentially hazardous excavated solids removed from the AOC must be immediately containerized in labeled drums or closable top roll-offs lined with 9-mil polyvinyl chloride (PVC) sheeting and are subject to LQG storage time limits. Nonhazardous excavated solids can be stockpiled either inside or outside of the AOC, do not have to be containerized and are not subject to hazardous waste regulations. Potentially hazardous excavated solids must not be mixed with nonhazardous excavated solids. All classes of excavated solid stockpiles should be maintained in a secure area onsite. At a minimum, the floor of the stockpile area will be covered with a 20-mil high density polyethylene liner that is supported by a foundation or at least a 60-mil high density polyethylene liner that is not supported by a foundation. The excavated material will not contain free liquids. The owner/operator will provide controls for windblown dispersion, run-on control, and precipitation runoff. The run-on control system will prevent flow onto the active portion of the pile during peak discharge from at least a 25-year storm and the run-off management system will collect and control at least the water volume resulting from a 24-hour, 25-year storm (USEPA, 1992). Additionally, the stockpile area will be inspected on a weekly basis and after storm events. Individual states may require that the stockpile be inspected/certified by a licensed professional engineer. Stockpiled material will be covered with a 6-mil polyvinyl chloride (PVC) liner or sprayed dust control product. The stockpile cover will be secured in place with appropriate material (concrete blocks, weights, etc.) to prevent the movement of the cover.

Decontamination Solutions

Decontamination solutions are generated during the decontamination of personal protective equipment and sampling equipment. Decontamination solutions may range from detergents, organic solvents and acids used to decontaminate small field sampling equipment to steam cleaning rinsate used to wash heavy field equipment. These solutions are to be labeled and stored in closed head drums compatible with the decontamination solution. Decontamination procedures, including personnel and field sampling equipment, must comply with applicable Arcadis procedural documents.

Disposable Equipment

Disposable equipment includes personal protective equipment (e.g., tyvek coveralls, gloves, booties and APR cartridges) and disposable sampling equipment such as trowels or disposable bailers. If the media sampled exhibits hazardous characteristics per results of waste characterization sampling, contaminated disposable equipment will also be disposed of as a hazardous waste. If compatible with the original IDW waste stream (i.e., the IDW is a solid and the disposal equipment is a solid), the disposable equipment can be combined with the IDW. If these materials are not compatible (i.e., the IDW is a liquid and the disposal equipment is a solid), the disposable equipment will be stored onsite in separate labeled 55-gallon drums. Uncontaminated or decontaminated disposable equipment can be considered nonhazardous waste.

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Purge Water

Purge water includes groundwater generated during well development, groundwater sampling, or aquifer testing. The volume of groundwater generated will dictate the appropriate storage procedure. Monitoring well development and groundwater sampling may generate three well volumes of groundwater or more. This volume will be stored in labeled 55-gallon drums. Aquifer tests may generate significantly greater volumes of groundwater depending on the well yield and the duration of the test. Therefore, large-volume portable polyethylene tanks will be considered for temporary storage pending groundwater-waste characterization.

Purged Water Storage Tank Decontamination and Removal

The following procedures will be used for inspection, cleaning, and offsite removal of storage tanks used for temporary storage of purge water. These procedures are intended to be used for rented portable tanks such as Baker Tanks or Rain for Rent containers. Storage tanks will be made of inert plastic materials. The major steps for preparing a rented tank for return to a vendor include characterizing the purge water, disposing of the purge water, decontaminating the tank, final tank inspection, and mobilization. Decontamination and inspection procedures are described in further detail below.

- Tank Cleaning: Most vendors require that tanks be free of any visible sediment and water before returning, a professional cleaning service may be required. Each specific vendor should be consulted concerning specific requirements for returning tanks.
- Tank Inspection: After emptying the tank, purged water storage tanks should be inspected for debris, chemical staining, and physical damage. The vendors require that tanks be returned in the original condition (i.e., free of sediment, staining and no physical damage).

8 WASTE MANAGEMENT

Soil/Solids Characterization

Waste characterization will be conducted in accordance with waste hauler, waste handling facility, and local/state/federal requirements. In general, RCRA hazardous wastes are those solid wastes determined by a Toxicity Characteristic Leaching Procedure (TCLP) test or to contain levels of certain toxic metals, pesticides, or other organic chemicals above specific applicable regulatory agency thresholds. If the one or more of 40 toxic compounds listed in Table I of 40 CFR § 261.24 are detected in the sample at levels above the maximum unregulated concentrations, the waste must be characterized as a toxic hazardous waste. Wastes can also be considered “listed” hazardous waste depending on site-specific processes.

Composite soil samples will be collected at a frequency of one sample per 10 cubic yard basis for stockpiled soil or one per 55-gallon drum for containerized. A four-point composite sample will be collected per 10 cubic yards of stockpiled material and for each drum. Sample and composite frequencies may be adjusted in accordance with the waste handling facility’s requirements. Waste characterization samples may be analyzed for the TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls (PCBs), as well as reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional

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sampling. Please note that state- or local-specific regulations may require a different or additional sampling approaches.

Wastewater Characterization

Waste characterization will be conducted in accordance with the requirements of the waste hauler, waste handling facility, and local/state/federal governments. In general, purge water should be analyzed by methods appropriate for the known contaminants, if any, that have been historically detected in the monitoring wells. Samples will be collected and analyzed in accordance with the requirements of the waste disposal facility. Wastewater characterization samples may be analyzed for TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls, as well as corrosivity (pH), reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional sampling. Please note that state- and/or local-specific regulations may require different or additional sampling approaches.

Sample Handling and Shipping

All samples will be appropriately labeled, packed, and shipped, and the chain-of-custody will be filled out in accordance with current Arcadis sample chain of custody, handling, packing, and shipping procedures and guidance instructions.

It should be noted that additional training is required for packaging and shipping of hazardous and/or dangerous materials. Please refer to the current Arcadis training requirements related to handling and shipping of samples, shipping determinations, and hazardous materials.

Preparing Waste Shipment Documentation (Hazardous and Nonhazardous)

Waste profiles will be prepared by the Arcadis CPM and forwarded, along with laboratory analytical data to the Client for approval/signature. The Client will then return the profile to Arcadis who will then forward to the waste removal contractor for preparation of a manifest. The manifest will be reviewed by Arcadis prior to forwarding to the Client for approval. Upon approval of the manifest, the Client will return the original signed manifest directly to the waste contractor or to the Arcadis CPM for forwarding to the waste contractor. Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an authorized representative of the generator.

Final drum labeling and pickup will be supervised by an Arcadis representative who is trained and experienced with applicable waste labeling procedures. The Arcadis representative will have a copy of the drum inventory maintained in the field book and will reconcile the drum inventory with the profile numbers on the labels and on the manifest. Different profile numbers will be generated for different matrices or materials in the drums. For example, the profile number for drill cuttings will be different than the profile number for purge water. When there are multiple profiles it is critical that the proper label, with the profile number appropriate to a specific material be affixed to the proper drums. A copy of the Arcadis drum inventory will be provided to the waste transporter during drum pickup and to the facility receiving the waste.

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9 DATA RECORDING AND MANAGEMENT

Waste characterization sample handling, packing, and shipping procedures will be documented in accordance with relevant Arcadis procedures and guidance instructions as well as applicable client and/or project requirements, such as a Quality Assurance Project Plan or Sampling and Analysis Plan. Copies of the chain-of-custody forms will be maintained in the project file. Arcadis should photograph or maintain a copy of any hazardous waste manifest signed on behalf of Client in the corresponding office DOT record file.

10 QUALITY ASSURANCE

The CPM or APM will review all field documentation once per week for errors or omissions as compared to applicable project requirements including but not limited to: the proposal/scope of work, QAPP, SAP, HASP, etc. Deficiencies will be noted, tracked, and resolved. Upon correction, they will be noted for project documentation.

11 REFERENCES

United States Environmental Protection Agency (USEPA). 1992. Guide to Management of Investigation-Derived Wastes. Office of Remedial and Emergency Response. Hazardous Site Control Division. January 1992.

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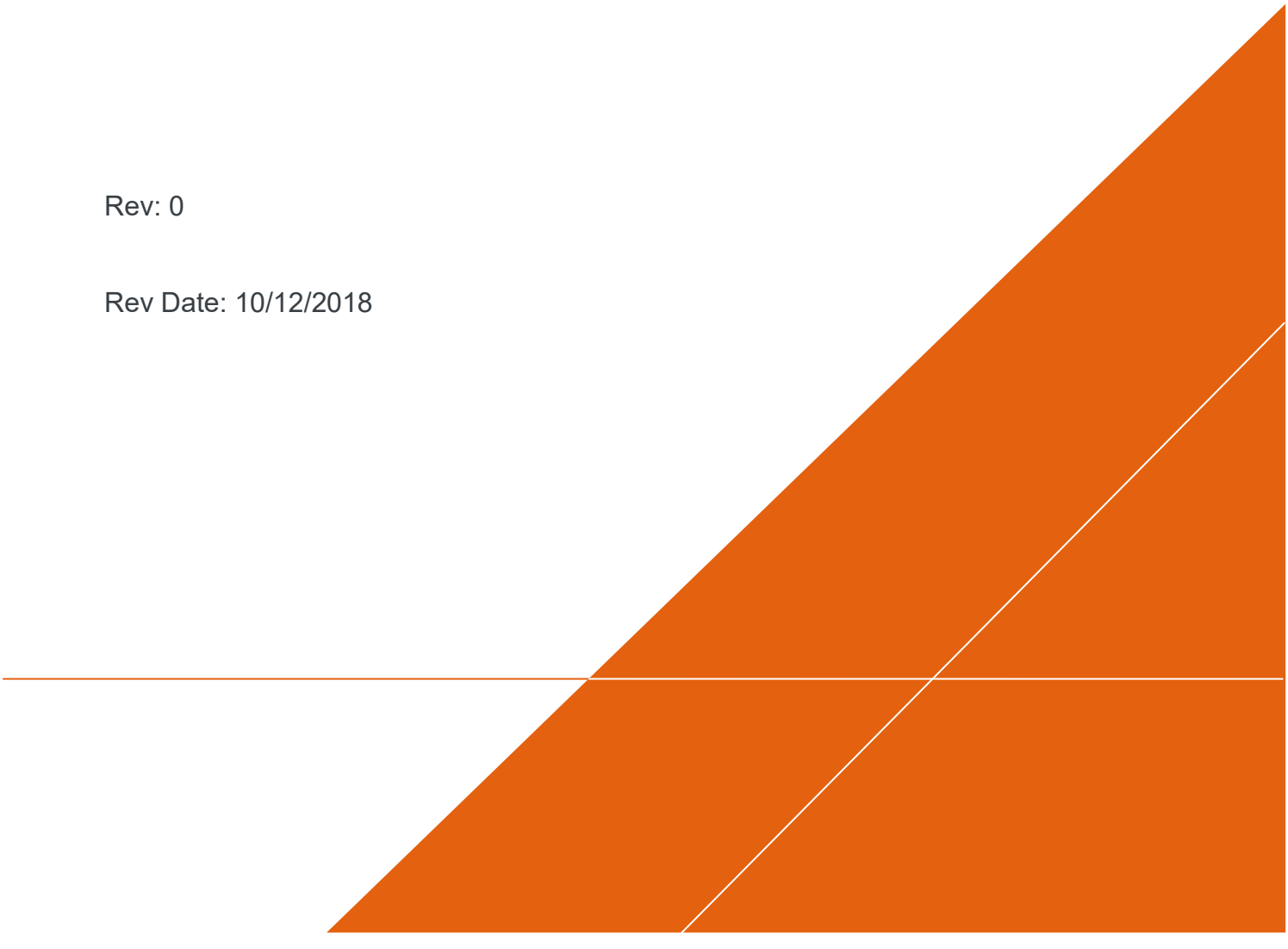
TECHNICAL GUIDANCE INSTRUCTIONS - VERTICAL AQUIFER PROFILING FOR PFAS ANALYSIS

Rev: 0

Rev Date: 10/12/2018



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 12, 2018	All	Created by combining aspects of the generic VAP TGI (Rev 0, June 22, 2018) and Ft. Leavenworth VAP TGI (Rev 1, July 19, 2018). PFAS-specific guidance.	Ankit Gupta

APPROVAL SIGNATURES

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Prepared by:  10/12/2018

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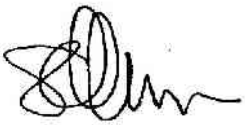
Technical Expert Reviewed by:  10/12/2018

Joseph A. Quinnan, PE, PG — Date:

Global Site Investigation Director

North America Emerging Contaminants Director

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 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.

2 SCOPE AND APPLICATION

The intent of this Technical Guidance Instruction (TGI) is to provide instructions for groundwater VAP sampling during United States Army Environmental Command (USAEC) per- and polyfluoroalkyl substances (PFASs) Preliminary Assessments and Site Inspections (PA/SI) at various Army Installations. It also covers specific considerations for PFASs due to their unique chemical and physical properties, low detection limits, and low regulatory standards.

Soil borings will be advanced via direct push technology (DPT) or rotosonic drilling techniques to enable vertical aquifer profile (VAP) groundwater sampling to collect single or multiple depth-discrete groundwater samples using low-flow or grab sampling methodologies. Both methods will enable retrieval of continuous soil cores and lithologic logging, as well as collection of multiple depth-discrete dry and saturated soil samples. VAP groundwater sampling intervals should be co-located with or biased towards potential discrete transport zones (and target slow advection zones when feasible) as indicated by soil

logging observations, permeability measurements (e.g., point slug tests, Geoprobe® hydraulic profiling tool [HPT] [preferred], Waterloo APS™ [alternate]), and/or interpreted hydrostratigraphy.

Multiple-depth discrete groundwater samples can be collected via drilling rod tooling They can be analyzed quickly by expedited, off-site, fixed lab or on-site mobile lab analysis to provide adaptive high-resolution quantitative groundwater concentration data. The vertical frequency of groundwater sampling within a formation should be determined relative to the scale of variability demonstrated in site hydrostratigraphy. Thin aquifers with transport zones only tens of feet thick can be sampled at intervals as close as 3 to 5 feet. In aquifers with transport zones of substantial thickness (e.g., more than 50 feet), sample spacing of 5 to 20 feet is usually adequate. It is important to note that field data should be evaluated to verify that sampling intervals provide sufficient resolution to meet data quality objectives (DQOs) (See **Section 7**).

3 PERSONNEL QUALIFICATIONS

VAP activities will be performed by persons who have been trained in proper drilling and sampling procedures under the guidance of an experienced field geologist, engineer, or technician. Drilling subcontractors will need current applicable drilling licenses. Arcadis and subcontractor personnel must also have completed any site/project/client-specific training requirements.

4 EQUIPMENT LIST

The following equipment and materials must be available for borehole advancement and VAP groundwater sampling:

- Site plan with proposed sampling locations;
- Relevant work plan (e.g., installation-specific Quality Assurance Project Plan [QAPP] Addendum);
- Site Safety and Health Plan (SSHP);
- Appropriate health and safety equipment, as specified in the SSHP;
- Drilling Equipment:
    - DPT and/or rotosonic drill rig (to be provided by drilling subcontractor). Type to be determined based on site-specific details;
    - Traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if not provided by the drillers;
    - Note: Prior to mobilizing to the site, Arcadis personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling equipment will be provided in quantities capable of achieving estimated target depths. Typical equipment/materials provided by the driller could include:
        - Acetate or other PFAS-free plastic liners;
        - Appropriate length of drilling rods and tooling;

- Drilling and sampling equipment decontamination materials; and,
- Decontamination pad materials, if required. See **Section 5.3** below for more information;

- Sampling:
  - Appropriate PFAS-free groundwater sampling equipment (e.g., disposable bailers for volumetric sampling, peristaltic pump for shallow groundwater sampling, submersible bladder pump for deeper sampling). Refer to the PFAS Field Sampling Guidance TGI (Arcadis 2018a) and Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells TGI (Arcadis 2016) for necessary equipment;
  - Direct push groundwater samplers (e.g., Geoprobe® SP-22 or Geoprobe® SP-16) or rotosonic sampling devices (e.g., Cascade Packer Isolation Groundwater Profiler or Geoprobe® SP-60 Sonic Groundwater Sampler) to be provided by drilling subcontractor;
  - Appropriate soil sampling equipment if included in scope. Refer to the PFAS-Specific Drilling and Monitoring Well Installation TGI (Arcadis 2018b) for necessary equipment;
  - Dedicated low-density polyethylene (LDPE) plastic sheeting to prevent sample contact with the ground;
  - YSI 6-Series multi-parameter water quality probe (e.g., conductivity, temperature, dissolved oxygen, oxidation reduction potential) with flow-through cell;
  - Turbidity meter;
  - Water level meter with fluorine-free materials (Geotech ET 3/8" with Delrin tip and Buna-N O-ring);
  - Laboratory provided PFAS-free water for field and equipment blank QC samples.
  - Laboratory-provided HPDE PFAS shaker test vials
  - Appropriate sample containers and labels;
    - Laboratory-supplied HDPE sample bottles: see the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a) for PFAS-specific considerations;
    - Polyethylene bags (Ziploc® brand only) to hold ice and samples;
    - Appropriate blanks (field reagent blanks supplied by the laboratory);
    - Packing and shipping materials;
    - Chain-of-Custody (COC) Forms; see the Sample Chain of Custody Standard Operating Procedure (SOP) for reference (Arcadis 2017a);
    - Appropriate transport containers (coolers) with ice and appropriate labeling, no blue ice;
- Decontamination/Waste Management:
  - PFAS-free decontamination fluids and equipment
    - HDPE or PVC brushes and squirt bottles, stainless steel bowl

        - HDPE buckets to hold decontamination fluids
        - Alconox or Liquinox (other detergents prohibited)
        - Distilled or laboratory-supplied deionized water
        - Laboratory provided PFAS-free water
    - See the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a) or the Groundwater and Soil Sampling Equipment Decontamination TGI (Arcadis 2017b) for additional guidance;
    - Portable field hand washing setup
    - Non-hazardous drum labels as required for investigation-derived waste handling: see the Investigation-Derived Waste Handling and Storage TGI for details (Arcadis 2017c);
- Field Notes:
    - Pens, pencils, and/or Sharpies® for writing;
    - Appropriate field forms;
    - Clipboards, field binders, field notebook, and field note pages that are not waterproof.
- Other
    - Field clothing made of cotton or other natural fibers that is well laundered (i.e., washed at least 6 times)
    - Well laundered cotton blankets for covering field vehicle seats
    - PFAS-free sunscreen and insect repellant

5 CAUTIONS

5.1 Utility Clearance

The appropriate drilling authorities will be contacted and a site visit for public utility line clearance at the proposed boring locations will be conducted at least 72 hours prior to work commencing. As applicable, utility maps will be reviewed during field reconnaissance of the proposed inspection locations to determine if any are co-located with public utility lines. Arcadis will also contract an independent geophysical survey company to verify that proposed boring locations are not co-located with existing underground utility/substructure features, as necessary. Arcadis will clear locations with soft dig methods to assess the presence of underground utilities, as necessary. See the Utility Location and Clearance Arcadis Health and Safety Standard (Arcadis 2017d) for reference.

5.2 PFAS-Specific General Sampling Considerations

This section provides a summary of methods and procedures applicable to the collection of environmental samples for field screening or laboratory analysis during PFAS site characterization activities. 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. For example, Teflon™ and other fluoropolymer containing materials are found in pumps, tubing, and sample storage containers and therefore should be avoided (Department of Environment Regulation [DER], Western Australia 2016; New Hampshire Department of Environmental Services [NHDES] 2016). Certain field documentation materials such as waterproof paper or field books, adhesive paper products, and some writing utensils (grouped as non-Sharpie® markers) are also prohibited items during PFAS sampling (DER 2016; NHDES 2016).

New nitrile gloves should be donned before any of the following activities:

- Decontamination of re-usable sampling equipment;
- Contact with sample bottles or PFAS-free water bottles;
- Handling clean sample tubing/down-well equipment or connecting tubing;
- Handling QC samples including field blanks and equipment blanks.

Additionally, new nitrile gloves should also 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.**

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:

- Keep field notes, writing implements, and electronic data collection tablets away from samples and sampling materials; and,
- Do not write on sampling bottles unless they are closed.

Tables 1 and **2** in **Attachment 1** provides recommendations for PFAS Site Inspection equipment. **Table 1** provides a summary of materials that have been approved for site inspection; this list is expected to grow longer as industry experience increases. **Table 2** 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 PFASs and/or retaining PFASs, these recommendations are considered preliminary and subject to change.

Given the extremely low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFASs, field personnel are typically advised to err on the side of caution by strictly following field wear guidelines and decontamination procedures as specified in the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a). **The most important consideration during PFAS related VAP sampling is to prevent contact between sample media and suspect PFAS sources.**

5.3 PFAS-Specific Groundwater Sampling

The potential presence of PFASs in equipment that may come in contact with the target water sample must be evaluated as part of the sample planning process to maintain sample integrity. For example, low-

flow sampling with a peristaltic pump should be conducted using silicone or HDPE tubing; Teflon™ tubing is prohibited (DER 2016). If a bladder pump is used to collect samples, the bladder and other internal parts (e.g., check balls, o-rings, compression fittings) should not be made of Teflon™ either, and bladder and o-rings should be changed between samples (DER 2016).

Note that if high concentrations of PFASs related to Class B firefighting foams are expected in a groundwater sample, it has been recommended to collect and shake a small portion of the sample at the time of sample collection (USACE 2016; Arcadis 2018a). If foaming is noted within the sample, it indicates elevated concentrations of PFASs may be present and the sample should be proactively diluted at the laboratory prior to analysis. The foaming should be noted on the sample chain of custody form. It is recommended to collect sampling equipment blanks following foam observation to confirm the effectiveness of decontamination procedures.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with borehole advancement and VAP groundwater sampling will be performed in accordance with the SSHP, a copy of which will be present on site during such activities.

7 PROCEDURE

The following sub-sections provide different approaches that can be utilized at different sites depending on the nature of the site to perform VAP sampling. The specific procedure for advancing borings for VAP groundwater sampling should be developed after careful review and consideration of project DQOs.

7.1 Direct Push Technology Vertical Aquifer Profile Sampling

Direct push tooling (DPT) is ideal for shallow unconsolidated aquifers (i.e. less than 100 feet bgs) and requires minimal water for drilling, thus reducing the potential for sample dilution. Typically, DPT VAP borings are conducted in boreholes adjacent to prior HPT borings to develop stratigraphic flux profiles. The primary advantage of completing permeability profiles via HPT in advance of sampling is to gain understanding of hydrofacies to ensure that the most appropriate intervals and sampling methods are used. Sampling depth intervals are determined based on the HPT profiles to target transport zones. Waterloo APS™ can be utilized as an alternative to HPT to provide permeability profiles, but it is more time intensive than HPT; therefore, it is not considered the preferred tool for permeability profiling. In the absence of HPT data from a co-located adjacent borehole, sampling depth intervals can be determined based upon lithologic logging of soil cores, either from a separate co-located adjacent borehole or from the same borehole. Soil lithologic logging should be performed in accordance with Arcadis TGI for Soil Descriptions (Arcadis 2018c).

The VAP groundwater samples are typically collected every 5 to 20 feet with a bias to the more permeable transport zones. Samples are collected by driving a screen point sampling device such as Geoprobe® SP-22 or Geoprobe® SP-16 to the target interval and the screen opened to collect a groundwater sample. In poorly sorted aquifers with appreciable amounts of silt, VAP sampling from an adjacent borehole after completing initial permeability profiling (e.g., Geoprobe® HPT or point slug tests) is typically more efficient and cost effective.

DPT VAP sampling will be completed using a top-down sampling approach, which requires pulling the tooling out after each sample depth interval, decontaminating the tooling, resetting the groundwater sampler, and advancing the tooling to the next planned interval. This requires more time per borehole than some other sampling methods (e.g. bottom-up); however, it minimizes any potential for cross-contamination, and is therefore the preferred approach for PFAS projects due to the low detection limits and regulatory levels associated with PFASs. Furthermore, the top-down approach allows for grouting of the borehole from its bottom to the surface as tooling is retracted during borehole abandonment.

Single-Interval VAP Sampling

In some cases, it may be preferred to perform single-interval VAP sampling from the first encountered shallow groundwater. It should be verified that samples are taken below the water table (i.e., not perched water in the vadose zone). Single-interval VAP sampling should be performed with a Geoprobe® SP-16 sampling device or similar (e.g., HydroPunch ™). A primary difference with single-interval methods relative to multi-interval VAP sampling is that the sampling screen is driven to the appropriate depth by the drill rig (as opposed to lowering the sampling screen through the drill tools after reaching the appropriate depth).

If using a Geoprobe® SP-16 sampling device, the following steps should be followed:

1. Ensure 4-gas meter, YSI 6-Series multi-parameter water quality probe, and turbidity meter are calibrated each morning (see QAPP worksheet #22 and P-09 Calibration and Control of Measuring and Test Equipment in PQAPP Appendix A). Document calibration results on equipment calibration log;
2. Advance Geoprobe® SP-16, equipped with stainless-steel screen, using standard Geoprobe® rods to the target depth interval in accordance with Arcadis TGI for PFAS-Specific Drilling and Monitoring Well Installation (Arcadis 2018b);
3. Retract the tool string and screen sheath to expose the screen for the desired sample interval length, using extension rods to hold the screen in place. The Geoprobe® SP-16 sampling screen can range from 0” to approximately 44”. Note: no soil cores will be retrieved using the Geoprobe® SP-16;
4. Go to Step 13.

If using a HydroPunch ™ sampling device, the following steps should be followed:

5. Ensure 4-gas meter, YSI 6-Series multi-parameter water quality probe, and turbidity meter are calibrated each morning (see QAPP worksheet #22 and P-09 Calibration and Control of Measuring and Test Equipment in PQAPP Appendix A). Document calibration results on equipment calibration log;
6. The drilling subcontractor will advance the borehole to approximately 2 feet above the depth from which a discrete water sample is to be obtained;
7. The drilling subcontractor will disassemble the HydroPunch™ sampling device according to the manufacturer’s instructions to allow the sampler to be decontaminated. The sampler should be completely disassembled, including O-rings and/or check valves;
8. Decontaminate the sampler per instructions in Section 10 as appropriate for the range of groundwater analytes to be sampled for, by washing with laboratory-grade detergent and potable

water wash, followed by solvent rinse (if sampling for organics) and final rinse with deionized or distilled water. Check the condition of the O-rings during each cleaning and replace if necessary;

9. The drilling subcontractor will reassemble the decontaminated HydroPunch™ sampling device according to the manufacturer's instructions and lower the device to the bottom of the borehole;
10. The drilling subcontractor will push or drive the HydroPunch™ 5 feet below the bottom of the casing or augers, then retract the sampler 3 feet upward. Subsurface friction will retain the drive point in place, exposing the screen and allowing groundwater to enter the sampling tool;
11. Allow sufficient time to allow the sampler to fill with water. Typically, 30 minutes is sufficient, except in low permeability materials;
12. Go to Step 13.

Complete the following steps for sample collection:

13. Place LDPE plastic sheeting 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. Do not allow vehicle exhaust to point towards the sample point;
14. Don a new set of nitrile gloves, connect tubing to sampling pump and flow-through cell and slowly lower tubing and/or pump into well. If possible, use two field personnel to insert tubing/pump into well to avoid contact with surrounding ground surface or other materials that could cause cross-contamination. Insert tubing (peristaltic pump, if depth to water <25 ft bgs), or pump intake (small-diameter bladder pump, if depth to water >25 ft bgs) at the approximate mid-depth of the sampler screen interval
    - Alternately, a Waterra-type inertial pump can be used to retrieve the water sample. If the formation has low-permeability and enough water is not anticipated in the tooling to allow purging of water, a stainless-steel bailer may be considered (after consulting with Arcadis RL);
15. Purge until water is visually clear of sediment, or for a maximum of 20 minutes before collecting GW samples;
    - Note: for low-permeability formations, collected a grab sample from the screen point sampling device and/or saturated soil sample from the soil core retrieved earlier, and then allow for overnight recovery of groundwater leaving temporary well casing and screen in the borehole for follow-up sampling the next day.
16. Don a new set of nitrile gloves prior to collecting groundwater sample and each QC sample. Do not use gloved hands to handle papers, pens, clothes, equipment, etc., before collecting samples;
17. Fill sample bottles using labeled HDPE bottles that are supplied by laboratory only. Make sure that the cap remains on the bottle until immediately prior to sample collection and gets placed back on the bottle immediately after sample collection. Do not place the cap on any surface, keep in hand opposite of sample collection, do not touch the inside of the cap;
18. If high concentration of PFAS related to class B Firefighting foams is expected in a groundwater sample (as specified in the QAPP Addendum), collect and shake a small portion of the sample (~10-25 mL) on site. If foaming is observed, document the foaming on the sample log and on the COC to notify laboratory personnel. The 'shaker test' vial can then be disposed;

19. Collect QC samples at frequency specified in PQAPP Worksheet #20. QC sample locations to be selected based on consultation with Arcadis RL;
20. Place filled sample bottles in a sealed (Ziploc) bag, record any label information that was not pre-filled out (i.e. sample time). Record the label information and time of sampling in the field notes and sampling forms. Place samples into sample coolers. Store PFAS samples in separate cooler from any other types of samples;
21. Fill out laboratory COC and check against the labels on the sample bottles progressively after each sample is collected;
22. Geoprobe® SP-16 sampling device is pulled back up and decontaminated (see Section 10);
23. Abandon the borehole as detailed in Section 7.3.

Multi-Interval VAP Sampling

In most cases, it is preferred to perform VAP sampling at multiple depth intervals in the same borehole. Multi-interval VAP sampling should be performed with a Geoprobe® SP-22 sampling device or similar. A primary difference with multiple-interval methods relative to single-interval VAP sampling is that the sampling screen is placed at the bottom of the borehole for sampling through the drill rods after retrieval of soil cores, rather than driven to the sampling depth by the drill rig.

If using a Geoprobe® SP-22 screen point sampling device, the following steps should be followed:

1. Ensure 4-gas meter, YSI 6-Series multi-parameter water quality probe, and turbidity meter are calibrated each morning (see QAPP worksheet #22 and P-09 Calibration and Control of Measuring and Test Equipment in PQAPP Appendix A). Document calibration results on equipment calibration log;
2. Advance dual-tube direct push casing with a plastic liner for soil core retrieval to target depth interval in accordance with Arcadis TGI for PFAS-Specific Drilling and Monitoring Well Installation (Arcadis 2018b);
3. Retrieve the soil core and characterize soils in accordance with Arcadis TGI for Soil Descriptions (Arcadis 2018c);
4. Lower the stainless-steel screen point sampling screen (Geoprobe® SP-22) to target depth and pull up the outer casing to expose the screen;
5. Place LDPE plastic sheeting 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. Do not allow vehicle exhaust to point towards the sample point;
6. Don a new set of nitrile gloves, connect tubing to sampling pump and flow-through cell and slowly lower tubing and/or pump into well. If possible, use two field personnel to insert tubing/pump into well to avoid contact with surrounding ground surface or other materials that could cause cross-contamination. Insert tubing (peristaltic pump, if depth to water <25 ft bgs), or pump intake (bladder pump, if depth to water >25 ft bgs) at the approximate mid-depth of the sampler screen interval;
7. Purge well until water is visually clear of sediment, or for a maximum of 20 minutes before collecting GW samples;

- Note: for low-permeability formations, collected a grab sample from the screen point sampling device and/or saturated soil sample from the soil core retrieved earlier, and then allow for overnight recovery of groundwater leaving temporary well casing and screen in the borehole for follow-up sampling the next day.

8. Don a new set of nitrile gloves prior to collecting groundwater sample and each QC sample. Do not use gloved hands to handle papers, pens, clothes, equipment, etc., before collecting samples;
9. Fill sample bottles using labeled HDPE bottles that are supplied by laboratory only. Make sure that the cap remains on the bottle until immediately prior to sample collection and gets placed back on the bottle immediately after sample collection. Do not place the cap on any surface, keep in hand opposite of sample collection, do not touch the inside of the cap;
10. If high concentration of PFAS related to class B Firefighting foams is expected in a groundwater sample (as specified in the QAPP Addendum), collect and shake a small portion of the sample (~10-25 mL) on site. If foaming is observed, document the foaming on the sample log and on the COC to notify laboratory personnel. The 'shaker test' vial can then be disposed;
11. Collect QC samples at frequency specified in PQAPP Worksheet #20. QC sample locations to be selected based on consultation with Arcadis RL;
12. Place filled sample bottles in a sealed (Ziploc) bag, record any label information that was not pre-filled out (i.e. sample time). Record the label information and time of sampling in the field notes and sampling forms. Place samples into sample coolers. Store PFAS samples in separate cooler from any other types of samples;
13. Fill out laboratory COC and check against the labels on the sample bottles progressively after each sample is collected;
14. Screen point sampling screen is pulled back up and decontaminated (see Section 10);
15. A new plastic liner is lowered back in and the entire assembly is then advanced to the next depth interval;
16. Repeat these steps until all samples have been collected from all target intervals;
17. Abandon the borehole as detailed in Section 7.3.

7.2 Sonic Drilling Vertical Aquifer Profile Sampling

For sites with deep unconsolidated aquifers or challenging drilling conditions (e.g., presence of dense tills, caliche, cobbles), direct push drilling may not be feasible or cost effective due to limited production rates. In these cases, alternate drilling methods (e.g., rotosonic) are required. Like direct push, groundwater profilers can be used to collect multiple depth-discrete groundwater samples biased towards transport zones based on soil lithological cores. The configuration of individual samplers varies based on their manufacturer and drilling contractor (e.g., Cascade Packer Isolation Groundwater Profiler or Geoprobe® SP-60 Packer Sampler). The overall strategy of sonic drilling VAP sampling is consistent with direct push VAP sampling; however, drilling with sonic or some rotary methods requires the introduction of drilling water that can potentially affect the integrity of the groundwater sample. If drilling water is used, a source blank sample will be collected prior to the start of work. Additionally, source water should be spiked with non-toxic fluorescence dyes per Arcadis SOP for use of visible tracer in drilling fluid to obtain representative groundwater samples during drilling (Arcadis 2010).

Sonic VAP sampling will be performed in a top-down manner using dual-tube casing. Packer Isolation Groundwater Profilers will be used to conduct VAP sampling. Thus, sampling will require pulling the

tooling after each sample interval, decontaminating the tooling (if necessary), resetting the groundwater sampler, and advancing the tooling to the next planned interval. The biggest advantage of this device is that groundwater sampling depth intervals can be determined based on lithological logs obtained from the same borehole (since HPT is not deployable via rotosonic drilling methods), and the potential for cross-contamination between adjacent sampling intervals is limited.

The following steps should be followed:

1. Ensure 4-gas meter, YSI 6-Series multi-parameter water quality probe, and turbidity meter are calibrated each morning (see QAPP worksheet #22 and P-09 Calibration and Control of Measuring and Test Equipment in PQAPP Appendix A). Document calibration results on equipment calibration log;
2. Advance dual-tube sonic tooling casing to target depth interval in accordance with Arcadis TGI for PFAS-Specific Drilling and Monitoring Well Installation (Arcadis 2018b);
3. Retrieve the soil core and the inner sonic core barrel. Characterize soils in accordance with Arcadis TGI for Soil Descriptions (Arcadis 2018c);
4. Insert the stainless-steel screen and packer assembly (e.g., Cascade Packer Isolation Groundwater Profiler or Geoprobe® SP60 Packer Sampler) to the base of the sonic casing;
5. Extract the outer sonic casing to expose the screen to the formation;
6. Inflate the packer to isolate the screened interval from any water that might be above the packer in the sonic casing;
7. Place LDPE plastic sheeting 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. Do not allow vehicle exhaust to point towards the sample point;
8. Don a new set of nitrile gloves, connect tubing to sampling pump and flow-through cell and slowly lower tubing and/or pump into well. If possible, use two field personnel to insert tubing/pump into well to avoid contact with surrounding ground surface or other materials that could cause cross-contamination. Insert tubing (peristaltic pump, if depth to water <25 ft bgs), or pump intake (bladder pump, if depth to water >25 ft bgs) at the approximate mid-depth of the sampler screen interval;
9. Purge well until water is visually clear of sediment, or for a maximum of 20 minutes before collecting GW samples;
    - Note: for low-permeability formations, collected a grab sample from the screen and/or saturated soil sample from the soil core retrieved earlier, and then allow for overnight recovery of groundwater leaving temporary well casing and screen in the borehole for follow-up sampling the next day.
10. Don a new set of nitrile gloves prior to collecting groundwater sample and each QC sample. Do not use gloved hands to handle papers, pens, clothes, equipment, etc., before collecting samples;
11. Fill sample bottles using labeled HDPE bottles that are supplied by laboratory only. Make sure that the cap remains on the bottle until immediately prior to sample collection and gets placed back on the bottle immediately after sample collection. Do not place the cap on any surface, keep in hand opposite of sample collection, do not touch the inside of the cap;
12. If high concentration of PFAS related to class B Firefighting foams is expected in a groundwater sample (as specified in the QAPP Addendum), collect and shake a small portion of the sample

(~10-25 mL) on site. If foaming is observed, document the foaming on the sample log and on the COC to notify laboratory personnel. The 'shaker test' vial can then be disposed;
13. Collect QC samples at frequency specified in PQAPP Worksheet #20. QC sample locations to be selected based on consultation with Arcadis RL;
14. Place filled sample bottles in a sealed (Ziploc) bag, record any label information that was not pre-filled out (i.e. sample time). Record the label information and time of sampling in the field notes and sampling forms. Place samples into sample coolers. Store PFAS samples in separate cooler from any other types of samples;
15. Fill out laboratory COC and check against the labels on the sample bottles progressively after each sample is collected;
16. Deflate the packer;
17. Packer Isolation Groundwater Profiler is pulled back up and decontaminated (see Section 10);
18. The dual-tube sonic tooling casing is then advanced to the next depth interval;
19. Repeat these steps until all samples have been collected from all target intervals;
20. Abandon the borehole as detailed in Section 7.3.

7.3 Borehole Abandonment

Borehole abandonment will be completed in accordance with the requirements set forth by applicable State agencies. Upon completion, each borehole is backfilled with bentonite grout from the terminal end (i.e. bottom) of the boring upward. A tremie grout pipe will be used to assist backfilling of deeper VAP boreholes. The top portion of each boring is sealed with asphalt or concrete to match the existing grade.

8 WASTE MANAGEMENT

Investigation-derived waste (IDW) soil cuttings, purge water, and decontamination water generated during cleaning procedures will be collected and contained on site in appropriate containers: see the Investigation-Derived Waste Handling and Storage TGI for details (Arcadis 2017c). All IDW generated during field activities will be placed in Department of Transportation approved containers, sealed, and labeled. Containerized IDW will be stored on site until waste characterization samples are analyzed and waste profile generated and are 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 (QAPP addendum) and will be consistent with applicable Army policies and Army post requirements. Personal protective equipment (e.g., gloves, disposable clothing, disposable equipment) resulting from personnel cleaning procedures and soil sampling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

9 DATA RECORDING AND MANAGEMENT

The supervising field lead will be responsible for documenting drilling events to record all relevant information in a clear and concise format. The record of drilling events should include:

- Start and finish drilling dates;

- Project name and location;
- Project number, client, and site location;
- VAP boring number and depths;
- Soil descriptions;
- Depth to water;
- Type of VAP-special tools;
- Core barrel size;
- Names of contractor's drillers, inspectors, or other people onsite; and,
- Weather conditions.

Field staff should ensure COC Forms are properly completed, and verify which PFAS analytes (e.g., just PFOS and PFOA, some or all of the modified method 537 target analyte list) are required for analysis and note on the COC. All documents (and photographs) should be scanned and electronically filed in the appropriate project directory for easy access.

10 DECONTAMINATION

To avoid cross-contamination during drilling and sampling, all reusable groundwater sampling equipment that has or is suspected to have come into contact with groundwater or soil will be decontaminated between each sample using the following steps. If Class B firefighting foam is a suspected PFAS source at any sampling location, then these steps should be performed twice.

- Don new pair of Nitrile gloves prior to decontamination
- Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox) and plastic brush;
- Double-rinse in potable deionized or distilled water;
- Rinse once with methanol or isopropyl alcohol;
- Rinse once with laboratory-certified PFAS-free water;
- Collect all rinsate in a sealed pail for disposal
- Allow time for equipment to air dry prior to re-use.

While strongly recommended, the use of solvents may be excluded for project-specific H&S concerns. If solvents are prohibited after DQO development, 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. Additionally, the following decontamination procedure could be utilized when organic solvent use is not possible.

- Don new pair of Nitrile gloves prior to decontamination

- Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox) and plastic brush;
- Single-rinse in potable deionized or distilled water;
- Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox) and plastic brush;
- Rinse twice with deionized water and once with PFAS-free water;
- Collect all rinsate in a sealed pail for disposal
- Allow time for equipment to air dry prior to re-use.

Drive casings and other drilling tooling (including Geoprobe® SP sampling tools, Packer Isolation Groundwater Profiler) will be steam cleaned between boreholes. Steam cleaning will be performed by the drillers within a temporary decontamination or other containment area designated by the supervising engineer or geologist that is located outside of the work zone. All decontamination water will be collected and containerized for disposal.

See additional specifics in P-04, TGI - Groundwater and Soil Sampling Equipment Decontamination in PQAPP Appendix A.

11 QUALITY ASSURANCE

In general, the following quality assurance and quality control (QA/QC) samples should be collected:

- Equipment blanks
- Field (i.e., reagent) blanks
- Field duplicates
- Matrix spike/matrix spike duplicate

Details on QC sampling requirements (e.g., frequency of collection, types of QA/QC samples) are provided in the PQAPP and will be outlined in various Site-specific sampling scopes of work in the QAPP Addendum. Additionally, detailed procedures related to equipment and field (i.e., reagent) blank sample collection are outlined in the Equipment and Reagent Blank Sample Collection TGI (Arcadis 2018d). In general, equipment blanks should be collected from every piece of downhole equipment that could come in contact with soil or groundwater during sample collection. This includes the profiling tools (e.g., Geoprobe® SP-16, Geoprobe® SP-22, Geoprobe® SP-60, Cascade Packer Isolation Groundwater Profiler).

Prior to initiating field activities, water sources to be used during drilling activities should be sampled to verify those sources are PFAS-free. While not part of the PQAPP, this is considered best practice and should be completed to the extent possible.

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 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.**

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ATTACHMENT 1

Table 1 and Table 2: PFAS Inspection Material Recommendations

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

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™	Low density polyethylene (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 inspections	--
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		
Sharpie®	--	NHDES 2016; USACE 2016; MassDEP 2017
Ball point pens	--	MassDEP 2017
Standard paper and paper labels	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Decontamination		
Water-only decontamination	Confirm PFAS-free water source via laboratory analysis prior to inspections	DER 2016
Alconox®, Liquinox® or Citranox® followed by deionized water or PFAS-free water rinse	Alconox® known to contain trace levels of 1,4-dioxane	NHDES 2016; USACE 2016; MassDEP 2017
Methanol, isopropanol, or acetone	Special health and safety precautions are necessary	UNEP 2015; USACE 2016

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 2: Summary of Equipment and Materials Not Recommended for PFAS Site Inspections

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFASs	References
Water Sampling Materials				
Teflon® or polytetrafluoroethylene (PTFE)-containing or coated field equipment (e.g., tubing, bailers, tape, plumbing paste)	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				
Aluminum foil			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Drilling fluid containing PFASs	x	x		DER 2016
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
Non-Sharpie® markers		x		NHDES 2016
Decontamination				
Some detergents and decontamination solutions (e.g., Decon 90® Decontamination Solution)	x	x		DER 2016; NHDES 2016; MassDEP 2017

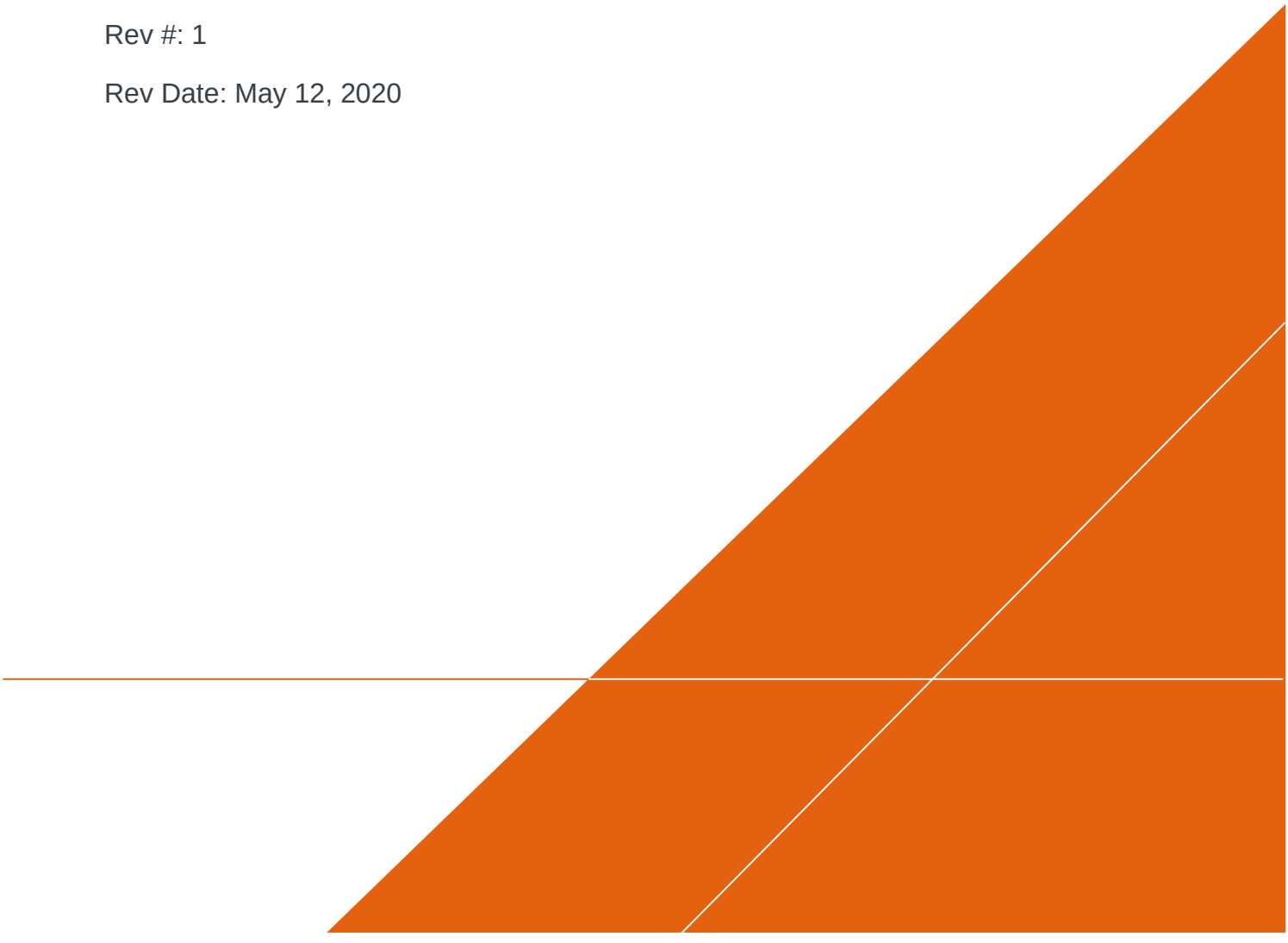
Note: For materials that are suspected of containing PFASs, or have the potential to retain PFASs, project specific considerations may provide adequate justification for use during the field event. For example, further evaluation may be conducted in the form of pre-field equipment blank sample analysis.

ARCADIS Design & Consultancy for natural and built assets

TGI – SOIL DRILLING AND SAMPLE COLLECTION

Rev #: 1

Rev Date: May 12, 2020



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 11, 2018	All	Updated and re-written as a TGI	Marc Killingstad
1	May 12, 2020	None	Review – no changes necessary	Marc Killingstad

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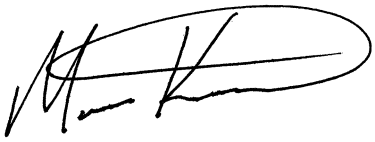
APPROVAL SIGNATURES

Prepared by:		10/11/2018
	Christopher Keen	Date:
Technical Expert Reviewed by:		05/12/2020
	Marc Killingstad (Technical Expert)	Date:

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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

This Technical Guidance Instruction (TGI) describes general drilling procedures and the methods to be used to field screen and collect soil samples for laboratory analysis in unconsolidated sediments. For soil description procedures, please refer to the *TGI - Soil Description*. For monitoring well installation in granular aquifers, please refer to the *TGI - Monitoring Well Installation*.

Overburden (unconsolidated sediments) drilling is commonly performed using the hollow-stem auger drilling method. Other drilling methods suitable for overburden drilling, which are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and hand tools may also be used. Drilling within consolidated materials such as fractured bedrock is commonly performed using water-rotary (coring or tri-cone roller bit), air rotary or rotasonic methods. For guidance when drilling in consolidated materials (i.e., bedrock), please refer to the *TGI – Bedrock Core Collection and Description*.

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The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling depths, site or regional geologic knowledge, types of sampling to be conducted, required sample quality and volume, and cost.

Field screening of soil samples is commonly performed using a photoionization detector (PID) and/or a flame ionization detector (FID). These instruments are used to measure relative concentrations of volatile organic compounds (VOCs) for the selection of samples for further laboratory or field analysis. Field screening for dense non-aqueous phase liquids (DNAPL) may be performed using hydrophobic dye (Oil Red O or Sudan IV), which is pertinent at chlorinated solvent sites.

Collection of soil samples for laboratory analysis may be performed using a variety of techniques including grab samples and composite or homogenized samples. Samples may require homogenization across a given depth interval, or several discrete grabs (usually five) may be combined into a composite sample. Samples for VOC analysis will not be homogenized or composited and are collected as discrete grab samples.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools).

3 PERSONNEL QUALIFICATIONS

Arcadis field 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 state/federal 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, Arcadis field personnel will review and be thoroughly familiar with relevant site-specific documents including but not limited to the task-specific work plan or field implementation plan (FIP), Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field 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. Personnel responsible for overseeing drilling operations will have at least 16 hours of prior training overseeing drilling activities with an experienced geologist, environmental scientist, or engineer with at least 2 years of prior experience.

Arcadis personnel directing, supervising, or leading soil sampling activities will have a minimum of 1 year of previous environmental soil sampling experience. Field employees with less than 6 months of experience will be accompanied by a supervisor (as described above) to ensure that proper sample collection techniques are employed.

Additionally, the Arcadis field 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.

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4 EQUIPMENT LIST

The following materials will be available, as required, during soil boring drilling, field screening, and sampling activities:

- Site-specific HASP and health and safety documents identified in the HASP
- Field Implementation Plan (FIP)/work plan that includes site map with proposed boring locations, field sampling plan (with corresponding depths, sample analyses, sample volume required, and sample holding time), and previous boring logs (as available)
- Appropriate personal protective equipment (PPE), as specified in the HASP
- Traffic cones, delineators, and caution tape as appropriate for securing the work area as specified in the Traffic Safety Plan (TSP)
- Photoionization detector (PID), flame ionization detector (FID) or other air monitoring equipment, as needed, in accordance with the HASP
- Drilling equipment required by *ASTM D1586*, when performing split-spoon sampling
- Disposable plastic liners, when drilling with direct-push equipment
- Appropriate soil sampling equipment (e.g., stainless steel spatulas/spoons/bowls, knife)
- Stainless steel hand auger and stainless-steel spade if using manual methods
- Indelible ink pens
- Engineer's ruler or survey rod
- Sealable plastic bags (e.g., Ziploc®)
- Air-tight sample containers and 8-oz. glass Mason jars or driller's jars
- Aluminum foil
- Plastic sheeting (e.g., Weatherall Visqueen)
- Decontamination equipment (buckets, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels)
- Appropriate sample blanks (trip blank supplied by the laboratory), as specified in the FSP
- Soil sample containers and labels (supplied by the laboratory) appropriate for the analytical method(s) with preservative, as needed (parameter-specific)
- Appropriate transport containers (coolers) with ice and appropriate labeling, packing, and shipping materials;
- Appropriate soil boring log (**Attachment 1**)
- Chain-of-custody forms
- Field notebook.

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- Digital camera (or smart phone with camera)
- Drums or other containers appropriate for soil and decontamination water, as specified by the site investigation-derived waste (IDW) management plan, and appropriate drum labels

5 CAUTIONS

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be delineated by the drilling contractor or an independent underground utility locator service. See appropriate guidance for proper utility clearance protocol. Work will be performed in accordance with the Arcadis *Utility Location and Clearance Health and Safety Standard* and the *Utilities and Structures Checklist* will be completed before beginning any intrusive work.

Prior to beginning field work, the project technical team will ensure that all field logistics (e.g., access issues, health and safety issues, communication network, schedules, etc.) and task objectives are clearly understood by all team members. An internal call with the project technical team to review the FIP/work plan scope and objectives is strongly recommended prior to mobilization to ensure that the field work will be effectively and efficiently executed.

Some regulatory agencies have specific requirements regarding borehole abandonment and grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling plan.

If DNAPL is known or expected to exist at the site, refer to the project specific documents (e.g., DNAPL Contingency Plan) for additional details regarding drilling to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquid (LNAPL) is known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Water used for drilling, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply will be considered.

Specifications of materials used for backfilling the borehole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPL is likely to be present or in groundwater with high salinity. In these situations, neat cement grout is preferred.

Store and/or stage empty and full sample containers and coolers out of direct sunlight. Be careful not to over-tighten lids with Teflon® liners or septa. Over-tightening can impair the integrity of the seal and can cause the glass to shatter and create a risk for hand injuries.

NOTE: *Field logs and some forms are considered to be legal documents. All field logs and forms will therefore be filled out in indelible ink. Do not use permanent marker or felt-tipped pens for labels on*

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sample container or sample coolers. Permanent markers could introduce volatile constituents into the samples.

NOTE: *An Arcadis employee that is appropriately trained at the correct level of internal hazardous materials/DOT (Department of Transportation) shipping must complete an Arcadis shipping determination to address applicable DOT and IATA (International Air Transport Association) shipping requirements. Review the applicable Arcadis procedures and guidance instructions for sample packaging and labeling. Prior to using air transportation, confirm air shipment is acceptable under DOT and IATA regulations.*

6 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 worn at all times 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.

Working outside at sites with suspected contamination may expose field personnel to hazardous materials such as contaminated groundwater or non-aqueous phase liquid (NAPL) (e.g., oil). Other potential hazards include biological hazards (e.g., stinging insects, ticks in long grass/weeds, etc.), and potentially the use of sharp cutting tools (scissors, knife). 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.

If thunder or lighting is present, discontinue drilling and sampling until 30 minutes have passed after the last occurrence of thunder or lighting.

7 PROCEDURE

The procedures for drilling and the methods to be used to field screen and collect soil samples for laboratory analysis are presented below:

DRILLING PROCEDURES

Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area.
2. Advance boring to designated depth:
    a. Collect soil samples at appropriate interval as specified in the FIP/work plan (or equivalent)
    b. Collect, document, and store samples for laboratory analysis as specified in the FIP/work plan (or equivalent)

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c. Decontaminate equipment between samples in accordance with the FIP/work plan (or equivalent)

d. A common sampling method that produces high-quality soil samples with relatively little soil disturbance is described in *ASTM D1586 – Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils* (ASTM D1586).

   i. Split-spoon samples are obtained during drilling using hollow-stem auger, drive-and-wash, spun casing, and fluid/mud rotary

e. Rotasonic drilling produces soil cores that, for the most part, are relatively undisturbed, but note that when drilling in consolidated or finer-grained sediment the vibratory action during core barrel advancement may create secondary fractures or breaks

f. Dual-rotary removes cuttings by compressed air or water/mud and allow only a general assessment of geology

3. Describe each soil sample as outlined in the appropriate project records (refer to the description procedures outlined in the *TGI - Soil Description*)

   a. Record descriptions on the soil boring log (**Attachment 1**) and/or field notebook.

   b. When possible photo document the samples (e.g., soil cores, split-spoons)

   c. During soil boring advancement, document all drilling events in field notebook, including blow counts (i.e., the number of blows from a soil sampling drive weight [140 pounds] required to drive the split-barrel sampler in 6-inch increments) and work stoppages

   d. Blow counts will not be available if rotasonic, dual-rotary, or direct-push methods are used; however, if standard penetration testing is required during rotasonic drilling, an automatic drop hammer may be used in conjunction with the method to switch from core barrel advancement to standard penetration testing

4. The drilling contractor will be responsible for obtaining accurate and representative samples, informing the supervising Arcadis geologist of changes in drilling pressure, and keeping a separate general log of soils encountered, including blow counts

   a. The term “samples” means soil materials from particular depth intervals, whether or not portions of these materials are submitted for laboratory analyses

   b. Records will also be kept of occurrences of premature refusal due to boulders or construction materials that may have been used as fill

   c. Where a boring cannot be advanced to the desired depth, the boring will be abandoned, and an additional boring will be advanced at an adjacent location to obtain the required sample

   d. Where it is desirable to avoid leaving vertical connections between depth intervals (e.g., if DNAPL or perched LNAPL are known or expected to exist at the site), the borehole will be sealed using cement and/or bentonite (see **Section 5** above)

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e. Multiple refusals may lead to a decision by the supervising geologist to abandon that sampling location

Direct-Push Method

The direct-push drilling method may also be used to complete soil borings. Examples of this technique include Geoprobe®, Diedrich Environmental Soil Probe (ESP) System, or AMS PowerProbe. Environmental probe systems typically use a hydraulically operated percussion hammer.

Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff to medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual tube liner for sampling soil (dual tube sampling system).

The outside diameter (OD) of the outer casing ranges from 2.25 to 6 inches and the OD of the inner sampling tube diameter ranges from 1.4 to 4.5 inches. The outer casing isolates overlying soil and permits the unit to continue to probe at depth. The dual tube sampling system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, a single rod system may be used that does not provide a cased boring and which does not allow for tremie-grouting from the bottom up.

The known or expected site conditions (e.g., presence of NAPL) will be evaluated when selecting the type of direct-push sampling system to be employed.

Direct-push drilling can generally achieve target depths 100 feet or less and the achievable depth is based on the site geology.

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area
2. Advance soil boring to designated depth.
    a. Collect soil samples at appropriate interval as specified in in the FIP/work plan (or equivalent)
    b. Collect, document, and store samples for laboratory analysis as specified in in the FIP/work plan (or equivalent)
    c. Decontaminate equipment between samples in accordance with in the FIP/work plan (or equivalent)
    d. Samples will be collected using dedicated, disposable, plastic liners
3. Describe samples in accordance with the procedures outlined in **Step 3** under ***Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods*** above (refer to the description procedures outlined in the *TGI - Soil Description*)

Manual Methods

Manual methods may also be used to complete shallow soil borings. Examples of this technique include using a spade, spoon, scoop, hand auger, or slide hammer. Manual methods are typically used to collect surface soil samples (0 to 6 inches) or to complete soil borings/collect soil samples from a depth of 5 feet or less.

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1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area
2. Clear the ground surface of brush, root mat, grass, leaves, or other debris
3. Use a spade, spoon, scoop, hand auger, or slide hammer to collect a sample of the required depth interval
4. Use an engineer's ruler or survey rod to verify that the sample is collected to the correct depth and record the top and bottom depths from the ground surface
5. To collect samples below the surface interval, remove the surface interval first; then collect the deeper interval
    a. To prevent the hole from collapsing, it may be necessary to remove a wider section from the surface or use cut polyvinyl chloride (PVC) pipe to maintain the opening
    b. Collect soil samples at appropriate interval as specified in the FIP/work plan (or equivalent)
    c. Collect, document, and store samples for laboratory analysis as specified in the FIP/work plan (or equivalent)
    d. Decontaminate equipment between samples in accordance with the FIP/work plan (or equivalent)
6. Describe samples in accordance with the procedures outlined in **Step 3** under ***Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods*** above (refer to the description procedures outlined in the *TGI - Soil Description*)

FIELD SCREENING PROCEDURES

PID and FID Screening

Soils are typically field screened with a PID or FID for a relative measure of the total VOCs at sites where VOCs are known or suspected to exist. The PID employs a UV lamp to measure VOCs and the ionization energy (IE) of the site constituents need to be considered when selecting the type of lamp (e.g., 10.6 eV, 11.7 eV) that will be used. In general, any compound with an IE lower than that of the lamp photons can be measured. The FID has a wide linear range and responds to almost all VOCs. Field screening is performed using one (or both) of the following two methods:

1. Upon opening the sampler, the soil is split open and the PID or FID probe is placed in the opening and covered with a gloved hand. Such readings will be obtained at several locations along the length of the sample.
2. A portion of the collected soil is placed in a jar, which is covered with aluminum foil, sealed, and allowed to warm to room temperature. After warming, the cover is removed, the foil is pierced with the PID or FID probe, and a reading is obtained.

Initial PID readings will be recorded on the soil boring log (**Attachment 1**) and/or in the field notebook. The soil sample will be separated from the slough material (if any) by using disposable gloves and a pre-cleaned stainless-steel spoon.

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For the second method, a representative portion of the sample will be placed in a pre-cleaned air-tight 8-ounce container (as quickly as possible to avoid loss of VOCs), filling the container half full to allow for the accumulation of vapors above the soil. An aluminum foil seal will be placed between the glass and metal cap and the cap will be screwed on tightly. Unless the screening will be performed immediately after the sample is placed in the container, the sample containers will be stored in a cooler chilled to approximately 4ºC until screening can be performed.

The headspace of the 8-ounce container will be measured using a PID or FID as follows:

1. Samples will be taken to a warm work space and allowed to equilibrate to room temperature for at least one hour.
2. Prior to measuring the soil vapor headspace concentration, the 8-ounce container will be shaken.
3. The headspace of the sample will then be measured directly from the 8-ounce container by piercing the aluminum foil seal with the probe of the PID or FID and measuring the relative concentration of VOCs in the headspace of the soil sample. The initial (peak) reading must be recorded.

The PID or FID must be calibrated according to the manufacturer's specifications at a minimum frequency of once per day prior to collecting PID or FID readings. The PID will be calibrated to a benzene-related compound (isobutylene) while the FID will be calibrated to methane.

The time, date, and calibration procedure must be clearly documented in the field notebook and/or the calibration log book.

If at any time the PID or FID results appear erratic or inconsistent with field observations, then the instrument will be recalibrated.

If calibration is difficult to achieve, then the PID's lamp will be checked for dirt or moisture and cleaned, or technical assistance will be required. Maintenance and calibration records will be kept as part of the field quality assurance program.

NAPL Screening

To screen for the potential presence of non-aqueous phase liquid (NAPL) in soil, drilling procedures must allow for high-quality porous media samples to be taken. Split-spoon samplers or direct-push samplers will be collected continuously ahead of the auger, drill casing/rods, or probe rods.

Upon opening each split-spoon sampler or direct-push plastic liner sleeve, the soil will immediately be evaluated for the presence of visible NAPL. If NAPL is immediately visible in the sample, its depth will be noted.

Additionally, the soil will be screened for the presence of organic vapors using a PID or FID. During screening, the soil will be split open using a clean spatula or knife and the PID or FID probe will be placed in the opening and covered with a gloved hand (**Method 1** above). Such readings will be obtained along the entire length of the sample. Alternatively, **Method 2** for PID/FID screening (outlined above) may also be performed. If the PID or FID examination reveals the presence of organic vapors above 100 parts per million (ppm), the sample will undergo further detailed evaluation for visible NAPL.

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The assessment for NAPL will include the following tests/observations:

- Evaluation for Visible NAPL Sheen or Free-Phase NAPL in Soil Sampler
    - NAPL sheen will be a colorful iridescent appearance on the soil sample
    - NAPL may also appear as droplets or continuous accumulations of liquid with a color typically ranging from yellow to brown to black, depending on the type of NAPL
    - Creosote DNAPL (associated with wood-treating sites) and coal tar DNAPL (associated with manufactured gas plant [MGP] sites) are typically black and have a characteristic, pungent odor
    - Pure chlorinated solvents may be colorless in the absence of hydrophobic dye. Solvents mixed with oils may appear brown
    - Particular care will be taken to fully describe any sheens observed, staining, discoloration, droplets (blebs), or NAPL saturation
- Soil-Water Pan Test
    - A portion of the selected soil interval with the highest PID or FID reading above 100 ppm will be placed in a disposable polyethylene dish along with a small volume of potable or distilled water
    - The dish will be gently tilted back and forth to mix the soil and water, and the surface of the water will be viewed in natural light to observe the development of a sheen, if any
    - A small quantity of Oil Red O or Sudan IV hydrophobic dye powder will be added, and the soil and dye will be manually mixed for approximately 30 to 60 seconds and smeared in the dish to create a paste-like consistency
    - A positive test result will be indicated by a sheen on the surface of the water and/or a bright red color imparted to the soil following mixing with dye
- Soil-Water Shake Test
    - A small quantity of soil (up to 15 cc) will be placed in a clear, colorless, jar containing an equal volume of potable or distilled water (40-mL vials are well suited to this purpose, but not required)
    - After the soil settles into the water, the surface of the water will be evaluated for a visible sheen under natural light
    - The jar will be closed and gently shaken for approximately 10 to 20 seconds
    - Again, the surface of the water will be evaluated for a visible sheen or a temporary layer of foam
    - A small quantity (approximately 0.5 to 1 cc) of Oil Red O or Sudan IV powder will be placed in the jar
    - The sheen layer, if present, will be evaluated for a reaction to the dye (change to bright red color)
    - The jar will be closed and gently shaken for approximately 10 to 20 seconds
    - The contents in the closed jar will be examined under natural light for visible bright red dyed liquid inside the jar

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- A positive test result will be indicated by the presence of a visible sheen or foam on the surface of water, a reaction between the dye and the sheen layer upon first addition of the dye powder, a bright red coating on the inside of the vial (particularly above the water line), or red-dyed droplets within the soil

NOTE: *If NAPL is obviously present upon opening the soil sampler or evaluating the soil sample within the split-spoon sampler or direct-push liner sleeve, it is not necessary to perform a soil-water pan test or soil-water shake test. In addition, it is not necessary to perform both a soil-water pan test and a soil-water shake test; either test method is acceptable. The pan test may be preferred in some circumstances because the presence of a sheen may be easier to see on a wider surface.*

NOTE: *When using hydrophobic dye in the tests above, color will be assessed outdoors under natural light during the period between sunrise and sunset, regardless of the degree of cloud cover. The hydrophobic dye Safety Data Sheets (SDS) will be incorporated into the HASP and reviewed prior to use and the dyes will be carefully handled and disposed in accordance with regulations*.

SOIL SAMPLE COLLECTION FOR LABORATORY PROCEDURES

If not specifically identified in the FIP, soil samples will be selected for laboratory analysis based on:

1. Their position in relation to identified source areas
2. The visual presence of source residues (e.g., NAPL)
3. The relative levels of total VOCs based on field screening measurements
4. The judgment of the field coordinator

Samples designated for laboratory analysis will be placed in the appropriate containers.

Sample containers for VOC analysis will be filled first immediately following soil core retrieval to reduce loss of VOCs.

If samples will be collected for other analytical parameters, a sufficient amount of the remaining soil will then be homogenized as described below and sample containers will be filled for other parameters.

VOC samples will be collected as discrete samples using a small diameter core sampler (e.g., En Core® Sampler, Terra Core™ Sampler).

The En Core® Sampler is a disposable volumetric sampling device that collects, stores and delivers soil samples without in-field chemical preservation. The En Core® Sampler requires the use of a reusable T-handle.

The Terra Core™ Sampler is a one-time use transfer tool, designed to collect soil samples and transfer them to the appropriate containers for in-field chemical preservation (e.g., methanol).

The small diameter core sampler will be used according to the manufacturer's instructions (e.g., En Novative Technologies). Some regulatory agencies have specific requirements regarding VOC sample collection. Determine whether the oversight agency has specific requirements prior to commencing sampling and collect samples at appropriate interval as specified in the FIP/work plan (or equivalent). Samples may require homogenization across a given depth interval, or several discrete grabs (usually five) may be combined into a composite sample.

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NOTE: *Samples for VOC analysis will NOT be homogenized or composited and will be collected as discrete samples as described above*.

The procedure for mixing samples is provided below.

1. Mix the materials in a stainless steel (or appropriate non-reactive material) bowl using a stainless-steel spoon (or disposable equivalents)
    a. When dealing with large sample quantities, use disposable plastic sheeting and a shovel or trowel
    b. NOTE: *When preparing samples for metals analyses, do not use disposable aluminum (or metal tools or trays other than stainless steel), as it may influence the analytical results*
2. Flatten the pile by pressing the top without further mixing
3. Divide the circular pile by into equal quarters by dividing out two diameters at right angles
4. Mix each quarter individually using appropriate non-reactive bowls, spoons and/or sheeting
5. Mix two quarters (as described above) to form halves, then mix the two halves to form a composite or homogenized sample
6. Place composite or homogenized sample into specified containers
7. Remaining material will be disposed of in accordance with project requirements and applicable regulations
8. Sample containers will be labeled with sample identification number, date, and time of collection and placed on ice in a cooler (target 4° Celsius)
9. Samples selected for laboratory analysis will be documented (chain-of-custody forms), handled, packed, and shipped in accordance with the procedures outlined in the FIP/work plan (or equivalent).

8 WASTE MANAGEMENT

Investigative-Derived Waste (IDW) generated during drilling activities, including soil and excess drilling fluids (if used), decontamination liquids, and disposable materials (plastic sheeting, PPE, etc.) will be stored on site in appropriately labeled containers (disposable materials will be contained separately) and disposed of properly. Containers must be labeled at the time of collection and will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, PPE). 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 log book.

9 DATA RECORDING AND MANAGEMENT

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

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In general, drilling activities will be documented on appropriate field/log forms as well as in a proper field notebook. All field data will be recorded in indelible ink. 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.

Initial field logs and chain-of-custody records will be transmitted to the Arcadis Certified Project Manager (CPM) and Technical Lead at the end of each day unless otherwise directed by the CPM. The field team leader retains copies of the field documentation.

Additionally, all documents (and photographs) will be scanned and electronically filed in the appropriate project directory for easy access. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of drilling activities, soil descriptions, soil boring information, and quantities of materials used.

In addition, the locations of soil borings will be documented photographically and in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

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

10 QUALITY ASSURANCE

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

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate TGI.

Field-derived quality assurance blanks will be collected as specified in the FIP/work plan and/or site-specific QAPP, depending on the project quality objectives. Typically, field rinse blanks (equipment blanks) will be collected when non-dedicated equipment (e.g., split-spoon sampler, stainless steel spoon) is used during soil sampling. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site conditions. Trip blanks for VOCs, which aid in the detection of contaminants from other media, sources, or the container itself, will be kept with the coolers and the sample containers throughout the sampling activities and during transport to the laboratory.

Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook.

11 REFERENCES

ASTM D1586 - *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*. ASTM International. West Conshohocken, Pennsylvania.

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12 ATTACHMENTS

Attachment 1. Soil Boring Log Form

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ATTACHMENT 1

Soil Boring Log Form

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SOIL BORING LOG

Boring/Well ____________ Project ______________________________ Page ____ of ____

Site Location ______________________________ Drilling Started ____________

Total Depth Drilled ________ Feet Hole Diameter ________ inches Drilling Completed ____________

Type of Sample or Coring Device ____________ Length and Diameter of Coring Device ____________________ Sampling Interval ____________ feet

Drilling Method ____________ Drilling Fluid Used ____________

Drilling Contractor ______________________________ Driller ____________

Prepared By ______________________________ Helper ____________

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD		SAND					GRAVEL				**Udden-Wentworth Description:** principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, additional comments
			clay	silt	very fine	fine	medium	coarse	very coarse	granular	pebble	cobble	boulder	

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SOIL BORING LOG (CONT'D)

Boring/Well __________________ Prepared By ____________________________ Page ___ of ___

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD		SAND					GRAVEL				Udden-Wentworth Description: principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, addtl. Comments
			clay	silt	very fine	fine	medium	coarse	very coarse	granular	pebble	cobble	boulder	

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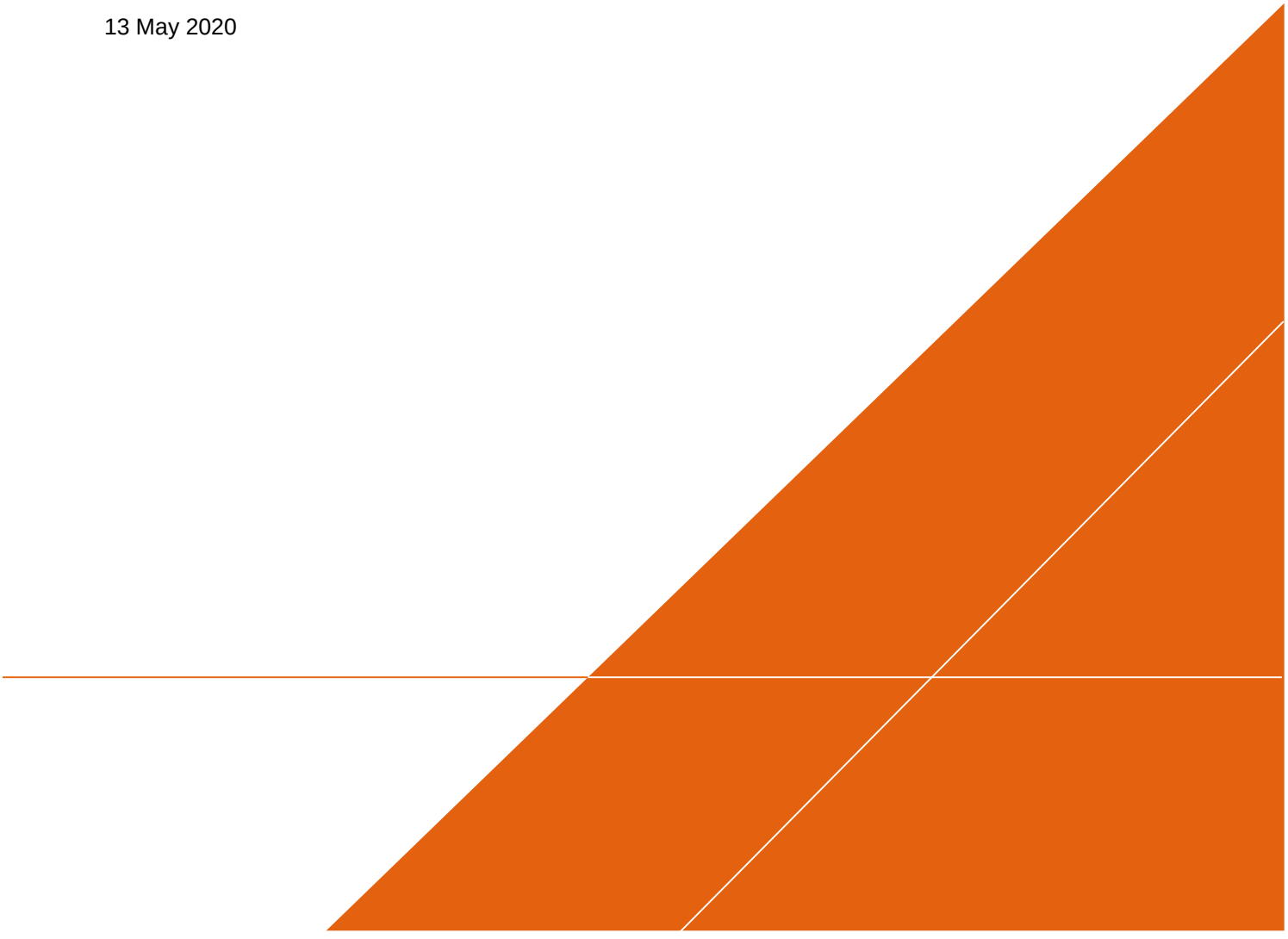
UTILITY LOCATION AND CLEARANCE STANDARD (ARC HSFS019) SUPPLEMENTS

13 May 2020



VERSION CONTROL

Revision Date	Reviewed or Revised By	Reason for Change
13 May 2020	A. MacAdam/D. Balcer/G. Mason/J. Santaniello	Combined document creation

CONTENTS

1 BEST PRACTICES FOR PROJECT MANAGERS (OR THEIR DELEGATES) CONCERNING UTILITY LOCATION & CLEARANCE

The purpose of this supplemental information is to assist Arcadis field staff with putting the Utility Clearance and Location Standard into practice. The following sections will provide best practices that can be utilized to improve the overall effectiveness of the implementation of the utility location and clearance process.

During the planning phase of a project the project manager (PM) should provide an adequate budget and schedule to allow for the clearance of utilities and is responsible for the appropriate allocation and completion of utility location and clearance responsibilities. Likewise, the PM should determine whether the number and confidence level in each of the reliable lines of evidence utilized is sufficient to accurately identify and locate structures, aboveground, subsurface, and submerged utilities to safely complete the work. The PM is responsible for verifying the utility location and clearance activities are documented on the Utilities and Structures Checklist (Excel Version) or (PDF Version).

Communication and Coordination

Project managers or their delegate/TMs

- Communicates verbally and in writing the responsibilities for utility location with relevant involved parties (field staff, subcontractors, and client/property owner/manager).
- Instructs field staff to be aware of and implement the procedures in the HSS and utilize the appropriate Utility and Structures Checklist (USC); and verifies the USC is complete.
- Ensures that field staff are properly trained, comfortable and empowered to ask questions about the locating technologies being utilized, including limitations of equipment and to understand interference potential.
- Reviews the field staff training and experience that are required as per the standard to be appropriate to complete the utility location and clearance activities.
- When practical, schedules a joint meeting between the public/private utility locators, field staff, and subcontractors to review the subsurface utility locating and marking in the field.
- Ensure that Arcadis representatives and subcontractors are familiar with the proposed scope of work and, where feasible, are **onsite** when utilizing a private utility locator (PUL).
- Communicates with and provides utility location documentation to the subcontractors, PUL, or the party performing the intrusive work to verify with them the PM's understanding of the utility locations and discusses methods to be used by the utility locators and/or intrusive work parties to clear and protect utilities in their work area;

- Understands the subcontractor's methods for utility location, clearance and documentation of the methods used with a clear delineation of responsibilities

- Provides adequate size drawings/figures to field staff to utilize in the field during the location and clearance activities; PMs are to interact with Arcadis Geophysics Community of Practice staff to gain assistance on utility location and clearance methodologies based on site conditions and characteristics; and

- PMs are responsible for utilizing the Arcadis standard contract, which contains specific indemnification language. If non-standard contracts are utilized, PM must contact Legal for support.

Field Leads

- Completes the Utilities and Structures Checklist (Excel Version) or (PDF Version).

- The field lead verifies that the PUL has received all utility information provided by the client or property owner/manager and the scope of work.

- Provides any other pertinent information to the subcontractor and PUL related to the scope of work and current site conditions.

- Implements traffic control devices as per the Traffic Safety Plan (TSP) as needed from one location to another unless provided by a third-party traffic control provider.

- Completes the 811 DigSafe state One Call (Nationwide "811") or equivalent if not done so by the subcontractor performing the intrusive activities (or in conjunction with the subcontractor, determined by State-specific requirements) at least 48-72 hours prior to intrusive activities and documents any responses on the USC.

- Communicates any conflicts or non-responses from the One Call system or its equivalent to the TM or PM prior to intrusive activities.

- Be sure to be present during PUL activities, relay findings or issues to PM and or client, asking questions of the PUL related to equipment limitations, potential interference, etc.

- Review the results of the utility locating activities with the PM and the information gathered on the USC.

- In large complex projects, multiple USCs should be utilized and broken down to Areas of Concern (AOCs), to simplify utility and scope of work information. This helps to reduce confusion and can keep large work areas more organized.

Subcontractors

Working with our subcontractors and those contracted directly to the client are typical situations that may arise when conducting location and clearance activities prior to intrusive work. In most cases when the subcontractor is working under contract with AUS, then:

- The utility location requirements must meet the ARC HSFS-019 HSS at a minimum if the contractor was operating under their own H&S program or utility location standard. This is to ensure the safety of AUS oversight staff.

- AUS staff can assist in providing any utility and structure information to the subcontractor that was provided by the client or property manager or other entity.
- The field lead needs to be present during utility location and clearance activities to ensure adherence utility standard.
- PM/Field lead should review the completed USC and One Call ticket information prior to intrusive activities. Any discrepancies need to be resolved prior to intrusive work as well.
- In some states it is required for both General contractor and subcontractor to perform the One Call requirements. Check the state requirements and work with the subcontractor to complete said requirements. Common Ground Alliance One Call State Law Directory (https://commongroundalliance.com/map).
- Open communication must be utilized when the subcontractor begins intrusive work so that AUS staff can be present for oversight.

When subcontractors are contracted directly to the client:

- The oversight personnel must adhere to the contract requirements and scope of work as dictated by the client.
- This means the subcontractor could be responsible for all utility location and clearance activities and they do not have to meet ARC HSFS-019 requirements.
- If at any time, the AUS staff overseeing the intrusive work feels unsafe or uncomfortable how the contractor is carrying out intrusive work around utilities then, they should try to get the client contractor to Stop Work, if unable to do so they are to leave the area and report into the PM immediately. The PM needs to communicate these concerns to the client to resolve the situation.

Client or Property Owner/Manager

Working with the client or property owner/manager is an important process and can be difficult at times to locate utility information:

- Diligence should be taken to obtain utility information that can be gathered from the client or the property owner/manager (i.e. maps, figures, as-builts, etc.).
- Communication or onsite review with property managers can lead to more information about utilities present, inactive and/or abandoned. This information should be reviewed in conjunction with private utility location results.
- Areas where active utilities are present, a potential de-energizing process (e.g., LOTO - lockout/ tagout) should be discussed as an option to reduce the risk of striking a “live” utility. This decision should be documented in the field notes after discussion options with the PM and property owner/ client. The location of shut-off valves should also be discussed if water-related utilities are present if a strike were to occur.
- Contingency for utility strike repairs or response procedures should be laid out with the client/property manager prior to the intrusive activities.
- Reporting requirements for utility strikes on client properties in addition to the AUS reporting requirements should be determined prior to intrusive activities.

Design Considerations

During the design phase of a project, we have the opportunity to eliminate or minimize the risk of striking a utility due to the proposed intrusive activities. Here are some design considerations:

- During the design phase, use the best/ most recent utility information available; design staff should field verify information whenever possible.

- Design intrusive activities to remain greater than 30 inches away of existing known structures and utilities, in other words stay outside of the Arcadis 30-in. Tolerance Zone. When proposing intrusive activities take into consideration the distance necessary to not disturb or impact the integrity of the utility or media bed it is housed in, which may be more than the minimum 30-inch requirement. If necessary, increase distance away from the utility or build in flexibility to move intrusive activities during field verification. Bear in mind the measurement of the Arcadis 30-in. Tolerance Zone is measured radially in all directions from the outermost point of the utility.

- Work areas and travel corridors of heavy equipment need to be evaluated for loading concerns to prevent potential damage to shallow utilities. These travel/work areas should also be cleared for utilities and approximate depths to further define necessary load-control measures. The utility provider may also have specific requirements; therefore, the utility owner should be contacted during the design phase.

- Design considerations should focus on the avoidance of 'Critical areas' (i.e. USTs, dispenser canopies, high voltage lines, etc.). Since these areas are very sensitive to disturbance, strict avoidance should be used when planning intrusive activities in these areas. This may require challenging a regulator, client, or even the design team on proposed locations for the intrusive work. It is important to recognize and communicate the risk of injury to the field workers if a utility strike were to occur. This is a good opportunity to utilize the STOP work authority before the work is even fully designed.

- There are many designed activities where intrusive work tasks are not the primary component of the scope of work. These activities can include: Silt fence installation, fence post installation, hand augering, installation of survey stakes, installation of ground rods, and equipment tie down points for wind or earthquake protection. It is important to recognize that these activities have the potential to impact utilities too, and avoidance measures should be considered as part of the design as well as the field work. Types of utilities that would be especially prone to damage are communication or fiber optic lines, UST piping, and plastic/PVC constructed utilities/conduits. Design and scope of work costing should be put in place to account for utility clearance of such areas.

- When Arcadis is installing infrastructure (i.e. treatment system piping), plan and budget for surveying the installed location and updating the record drawings for the site owner and/or as part of public recording. Also, consider use of utility indicators to aid in future location of the installed line.

Excavation Area Considerations

- If a utility is identified in the proposed excavation limits, consider changing the excavation limits to avoid the utility and potential disturbance to its infrastructure.

- For identified utilities in a proposed excavation area, consider cut and capping the utility or potential rerouting to prevent potential damage.

- Determine engineered support requirements if excavating around the utility; recognize that any suspended/braced utility has the potential to break so understand the "what if" situation

- Coordination with the utility owner/provider must be completed if the excavation limits will impact the infrastructure of the utility or the bedding materials.
- Excavation limits should consider the use of sloping/shoring/or benching based on the proposed depth of the excavation if need to be entered (i.e. hand clearing utilities or sample collection)
- Where feasible, consider deactivating/de-energizing and LO/TO of a utility in the excavation limits or that has the potential to be impacted from the intrusive work. The decision-making process needs to be documented as well.

2 BEST PRACTICES FOR FIELD PERSONNEL CONCERNING UTILITY LOCATION AND CLEARANCE

The purpose of this supplemental information is to assist field staff with the practical application of the Arcadis Utility Clearance and Location Standard. The following sections will provide best practices that can be utilized to improve the overall effectiveness of the implementation of the utility location and clearance process.

Pre-Job Planning and Preparation

Field team members should work with the project manager or their delegate on the following topics:

- Identifying project goals and define minimum H&S expectations.
- Obtain site access/permits, if required.
- Identify traffic control measures utilizing the Arcadis Field Guide to Roadway Work Zone Safety.
- Identify any utility critical areas (UST systems, product distribution lines, etc.).
- Identify “back up” drilling locations in case primary points are inundated with utilities.
- Develop a site plan showing relevant above- and below-grade features.
- Complete the Utility and Structures Checklist (USC).
- Identify field staff – ideally the staff member qualified in utility location and clearance should be on-site during locating events (811, GPR, site walk, etc.) as well as during the intrusive activities.

Completion of the State One Call or Nationwide 811

As part of the Utility Standard and associated checklist, the One Call is a requirement prior to any intrusive activities. For detailed information on completing the One Call, refer to Section 4 of this Supplement. Allow ample time for mark outs to be performed, 48-72 hours prior to intrusive activities.

Recognize that One Call/ 811 will only mark public areas and not private property. The work area should be clearly marked in white paint and with stakes/flagging for high vegetation or snow-covered areas. For areas with constant snowfall, survey pins can be installed in pavement to mark location of utilities. For purposes of field personnel completing the US, the following items should be documented on the USC:

- Utility companies notified and responses as part of the One Call notification process.
- The One Call ticket number or attach ticket to USC.
- Type of device used to mark utilities (paint, pin, flags, other or none).
- Utility companies marked utilities or provided “no conflict” status.
- Name of utility providers that do not participate in the One Call system that require notification. Record call date and name of utility representative. Confirm they have marked the work area.
- Field staff should accompany the utility companies where possible, such that field staff can ask questions and provide work scope clarification.

Field staff must reconcile any discrepancies of utility company mark outs or absence of mark outs prior to starting subsurface intrusive work.

It has been identified during incident investigations that switching project personnel during the utility location and clearance phase and/or the intrusive activity phase has been a Contributing Factor in past utility strike incidents. As a best practice, having the same project personnel completing the utility location and clearance and intrusive activities is recommended. This allows site knowledge and utility location/clearance information gathered during the utility clearance phase to be kept up to date and this historical perspective available to minimize the potential for a utility strike. If it is not feasible to have the same project personnel throughout the work activity, then a thorough knowledge transfer on the site utilities, locations and clearance results and proposed intrusive activities must be completed.

Review of Site Utility Drawings and Conducting Interviews

Review all available site utility drawings, plans, and "as-builts" and/or interview site representatives about their facility knowledge. All utilities must be considered regardless of age or current status of use (i.e. active vs. abandoned in place). Drawings provided to field staff should be prepared with the following considerations:

- The drawing should be large enough to use in the field.
- Field staff should be able to make a master drawing to incorporate utilities with correct utility specific color coding.
- Compare drawings to current site features to evaluate if conditions have changed (i.e., structures added or removed from site, etc.)
- Example drawings to be reviewed (i.e., tank dip charts, aerial photos, "as-builts", easements/right of ways, fire insurance plans, etc.)
- Hold a review session with "persons of interest" (i.e., current, or past site managers) to confirm accuracy of drawings.
- Document all interviews on the USC.

If discrepancies are noted in utility locations or any potential conflict exists with our planned subsurface work, STOP WORK and re-assess the situation. Call the Project Manager and/or engineer/geologist to re-evaluate.

In Field Utility Location and Clearance

Conducting the Visual Site Inspection

Verify mark out presence and approximate location of utilities on-site. This information can be documented on page 2 of the USC. In addition:

- Time your site visits prior to and after 811 DigSafe One Call mark outs (to visually confirm that mark outs have been performed).
- Identify and visually trace above-grade indicators of utilities (USTs, power poles, hydrants, utility warning markers, faucets, light poles, water meters, power transformers, manhole covers, linear ground depressions, soil/lawn scars, pavement cut marks/patching, etc.).
- Identify utility sources to receptors (a water faucet and the water meter).
- Include site/property managers in site inspection to provide site-specific information or utility locations based on historical knowledge.
- See the big picture, look outside your area for other utilities that may cross your area.
- Confirm utility color(s) marked match One Call responses. **Reconcile any discrepancies.**

- Check for overhead utilities and structures. The chart below provides minimum clearance distances for overheard power lines and heavy equipment.

Power Line Voltage (kV)	Minimum Safe Clearance (ft)
50 or below	10
>50-200	15
>200-350	20
>350-500	25
>500-750	35
>750-1,000	45
Source: ANSI Standard B30.5-2004, 5-3.4.5	

Know the locations of all subsurface and above ground utilities before conducting any intrusive field activities. In addition, subsurface utility locations marked by public utility locators are typically only good for 2 weeks before they expire. Project teams need to research the state specific regulations for the state in which the work is completed (https://commongroundalliance.com/map). If subsurface work activities are not conducted during the time period specified by state law, all lines of evidence must be re-verified, including but not limited to requesting that the public utility locators remark/verify the subsurface utility locations.

NOTE: At no time should subsurface work be conducted based on old markings, hand-drawn maps/sketches, photographs, or by recollection/memory of field staff. If markings are smeared, removed, damaged, covered (e.g., mud or snow), or impacted in any way, the site should be remarked before subsurface intrusive work begins. When marking the approximate location of a utility, use a reasonably permanent marking means appropriate for the site, such as flags or paint.

Three Reliable Lines of Evidence

If any of the required minimum three lines of evidence are not available or the level of confidence in the three lines of evidence is not sufficient to proceed with intrusive activities, additional methods can be utilized to gain more information about subsurface utilities. For further information refer to Section 3 of this Supplement, Use and Limitations of Common Utility Location Technologies and Clearance Methods. Project team members should communicate the level of confidence of each line of evidence as they are collected. Any of these methods can be documented on the USC.

On-site Verification – Private Utility Locate

The private utility locator (PUL) is used to gain/confirm information on known utilities and investigate the presence of unknown utilities. The selection of the PUL should be based on:

- Their performance/reputation from colleagues that have utilized their services.
- Their knowledge of the area/facility including past work at the site, if any.
- Their capabilities and locating technologies.
- Adequate locating experience/training of their field personnel.

Private Utility Locator Field Implementation Considerations

The selection of the locating technology and the site conditions can be difficult. Review Section of this Supplement to assist with selection. The following guidelines should also be considered:

- The size and number of the areas to be scanned/located and general conditions of the areas (e.g., availability, traffic).
- Allow PUL personnel adequate time to thoroughly mark entire work area.
- Match utility location technologies with site conditions and subsurface characteristics, such as soil type, density, moisture, etc.
- Scan a known utility to confirm that equipment is functioning correctly, preferably a utility marked out from the One Call service would be a good example.

The location technologies utilized must be tracked on the USC. Some location equipment examples include:

- Acoustic Pipe Location (APL)
- Ground penetrating radar (GPR)
- Radiofrequency (RF),
- Metal detector
- Electromagnetic Detection (EM)
- Sonde

Clearance Methods

Determine the clearance or soft dig method based on site conditions and utilize the least invasive method possible. The following clearance methods are listed from least invasive to most:

Vacuum Extraction/Potholing (air or water-based), air knifing, hydro-knifing, probing, hand augering, hand digging and posthole digging. Each method of clearance must be documented on the USC.

Paving/Concrete Surface Removal

Removing paving or concrete during subsurface intrusive activities adds risk. It has resulted in several utility strikes. The method selected should ensure the least amount of downward force into the subsurface to reduce the risk of collateral damage to subsurface utilities.

- Energize utilities where possible when an electronic survey is performed using a pipe and cable locator in passive mode (i.e., detects 60 Hertz frequency but only if current is flowing).
- An electronic survey is recommended, where available, particularly for large surface cover area removals.
- Only cut or core as far as needed to penetrate the surface cover. Do not use a jackhammer.
- Large surface removals should begin at the perimeter of the removal area to identify utilities passing into the work zone.
- For a large area, a concrete saw may not be practical. Heavy equipment is often used. During this process, a spotter should guide heavy equipment and look for warning signs of utilities. Heavy equipment should not use “teeth” which could protrude into a utility. Once cover is removed around the perimeter, vacuum, or hand dig. The depth of the vacuum or hand dig should be based on available information about the subsurface utility depth below ground surface or a minimum of 5 feet below ground surface, whichever is greater.
- Working inside buildings has the increase potential for utilities in the concrete or at the concrete/soil interface. Mini GPR units can be used to grid out rebar locations and other anomalies. When feasible, it is recommended to de-energize utilities and use LO/TO by a qualified staff member to minimize potential for electrical shock if subsurface activity results in electrical line strike.

- **For exposing utilities, no mechanical equipment can be used within a the Arcadis 30-in Tolerance Zone. Soil removal must be completed by hand digging techniques or soft dig technologies, such as soil vacuum extraction.**

The Arcadis 30-Inch Tolerance Zone

Prior to the start of intrusive activities, all utilities must be located, cleared and the utility specific measurements applied to avoid subsurface utility hazards. Do not conduct subsurface work within 30 inches of a line marking of the utility in a 360º direction. If subsurface work must take place within the 30-in. Tolerance Zone of the line marking, the utility must be exposed (pothole or daylight) by soft dig/clearance methods prior to starting intrusive work; **no mechanized equipment is permitted for the exposing of the utility**. Once the utility has been exposed, if mechanized equipment is planned for use within the 30-inch Arcadis Tolerance Zone of the utility, such activity must receive pre-approval by Corporate H&S and others, as necessary, to mitigate or accept the risk associated with the planned work. Additional excavation safety procedures may have to be developed as part of the approval to proceed. It should be noted that any disturbance within the 30 inches or disruption of the bedding materials could affect the integrity of the utility.

If and when any line of evidence reveals that planned subsurface work will be located inside the 30-inch Tolerance Zone of known/marked/located/observed utilities, the project team must Stop Work and contact Corporate H&S as early as possible for pre-approval.

For horizontal borings, do not drill within 30 inches of the line in the vertical direction (above or below the top or bottom of the utility). Make sure to factor the diameter of the line when computing the 30-inch Tolerance Zone. When exposing utilities for horizontal borings, the same exposing techniques would be required as above.

During well installations via mechanical equipment, the 30-inch Tolerance Zone applies outward from the outside edge of the largest diameter auger or tool to be used for installation and abandonment (e.g. over drilling). In cases where wells have been previously installed and the 30-inch rule has not been followed, approval for using mechanized equipment to work within the 30-inch Tolerance Zone will require approval from Corporate H&S.

Warning Signs

Below is a list of visual indicators that may indicate a subsurface utility or structure is present. STOP WORK IMMEDIATELY and re-evaluate subsurface clearance approach/work locations if any of the indicators below are observed during clearance activities.

- Warning Tape (typically indicative of underground services), usually red in color.
- Pea Gravel/Sand/Non-Native Soils / Unusual Fill Material (typically indicative of tanks or lines).
- Red Concrete (typically indicates electrical duct banks).
- Surface or slightly subsurface whiskers.
- Abrupt absence of soil recovery in the hand auger, which could indicate non-cohesive utility backfill (pea gravel or sand), except in areas where native soil conditions typically result in poor hand auger recoveries.

- Patches in asphalt or concrete that do not match surrounding areas.
- Any unexpected departure from the native soil or backfill conditions as established by other onsite digging or drilling.

If unexpected conditions are encountered (refusal, debris, pea gravel, etc.) while completing the intrusive activity, all work should be immediately halted. Note that subsurface utilities at many industrial facilities are often placed in conduits or concrete to prevent damage. Additionally, non-native fill may have been placed at the site changing the depth of locations and change in stratification of soils. If a utility or subsurface structure is compromised, the field staff should initiate the process as described in Section 5 of this Supplement, Utility Strike Emergency Action Plan Guidelines; however, more detailed emergency action procedures should be reviewed with the client and documented in the site specific health and safety plan (HASP) prior to initiating work.

De-Energizing Utilities

If activities take place in the vicinity of an aboveground utility, the utility line can be rendered controlled (i.e., through ARC HSFS004 Control of Hazardous Energy (Lockout/Tagout)) or protected from damage (i.e., covering overhead power lines). Safe work distances described in the ARC HSFS019 Utility Location and Clearance Section 4.5 or relevant Field Health and Safety Handbook section must be followed without exception if the lines cannot be properly de-energized or covered by the owner or operator of the line.

If an aboveground utility on private property is discovered that has not been previously identified prior to mobilizing to the field, the field staff should notify the Project Manager who requests the client to assist in the identification of the utility and the implementation of control procedures as appropriate.

Special Considerations

Presence of Plastic Utilities

The presence of small diameter plastic piping (i.e., irrigation lines, storm drains, PVC/HDPE, etc.) can be very difficult to detect with locating technologies. In the case where irrigation lines are known to exist, the project team will work with the property manager or client to identify records/drawings of irrigation system layout. Potentially turning off the system during intrusive activities can also be option to utilize in case the system is damaged. Re-activation of the system to ensure no damage occurred is also recommended. This should be discussed with the client during the design phase of the project. Although the costs to make repairs to such a system are inexpensive, the potential for a water-based release can be costly and damaging to the property. Refer to Section 3 of this Supplement for further information on location of plastic type constructed utilities.

Work Inside Buildings

When performing utility location and clearance activities inside of buildings, the project team should consider the following aspects:

- Potential de-energizing of portions of the building in order to reduce the level of risk of unknown utilities and documentation of the decision-making process.
- GPR scan of concrete and approximate thickness to soil interface (there have been a lot of utility strikes due to utilities being present at the soil-concrete interface).
- GPR scan of the rebar pattern in concrete to reduce coring efforts when rebar is cored through.
- Utilization of saw cutting techniques rather than jack hammering to reduce risk of utility damage at the concrete/subsurface interface
- Signal inference with rebar, concrete thickness or multiple layers, and other metal infrastructure.

Heavy Equipment

- Heavy equipment is sometimes used for work activities but not necessarily for intrusive work. Damage to shallow subsurface utilities or structures can result from the travel of heavy equipment across soft surface areas.
- Risk assessments should be conducted, and in some instances, controls put in place to protect the subsurface (i.e., planking, installation of additional cover for shallow utilities, or markings to avoid crossing sensitive areas with heavy equipment).
- If overhead utilities are present in areas where heavy equipment will be operated, ensure adequate clearance is provided. Heavy equipment that is extendable or telescoping (e.g., excavators, dump trucks, extendable lift trucks), the field staff will evaluate with the contractor if the use of a spotter is necessary prior to operating heavy equipment when in proximity to the overhead utility.

Vegetation

- Consider other subsurface disturbances that may lead to damage of shallow underground utilities, such as clearing trees/shrubs/vegetation as roots may be entangled with underground piping or structures.

Incident Response and Notification

- Stop Work authority must be utilized, and Near Miss reports completed when any subsurface utility is encountered but **not damaged** while performing work. This provides an opportunity to evaluate why the utility was not found with locating technologies and/or missed during the data gathering process. All relevant information should be documented in the Near Miss report and communicated to the project manager.
- If a utility is struck or damaged, the utility provider should be notified first, followed by notification to the AUS PM to initiate the Investigation process. Refer to the site-specific HASP for emergency contact numbers and incident management procedures, if necessary

- If a utility or subsurface structure is compromised, the field staff should initiate the process described in Section 5 of this Supplement, Utility Strike Emergency Action Plan Guidelines; however, more detailed emergency action procedures should be reviewed with the client and documented in the site specific health and safety plan prior to initiating work.

- If an unknown utility is damaged and repaired during the course of the field event. The field staff must verify that the repair is competent and complete to prevent further damage to the site when the damaged utility is re-activated.

3 USE AND LIMITATIONS OF COMMON UTILITY LOCATION TECHNOLOGIES AND CLEARANCE METHODS

The purpose of this supplemental information is to assist field workers with implementation of the Utility Clearance and Location Standard into practice. The following sections will provide best practices that can be used to improve the overall effectiveness of the implementation of the utility location and clearance process. This supplement will assist you with identifying the best location technology or clearance method based on the site conditions, the best practices of each, and the limitations of the equipment or technology.

LOCATING TECHNOLOGIES

Ground Penetrating Radar (GPR)

The GPR system transmits high frequency electromagnetic waves into the ground and detects the energy reflected back to the surface. The GPR unit is pulled or pushed across the ground surface and should be done in a grid like pattern. Energy is reflected along boundaries that possess different electrical properties. Reflections typically occur at lithologic contacts or where subsurface materials have high electrical contrasts, including metal objects such as underground storage tanks (USTs), drums, and utility pipes. These reflections are detected by the antenna and are processed into an electrical signal that can be used to image the subsurface feature. The GPR data will be reviewed in the field to assist in the delineation of potential piping or other subsurface structures. GPR can also be used to identify subsurface features such as sinkholes or Karst formations that would create an unsafe situation to drill, excavate, or move heavy equipment over. The applications, limitations, and methodology for acquiring and interpreting subsurface data can found in the Ground Penetrating Radar SOP.

Cautions:

The detection of subsurface structures located at the site depends on the electrical properties of the soil and the structure's depth, diameter, and composition. The GPR response may be attenuated by saturated soils or soils with high clay content, and potential interference issues may include rebar-reinforced concrete at the surface. GPR can be run using different frequency antenna, with higher frequency antenna (500 MHz) providing better resolution, but less depth penetration. If utilities are expected at depths greater than 6 to 8 feet, a lower-frequency antenna (250 MHz) should also be used. GPR is limited when attempting to locate small-diameter pipes with depth. Generally, a pipe must increase in diameter by one 1 inch for each foot in depth to be seen using GPR. Also, plastic piping is more difficult to detect than metal piping using GPR, and caution should be used if **plastic utility lines** are suspected. Consider complimentary technologies to supplement GPR and provide multiple lines of evidence. Technologies may include radio frequency, magnetic and/or electromagnetic surveys.

Smaller version GPR units are available to identify rebar patterns in concrete. Further information about GPR applications, limitations, and methodology for acquiring and interpreting subsurface data can found in the Ground Penetrating Radar SOP.

Radio Frequency Detection (RFD)

This instrument operates on the principle of radio frequency transmission and detection. The transmitter applies a known frequency to the pipe and the receiver is able to detect this frequency along the length of the structure (Active mode). The success of RFD in tracing underground utilities is based on the composition of the structure (metal or plastic) and the ability to accurately position the transmitter unit so that it can be attached to or placed directly over the structure. The applications, limitations, and methodology associated with the use of Radio Frequency Detection Locators (RFD or RFLoc) using Direct Connect or Inductive Signal Transmission Methods to locate underground utilities can be found in the Utility Locating using Radio Frequency Methods SOP.

Cautions:

RFD should only be used to verify the location of utility mark-outs, and not as the primary method of utility identification.

Acoustical Pipe Locator (APL)

Acoustical pipe locators are used to mark out the location of non-metallic lines, such as PVC water pipes, that are accessible from the surface. Common methods include sound/pressure wave transmitters, such as the RD500 or “Thumper”, that transmit acoustical signals through fluid in the pipe, or the “Knocker” which attaches externally and transmits a signal along the pipe. The buried portion of the pipe can then be traced and marked using a receiver that detects the signal at the surface.

***Cautions*:**

The pipe must be exposed or daylight at the surface to attach the transmitter to. Only then can the layout of the piping be traced. Irrigation systems often have a valve control box that can be accessed for this purpose. Sound/pressure wave transmitters require that the pipe be fluid filled.

Electromagnetic Utility Location (EM)

Electromagnetic utility location tools include electromagnetic and terrain conductivity devices (EM-31), and electromagnetic and metal detection devices (EM-61 or TDEM time domain). These methods are very useful for locating/identifying buried metallic utilities and objects, non-metallic utilities with tracer wires, or energized electrical lines.

***Cautions*:**

These methods are best applied in large open areas with minimal interference issues (including rebar-reinforced concrete, metallic fences, nearby operating motors/generators, overhead power lines, etc.). As such, they are less suitable for use at many industrial or commercial sites in densely populated or congested areas.

Clearance Methods

The following is a brief discussion of clearance methodologies typically used as a line of evidence prior and/or during intrusive activities. This includes pre-clearing intrusive work location as well as for confirming locations and depths of utilities marked at the surface. The clearance methods should be selected to be the least invasive per the conditions at the project location. The use of manual digging/boring methods is generally a quick low-cost methodology for clearing subsurface utilities within

the same borehole planned as the intrusive work. These methods work well in well sorted sands, silts, and clays, but are less effective in heterogeneous soil materials where rock, construction debris, or other obstructions make digging/boring advancement difficult. These methods work well for shallow utilities (generally less than 5-6 ft in depth) but become more difficult to use and interpret any resulting obstructions at greater depth. These methods require additional planning, tools, and/or personal protective equipment if penetrating asphalt or concrete prior to digging/boring.

Cautions:

Since these methods can easily refuse at shallow depths, employees/subcontractors may be tempted to use other tools such as pickaxes or pry bars to clear obstructions. Use of these types of tools along with use of excessive downward force when using probes, shovels, or post hole diggers can damage utilities, thus defeating the purpose of the clearance activity. Additionally, use of pickaxes, pry bars, automated coring devices, etc. to remove surface asphalt or concrete may damage any utilities that may be present within or directly under surface materials. Always assume a utility may be present at any depth in the subsurface.

Soil Vacuum Excavation / Potholing

This method uses nondestructive vacuum excavation methods to create a visual test hole allowing the confirmation of buried utilities. This method is very accurate and relatively fast and can be performed prior to or during the drilling program. The limiting factors for this method are cost and availability. As with specialty drilling methods, a limited number of firms have the equipment to perform vacuum excavation.

The location of the structures to be cleared relative to the source and depth of impacted soil or groundwater is considered. If the zone to be cleared is known not to contain hazardous vapors or petroleum hydrocarbons, as evidenced by previous testing, continuous air monitoring is implemented using a lower explosive level (LEL)/O2 meter and photoionization detector (PID) or flame ionization detector (FID) to the depth of the boring. Also consistent with the site health and safety plan (HASP), air monitoring should be conducted continuously with the LEL/O2 meter during any activity if flammable or explosive vapors are suspected to be present. Prior to any subsurface investigation activities, air monitoring should be conducted to establish background levels for total organic vapors using a PID or FID. All work activity must STOP where tests indicate the concentration of flammable vapors exceeds 10% of the LEL, and the source of vapors must be investigated. The equipment being utilized should also be grounded/bonded to protect against static buildup and potentially explosive atmospheres.

Vacuum-assisted soil excavation utility clearance will not be used in areas know to contain hazardous vapors or petroleum hydrocarbons unless the equipment to be used is suitable for flammable/explosive atmospheres. There is a significantly increased risk of explosion if these materials are encountered while performing this type of utility clearance. Cautions will be performed, as identified below.

Given that many units and associated tanking are not explosion-proof, the following steps will be considered prior to using vacuum assisted utility clearance units where soils could be impacted with petroleum hydrocarbons or flammable vapors.

1. Request from the manufacturer and/or the contractor doing the work to supply manufacturers' documentation and specifications for use of the unit at environmental sites.
2. Request documentation that the unit is intrinsically safe and may be used in areas where petroleum hydrocarbon may be present.

3. Obtain the procedures for grounding portable units to discharge potential static electricity during operation.

4 If none of the above are available, then hand auger instead and do not use vacuum- assisted methods.

Cautions:

Many vacuum systems that are commonly used for utility clearance are considered unsuitable for use for environmental investigation sites. Most vacuum units are “Not for use with Hydrocarbons, Explosives, Corrosive or Toxic Material,” and are “Not Intrinsically Safe.”

Air Knifing

Air knifing utilizes a T-shaped handled lance that allows air to pass in the handle and exit through the tip which is manufactured into a long thin tip. This configuration allows the high-pressure air to cut/loosen soil. Once soil is loosened, it can be removed by hand, hand tools, or soil vacuum extraction to view the borehole for presence of buried utilities. This method is becoming more popular for borehole clearance. The air knifing system is typically driven by a large tow behind air compressor.

Cautions:

Dense clayey soils (i.e. glacial clay till) and cementitious soils (i.e. caliche) can be hard to loosen with this method. Also, the method intermixes soil and will not provide a consistent soil logging representation. High pressure air and hoses are utilized for this method and present additional hazards; this is also a high noise generating activity.

Hydro Knifing

This method is very similar to air knifing except it utilizes water instead of air as the mechanical means to loosen or cut through soil.

Cautions:

By utilizing water, this method can saturate soils, affect sample collection methods, and create a possibly difficult to manage waste stream once removed from the borehole. The method also has the ability to cause damage to smaller utilities if high water pressures are utilized.

Probing

A probing tool is typically a long shaft constructed of non-conductive materials (i.e. fiber glass) with a T-handle at the top. A blunt or rounded point is then thrusted into the ground surface to confirm the location of a known utility. A series of probe points at multiple angles is used to confirm the diameter and location of the utility. This should be used in conjunction with GPR or potholing of the utility.

Cautions:

Excessive force when contacting a utility even with a probe tool can cause damage. Soils that contain rocks or cobbles can provide false indication of the utilities. Probing depths can also be limited from the soil type being used in.

Hand Augering

This method utilizes manual effort to spin a metal hand auger down to clear soils and/or collect samples. It should be noted that if proposed borehole is larger than the diameter of the hand auger that a minimum of 3 individual clearance points would be required. Single point clearance must be at least 110% of the proposed borehole diameter or the diameter plus 2", whichever is greater. Soil environments that contain rocks, cobbles, or gravel can limit the effectiveness of clearing down to a target depth. For soil collection points, where the boring is to be undisturbed before sampling, a three-point clearance method around the collection point is recommended. This means doing three clearance borings in a triangle pattern directly around the collection point.

Cautions:

Excessive force can damage small diameter utilities, utilities that are constructed of plastic, PVC, and light gauge metals such as copper, and utilities not contained within conduit such as communication lines. Caution should be used when obstructions are contacted, or the force required to utilize the hand auger causes strain to the worker. Hand augers should not be used near live electrical lines for clearance.

Hand Digging

These methods are typically used to confirm the location of a known utility. First the surface cover is removed and then hand digging with a shovel or soil vacuum extraction. The soil media is removed enough to find the top or side of a utility to identify or confirm the depth and orientation. Avoid digging at a perpendicular angle directly over the mark. Begin slightly offset and dig at an angle towards the expected utility.

Cautions:

Hand digging using a variety of hand tools could strike a utility and cause damage. When utilizing rounded or blunt shovels, only enough force should be used to loosen and remove soil, NO pointed tools or pry bars should ever be used as a hand clearance method. Water or product could gather along utility corridors, caution should be used if this is observed while hand clearing. Review the soil vacuum excavation section below for other hazards related to this method. Utility bedding materials should not be removed unless it has been planned for via an engineered support for the utility.

Post Hole Digging

A post hole digger AKA "post holer" is a long-handled hand tool used to gain access to the subsurface. It works to dislodge soil with a downward thrust and then the handles are extended outward causing the clamshell like shovels to collect loose soil.

Cautions:

The initial downward force could contact a utility causing damage. Enough force just to loosen soil should be used. It can be used to create a large borehole for clearance of proposed intrusive activities to provide 110% diameter clearance. This method can cause fatigue and stress the worker performing the task.

Plastic Constructed Utilities and Conduits

Utilities that are constructed of plastic materials can be very difficult to locate and certainty diminishes more as the diameter decreases or as depth increases. The information below can help guide you

to better identify these types of utilities and prevent utility strikes. The methods should be discussed with the private utility locator to ensure the best results for location:

- Electromagnetic detectors, including radio frequency locators, are unreliable for non-metallic piping.
- Ground Penetrating Radar (GPR) may be useful if the piping has a large diameter and is fairly shallow (the threshold under optimum conditions being 1-inch diameter per foot of burial, at best). Moist/saturated or clayey soils will attenuate the signal and compromise results.
- The best tools are Acoustic Pipe Locators. Common methods include sound/pressure wave transmitters such as the RD500 or “Thumper” that transmits acoustical signals through fluid in the pipe, or the “Knocker” which attaches externally and transmits a signal along the pipe. The drawback is that the piping has to be exposed somewhere so you can attach to it, and fluid-filled in the case of the Thumper.
- The last option is to send a beacon/sonde or tracer wire down the piping and detect it from the surface. Again, you must have access to the pipe at the surface to accomplish this.

Table 1: Private Utility Technology Applications and Considerations

Technology → / Utility/Object ↓	Electro-Magnetic Detector	Ground Penetrating Radar (GPR)	Acoustic Plastic Pipe Locator	Probe, Beacon, Sonde, or Trace Wire	Cesium Magnetometer
Power/Instrument Line (Energized/Signaled)	G	Y	R	R	Y
Power Line (Non-energized)	Y	Y	R	R	Y
Sewer/Water Line (Metallic)	G	>12" diameter G <12" diameter Y	Y	G	(ferrous metallic only) Y
Sewer/Water Line (Non-metallic)	R	>12" diameter G <12" diameter Y	G	G	R
Instrument/Telecomm Lines (Non-energized)	R	R	R	R	R
Natural Gas Line (Pipeline) ◆	G	>12" diameter G <12" diameter Y	R	R	R
Metallic/Non-Metallic Line (w/Tracer Wire)	G	>12" diameter G <12" diameter Y	Y	Y	(ferrous metallic only) Y
Metallic/Non-Metallic Line (w/o Tracer Wire)	R	>12" diameter G <12" diameter Y	Y	Y	(ferrous metallic only) Y
Metal UST	G	G	R	R	G
Fiberglass UST	R	G	R	R	R

Additional Considerations

Technology → **Variable ↓**	Electro-Magnetic Detector ↯	Ground Penetrating Radar (GPR) ⊙	Acoustic Pipe Locator ☆	Probe, Beacon, Sonde, or Trace Wire	Cesium Magnetometer ▽
Moist Soil	G	Y	G	G	Y
Dry Soil	Y	G	Y	G	G
Clay	Y	R	G	G	Y
Concrete w/Rebar	R	Y	G	G	R
Long Horizontal Profile	G	G	G	G	G
Short Horizontal but Deep Vertical Profile	Y	G	R	R	G
Access to Line ✚	G	N/A	G	G	N/A
No Access to Line ✚	Y	G	R	R	G
Ferrous Metal	G	G	G	G	G
Non-ferrous Metal	Y	G	G	G	R

Green: Generally, an applicable technology. Yellow: May or may not be applicable. Red: Not generally applicable. Contact ANA Corporate H&S for further information on location and clearance methodologies.

❋ **Indicates Best Technology for Given Object**. Site structures, rebar in concrete, etc. can significantly affect performance and reliability of any electro / magnetic method.

□ **Metallic lines** - Have power running through them or can be connected to a tracer signal generator.

◆ **Natural gas** pipeline locating technicians must be trained/certified in the US requires DOT, Office of Pipeline Safety standards, other regions may have similar certification or requirements.

✚ **Access**: induce unique electronic signature, apply acoustical impulse, or insert probe/beacon/sonde.

↯ **Electromagnetic utility locator devices** include radio frequency locators (RFLoc), electromagnetic and terrain conductivity (e.g., EM-31), & electromagnetic and metal detection (e.g., EM-61, time domain)

☆ **Common methods** include sound/pressure wave transmitters, such as an RD500 or "Thumper" that transmit acoustical signals through fluid in the pipe, or the "Knocker" which attaches externally and transmits a signal along the pipe.

⊙ **Most sensitive to interpretation**; the skill, training, and experience of operator are critical. Utility locators often assume a shallow burial depth for utilities (<6') and therefore use a high frequency GPR antenna for best resolution. Lower frequency antennas are capable of seeing deeper, but with less resolution. If site conditions indicate that utilities may be deeper than 6', it would be advisable to do multiple runs with different frequency antennas (e.g., 400 MHz and 200 MHz).

▽ **Detects ferrous metallic objects only**, but with greater depth penetration than metal detectors (emerging technology with limited availability).

Each remediation site / project may have unique conditions, therefore do not use this table as the sole decision criteria for technology selection. Use the table as a starting point to assess available technology(s) applicable.

4 ONE CALL NOTIFICATION PROCESS AND MARK OUTS

The purpose of this supplemental information is to assist field staff with putting the Utility Clearance and Location Standard into practice. The following sections will provide best practices that can be utilized to improve the overall effectiveness of the implementation of the utility location and clearance process. This supplement will assist you with completing the proper notifications prior to staring intrusive work.

Intrusive Work Notifications

Prior to intrusive work on public property (i.e., rights-of-way, easements, etc.), the PM should ensure that the notification of a public one-call service center is completed a minimum of 48-72 hours (One-Call and State Law Directory) prior to initiating field activities (excluding Saturdays, Sundays, and legal holidays). Specific state or local laws related to utility location are evaluated with respect to notification and liability in the event of utility damage. During the call, the PM or his or her designated Task Manager:

- Provides an accurate description of the location of all areas of work that may affect utilities
- Documents the utility locate request to record the time and date of the call, the area to be marked, the and list of utility companies and municipalities that the one call service center will notify
- Records the associated ticket (or dig) number provided by the one call service center
- Cross references the notification list provided by the one-call service center with the list of known or suspected utilities for the property
- Provides accurate contact (responsible party name and phone numbers) and access information to the one call service center so they can subsequently communicate potential questions and/or delays related to the utility location and marking

In most cases, after receiving a request, the one-call service center sends separate requests to participating utility operators who have utilities in or near the work area. Each utility operator dispatches its own locator to mark its facilities, normally with paint or flags. The PM should attempt to have field staff and subcontractors present during the marking of the utilities by the locator to provide input on where the exact intrusive work will be performed. It is important to note:

- Not all utility operators and municipalities participate in one call programs. In some instances, one-call programs provide a list of utility providers that participate, and a list of those that do not. In such a case, the PM should directly contact the utility providers that do not participate in the one-call program and request they mark their own lines. The PM should document any correspondence with such utilities (date of call, person receiving call, and date lines will be marked, etc.) on the Utilities and Structures Checklist.
- Public utility locators are usually only required to mark utilities within the public spaces (e.g., right of ways) or at most up to a meter on private property. However, this can still provide valuable information about where utilities enter a site and their orientation. Where the work area is near a

property line, the One Call markings outside the work area can be used to help verify onsite markings completed by the PUL or other lines of evidence.

- Where One Call marks on private property and the work area is on private property – and therefore not marked by One Call – an additional line of evidence is required.

- Any knowledge of existing or suspected, but unmarked utilities should be documented by the PM and communicated to the field staff, applicable subcontractor(s), and the client prior to implementing field activities.

If a known or suspected subsurface utility does not participate in the state one-call program, and that utility owner has not been individually contacted prior to the start of intrusive work, then the field activities should be postponed until that utility owner or private utility locating company locates the utility.

In general, subsurface utility locations marked by public utility locators are only good for 2 weeks (the PM should research the applicable state-specific requirements). If intrusive work activities are not conducted during this time period, the One Call ticket must be renewed, and the site must be remarked.

NOTE: At no time is utility clearance to be conducted based on old markings, hand-drawn maps/sketches, photographs, or by recollection/memory of field staff. If markings are smeared, removed, damaged, or impacted in any way, the site must be remarked before work begins. When marking the approximate location of a utility, use a reasonably permanent marking means appropriate for the site such as flags or paint.

Nationwide Utility Locate Call Number 811

State and local utility notification centers participate in a "Call Before You Dig" number for public safety and to protect underground infrastructure. This national number is: **811**. The number is designed to help prevent excavators, drillers, and homeowners from damaging underground utility lines, or causing an injury or service outage while digging/drilling. For more information about the 811 services, visit www.call811.com or the National Sate Law One Call Directory https://commongroundalliance.com/map

The number 811 is an FCC designated national "n-11" number. This quick and efficient one call service will notify the appropriate utilities, who participate in the one call program. **However,** the Project Manager should still verify who the one call service contacts, and then determine which utilities may need to be contacted directly (e.g. those utilities not participating in the one call service) by following the requirements outlined above in this procedure.

Understanding the Marks

Interpreting the marks left by locators during the 811 process is an important aspect of utility avoidance. In most cases the mark outs are completed while staff are not onsite. It is recommended that staff be onsite during the 811 process or speak with locators while onsite. Utility marks should follow proper standards as outlined in the Uniform Color Code and Excavation Marking Guidelines. Some questions you may ask include:

- Are the marks of sufficient width, length, and spacing to help you clearly understand the location and direction of the underlying facilities?
- Were standard colors used to help you determine which facilities have been marked?

- Are changes in facilities direction and lateral connections clearly indicated?
- If no conflict is noted in the pre-marked excavation area is “No Conflict” placed inside of the pre-marked exaction area?

Below are Common Color Code Identifiers and Abbreviations used during the mark out processes, the project team should verify each facilities color prior to starting intrusive work.

COMMON COLOR CODE IDENTIFIERS	
WHITE	Proposed Excavation
PINK	Temporary Survey Markings
RED	Electric Power Lines, Cables, Conduit and Lighting Cables
YELLOW	Gas, Oil, Steam, Petroleum or Gaseous Materials
ORANGE	Communication, Alarm or Signal Lines, Cables or Conduits
BLUE	Potable Water
PURPLE	Reclaimed Water, Irrigation and Slurry Lines
GREEN	Sewers and Drain Lines

FACILITY IDENTIFIER		UNDERGROUND CONSTRUCTION DESCRIPTION		INFRASTRUCTURE MATERIALS	
CH	Chemical			ABS	Acrylonitrite-Butadiene-Styrene
E	Electric			ACP	Asbestos Cement Pipe
FO	Fiber Optic	C	Conduit	CI	Cast Iron
G	Gas	CDR	Corridor	CMC	Cement Mortar Coated
LPG	Liquified Petroleum Gas	D	Distribution Facility	CML	Cement Mortar Lined
PP	Petroleum Products	DB	Direct Buried	CPP	Corrugated Plastic Pipe
RR	Railroad Signal	DE	Dead End	CMP	Corrugated Metal Pipe
S	Sewer			CU	Copper
		JT	Joint Trench		
SD	Storm Drain	HP	High Pressure	CWD	Creosote Wood Duct
SS	Storm Sewer			HDPE	High Density Polyethylene
SL	Street Lighting	HH	Hand Hole	MTD	Multiple Tile Duct
STM	Steam	MH	Manhole	PLA	Plastic (conduit or pipe)
SP	Slurry System	PB	Pull Box	RCB	Reinforced Concrete Box
TEL	Telephone	R	Radius	RCP	Reinforced Concrete Pipe
TS	Traffic Signal	STR	Structure (vaults, junction boxes, inlets, lift station)	RF	Reinforced Fiberglass
TV	Television			SCCP	Street Cylinder Concrete Pipe
W	Water			STL	Steel
W	Reclaimed Water (purple)	T	Transmission Facility	VCP	Vitrified Clay Pipe

Typical Pre-marked Excavation Area Example Illustration

5 UTILITY STRIKE EMERGENCY ACTION PLAN GUIDELINES

When work activities result in the contact or compromise of a utility line, an appropriate response is critical to prevent injury, death, or significant property damage. Although circumstances and response vary depending on site specific conditions, the following guidelines provide information that is factored into emergency action planning associated with utility damage. In any event, emergency planning is coordinated with the entity that owns the utility and the client prior to the start of work. This planning and the appropriate response actions are documented in the project health and safety plan and reviewed with all field staff and applicable subcontractors. In the event of any subsurface encounter or above grade strike, notify Corporate Legal and Corporate H&S immediately and no later than 24 hours after the incident. All written correspondence regarding the incident to clients or 3rd parties must be cleared by Corporate Legal.

Contact with Above or Underground Electric

Contact with above ground or underground electric lines may result in the equipment being energized. Field personnel do not assume rubber tires on equipment are insulating the equipment from the ground. For underground electric strikes, contact with the line may not be immediately noticeable but indications of a strike include power outage, smoke, explosion, popping noises, or arching electricity. If contact with an electric line is made or is suspected, the following guidelines must be followed:

- Under most circumstances, the equipment operator, or any worker on a seat of the equipment should stay on the equipment. These workers should not touch anything, especially metal, on the equipment.
- If it is determined that the equipment should be vacated due to a life-threatening circumstance, the worker(s) should jump clear as far as possible from the equipment. When jumping keep both feet together and land with both feet on the ground at the same time, then shuffle or hop away a safe distance. Do not use hand holds or touch any part of the equipment when preparing to jump off.
- Workers on the ground should move away from the equipment.
- Keep others away from the equipment and the area.
- If anyone is injured and in contact with the line or equipment, any attempted rescue should be performed with extreme caution. Only use long, dry, clean, unpainted pieces of wood or fiberglass pole or long dry, clean rope to retrieve the victim. Perform first aid/CPR only after the victim is sufficiently clear from the electrical hazard.
- Notify the electric utility or the client as appropriate for the site. Call 911 or the client's emergency response phone number, as appropriate, for any serious injury or any situation that may result in fire or other hazard that could produce injury or property damage.
- In the event a line is impacted that is suspected to be inactive, qualified NFPA 70E trained personnel are to verify the status of the line via testing (via voltmeter, etc.). Field staff should know if the subcontractor's staff is qualified to work with energized equipment/lines and if not, should know the name and accessibility of the nearest ARCADIS staff that are properly trained and qualified.

Natural Gas

If a natural gas line of any size is compromised, immediately:

- Shut off the equipment and remove any other ignition sources.
- Evacuate the area as quickly as possible. Clear non-ARCADIS staff from the immediate area.
- DO NOT attempt to turn off any gas valves.
- Call 911 or the designated client emergency response number as appropriate.
- Call the gas utility if site response is not controlled by the client.
- Do not try to put out the fire. If its burning, let it burn.
- Do not return to the area until permitted by the utility or by the approved client emergency response personnel, as appropriate. Notify any potentially affected parties.

Pressurized Lines (all types)

Compromised pressurized lines may rapidly become a significant hazard especially if the line is under considerable pressure. Ruptured pressurized lines may undermine and wash out unconsolidated materials beneath equipment or structures causing them to become unstable, may create significant subsurface erosion, and may cause flooding or release of site contaminants. If a pressurized line is ruptured, the following guidelines should be followed:

- Promptly shut off all equipment.
- Lower masts or other high extension components of the equipment.
- Evacuate area and call the water utility or client emergency response number, as appropriate.
- Turn off the water if the valve location is known and on the site property.
- If potable water lines have been ruptured, attempt to divert any flow away from structures prone to being flooded. Use caution and keep a safe distance from the line break since the ground surface may be compromised. Additional measures may be required when repairing water lines including bleaching and/or flushing followed by potability testing. Confirm local requirements prior to making any repairs.
- For raw process water or other water of unknown quality, do not attempt to divert or contain. Avoid skin contact or accidental ingestion of any water.
- When returning to the area of the break, survey the area for signs of compromised land surface (cracks in asphalt or concrete, depressions in ground, observations of undercutting, etc.) and avoid moving any equipment until these conditions are repaired or resolved.
- Pressurized lines may require testing following repair. Contact the utility owner for repair and testing specifications prior to initiating repairs or burying the line.

Sewer (all types)

Use the same general guidelines as pressurized lines when responding to compromised sewers. If a sanitary sewer is compromised additional guidelines should be followed to avoid contracting any bacterial illnesses. These include:

- Promptly evacuate the area.
- Avoid contact with any sewage material.

- If contaminated, promptly wash with soap (antimicrobial) and water and promptly change impacted clothing.
- If sewage is accidentally ingested or infiltrates any breach of the skin or enters the eyes, seek medical attention as a precautionary measure.
- Decontaminate equipment with commercially available disinfectant solutions or a 10% chlorine bleach solution.

Communication Lines

Contact and compromise of communication lines are generally considered more of a financial concern and emergency response communication concern than a concern associated with injury but must be reported to the utility owner. Although, these lines may appear harmless if broken, eye damage may occur if looking into the ends of a cut fiber optic line. Do not look into the ends of fiber optic lines or other communication lines of unknown type. Repairs must be coordinated with the utility owner.

Product Lines and Underground Storage Tanks (all types)

Compromise of a product line or underground storage tank (UST) requires immediate action to mitigate impact to the environment. For gasoline stations and similar facilities, the following guidelines should be followed during a line or UST breach:

- Immediately shut down equipment and initiate the emergency shutoff switch for the facility dispensers.
- If there are no injuries, attempt to contain any flowing product using absorbent materials and/or by physically pumping or bailing product out of the breached area. If there are serious injuries, contact 911 as appropriate.
- If product is flowing on the surface away from the break area, attempt to protect down gradient storm drains, sewer drains, and surface water features form impact of the petroleum product using any readily available materials.
- If the bottom of a UST has been breached, immediately contact a pump truck to remove product from the affected UST.
- For releases involving diesel fuel, care will be taken to avoid any situation where diesel may be injected into the body from impalement by coated nails, wood splinters, etc. If diesel is injected into the body, seek prompt medical attention, even if no apparent symptoms of a problem exist. Injected diesel fuel may cause permanent tissue damage.
- Clear area and arrange for prompt repair after coordination with the Project Manager and utility owner.

For industrial sites with lines or USTs containing multiple products with varying hazards, similar guidelines may be followed as above if the material encountered is known and workers have a fundamental understanding of the hazards associated with the material. Upon discovery of a line or UST breach due to work activities at these sites:

- Immediately stop work and notify the client representative or call the client designated emergency number. For abandoned sites call 911.
- If the material is not known, promptly evacuate the area and let HAZMAT teams manage the release

6 UTILITY LOCATION PROCEDURES FOR AQUATIC WORK ACTIVITIES

Working on and adjacent to water presents unique hazards with regards to utility location. This Supplement must be followed, in conjunction with ARCHSFS019 (Utility Location and Clearance), whenever work activities are being conducted near or below the high-water mark for water bodies. Additional aquatic clearance support may be obtained from the Arcadis Community of Practice (CoP) Lead for the Sediments and Waterfront Group.

This Supplement describes the steps to be taken to identify, locate and mark (if possible) utilities prior to initiating any aquatic work. Examples of such utilities include, but are not limited to:

- water lines
- electrical power lines, cables, conduit, and lighting cables
- communication, alarm or signal lines, cables, or conduit
- gas, oil, steam, petroleum, or other gaseous material pipelines
- sewer pipelines
- industrial pipelines
- water intake structures
- reclaimed water, irrigation, and slurry lines
- river bottom discharge/diffuser structures

Many of these utilities may not show up on utility searches. If utilities cannot be located to address any reasonable concern, field personnel must use their Stop Work Authority until utility locations can be adequately identified.

This clearance procedure was developed and written with the intent of being implemented in the United States and is not applicable to work performed in other countries. Prior to undertaking intrusive subsurface or subaquatic work in other countries, local laws and codes governing utility locate procedures must be considered and followed.

Required Materials and Equipment

The following items are required, at a minimum, when implementing clearance procedures:

- Work Plan or Field Sampling Plan with figure(s) showing proposed remediation areas or sediment sampling locations, navigation channels, designated cable/pipeline corridors, locations of known utilities, and other pertinent site features.
- Utility Clearance Checklist for Aquatic Activities (Appendix A, located at the end of this document), which documents the completion of the steps associated with this procedure.
- Other location and marking equipment such as Global Positioning System (GPS), survey equipment, digital camera, etc. Additional items may be required based on field conditions.

Personnel Qualifications

Utility location activities for projects involving aquatic work activities must be conducted by qualified and experienced personnel that:

- Are familiar with ARCHSFS019 (Utility Location and Clearance) and the contents of this Supplement
- Have one-year field experience in the identification of subsurface utilities
- Received approval from the Arcadis CoP Lead for the Sediments and Waterfront Group.

Utility Clearance Procedures

This section presents the procedures for identifying and locating utilities in aquatic settings, which may include but are not limited to urban waterways, rural waterways, and open water environments. If intrusive work will be completed, the Project Manager will ensure that the steps outlined below and in the flow chart in Appendix B are implemented to identify the nature and location of any known or suspected subaquatic utilities in the work area before implementing intrusive work on site.

1. ***Contact One Call*.** The first step to identifying subaquatic utilities at the site is to contact One Call (811). One Call is a useful tool in identifying and marking public utilities in aquatic environments. At a minimum, One Call will provide a list of member utility companies that will be contacted by the One Call System. One Call should be contacted several days in advance of the start of field work, refer to the State or Local requirements for appropriate notice. Non-member utility companies will be contacted separately, if applicable. Prior to proceeding with Step 2, positive notification must be received from each identified utility and documented. Prior to contacting One Call, and if practical, mark the upland areas adjacent to the water body with white paint to indicate approximately where the work will take place. For example, if work will be performed within a river, mark the upstream and downstream limits of the intrusive work in white paint on the riverbank. For open water sites or for large or expansive areas it may not be practical to mark the areas in the field; in such cases the information should be provided to the utility companies on a scaled drawing and/or a meeting with the utility companies must be conducted at the project site.

2. ***Perform Desktop Review.*** The next step to identifying subaquatic utilities at the site is to perform a desktop review of any available drawings, site plans, navigational charts, and other reference materials for information regarding the presence of subaquatic utilities. This review will also include, as applicable, materials provided by the utility companies contacted through the One Call System, as well as materials provided by the client (e.g., locations of facility utilities, intakes, discharges).

   If applicable based on the type of waterway where the work will be performed, the National Oceanic and Atmospheric Administration's online nautical chart viewer must also be consulted. The link to the online chart viewer is provided below:

   https://charts.noaa.gov/ChartCatalog/MapSelect.html

   The desktop review also involves review of the state or local ordinances for specific requirements or procedures for utility location. Follow any such specific requirements that are identified, in addition to the steps described in this procedure.

3. ***Inspect the Site.*** The next step is to perform a field reconnaissance to inspect the site for visible evidence of utilities. Visible evidence of the presence of utilities may include flags or paint markings placed on the ground in adjacent upland areas by utility companies contacted via One Call. According to the American Public Works Association (APWA), the major types of utilities and corresponding universal color code for each are listed in the table below.

AWPA Uniform Color Code for Marking Underground Utility Lines

White	Proposed excavation/exploration
Pink	Temporary survey markings
Red	Electrical power lines, cables, conduit, and lighting cables
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Orange	Communication, alarm or signal lines, cables, or conduit
Blue	Potable water
Purple	Reclaimed water, irrigation, and slurry lines
Green	Sewer and drain lines

Visible evidence of the presence of subaquatic utilities may also include, but is not limited to: signs or markers, utility boxes, pipes running into the water, or visible evidence of trenching activities in the area. These markers may be visible on land and will indicate what utilities might be present in the area. If noted on the sign or marker, document the name of the utility company. It is important to note that markers are unlikely to define the exact locations of subaquatic utilities, and subaquatic utility crossings are not necessarily straight crossings between opposite shore landings. Therefore, it may be helpful to inspect the opposite shoreline for evidence of utilities entering/exiting the water. In addition, in some cases it may be appropriate and helpful to consult with adjacent property owners/managers regarding utility locations.

If locations of utilities can be positively identified on land, document their locations using GPS or other survey equipment/techniques (refer the specifications of the survey tools to understand their limitations and levels of accuracy).

4. ***List Possible Utility or Industrial Companies.*** Combine the knowledge obtained during the first three steps to list potential utility and industrial companies in the area of the work site. Review the list to determine if any major utility services have been overlooked, and if necessary, re-contact the state One Call service and/or local municipality. Section 4 of the checklist contained in Appendix A provides a table for documenting known/potential utility and industrial companies in the area of the work site.

5. ***Contact the Utility or Industrial Companies.*** If the utility locations are not known or there is uncertainty, contact the utility providers/industrial companies identified in Step 4 for further

information regarding the known or potential utilities in the project area. When contacting the utility providers/industrial companies, provide the location and description of the project work and request the specific locations and depths of subaquatic lines from the utility companies/industrial companies. In some situations, specifically at an open water site, GPS, geographic information system, or other survey data may be available. The Project Manager or designated ARCADIS personnel must request this survey data and ask the utility company to mark the locations of submarine utilities at the site. If necessary, to clarify the scope of the work activities or to verify utility presence or clarify subaquatic utility locations, hold a meeting at the site with a representative from the identified utility companies/industrial companies. Document all correspondence with the companies and maintain project file and/or at the project work site.

6. ***Contact a Marine Surveyor.*** If the utility companies are unable to provide the locations of the subaquatic utilities or if uncertainty regarding the locations exists, engage a marine surveyor or divers to help locate the subaquatic utilities and provide an additional line of evidence. Marine surveyors can implement a variety of hydrographic survey methods to identify subaquatic utilities, including magnetometer surveys, side scan sonar surveys, pulse-induced electromagnetic detection surveys and sub-bottom profiles. The marine surveyor must provide documentation of the locations of any identified or potential subaquatic utilities, preferably on a site drawing. Contact information for qualified marine survey companies commonly used by Arcadis can be obtained from the Arcadis CoP Lead for the Sediments and Waterfront Group.

7. ***Confirm that the information above is contained in the Utility Clearance Checklist for Aquatic Activities.*** The Project Manager must review the Utility Clearance Flowchart for Aquatic Activities (template presented in Appendix B) and the Utility Clearance Checklist for Aquatic Activities (template presented in Appendix A) to ensure that all required steps of this procedure have been completed. While reviewing the flowchart and checklist, the Project Manager must determine if any uncertainty remains about the presence of subaquatic utilities and/or their locations. If there is uncertainty, the project manager will work with the project team, including any subcontractors, to determine what steps must be taken to prevent damage to the subaquatic utilities and complete the work safely.

   Utilities that have been identified will be documented on a site drawing for use in the field, along with exclusion zones and proposed investigation or intrusive work locations. Sampling or other intrusive work locations that could encounter submarine utilities must be relocated or re-planned as necessary, being offset a safe distance on both sides of the utility line. As a general rule, locations must be offset a minimum of 50 feet; however, this distance may be modified based on site-specific circumstances and the accuracy of the utility location information.

   Additional aquatic clearance support may be obtained from the Arcadis CoP Lead for the Sediments and Waterfront Group.

Required Documentation

It is imperative to maintain accurate and up-to-date records of the steps taken to locate subaquatic utilities on a particular site. The following documentation must be maintained in the project file:

- Completed Utility Checklist for Aquatic Activities.
- Written documentation of all correspondence with identified utility companies.
- A site drawing that includes utilities that have been identified, as well as proposed intrusive work locations and any designated exclusion zones.

Quality Assurance

The following quality assurance procedures will apply to the implementation of this procedure:

- Utility clearance procedures will be overseen and reviewed by the Project Manager. The PM will initiate corrective action as necessary based on his/her review.
- All records (maps, checklists, and documentation of communications) used to determine the location of utilities shall be retained and kept in the project file and/or at the project worksite.
- This procedure will be reviewed annually by qualified personnel and updated accordingly.

•

Section 1 – Contact One Call			
ARCADIS Caller:		**Date called:**	
ARCADIS Caller's Office:			
Address:	**City:**	**State:**	**Zip:**
Phone:		**Fax:**	
Email:			
ARCADIS field contact:		**Phone (office/cell):**	
ARCADIS project manager:		**Phone (office/cell):**	
Client:			
Client project manager:		**Phone:**	
Anticipated project start date/time:		**Anticipated project duration:**	
Site address:	**City:**	**State:**	**Zip:**
Nearest cross streets (2)	**1:**	**2:**	
Work limits:			
If the work being performed includes blasting, directional drilling or work with 25' of road contact Corporate H&S and/or the CoP Lead for the Sediments and Waterfront Group.			
Type of work:		**Equipment to be used:**	
Length (if applicable):		**Depth:**	
Ticket number:		**Ticket expiration:**	
List of members notified by One Call:		**1.**	
2.		**3.**	
4.		**5.**	
6.		**7.**	
8.		**9**	
10.		**11.**	
Positive notification must be received by all member utilities. Confirm that all non-member utilities have been notified and identified.			
Section 2 – Perform Desktop Review			
Date of desktop review:		**Conducted by:**	
Information Reviewed		**Source**	
1.			
2.			
3.			
4.			
5.			
Are there any local or state utility clearance requirements? If yes, list the requirements below.			

How have the above requirements been complied with?

Section 3 – Inspect the Site	
Date of field reconnaissance:	**Site personnel:**

Site markings (check all that apply):

Pin flags		**Buoys**		**Comments/remarks:**
Paint markings		**Trenching**		
Signs		**Pipes**		
Utility boxes		**Utility crossings**		
Utility poles		**Outfall**		
Other:		**Other:**		

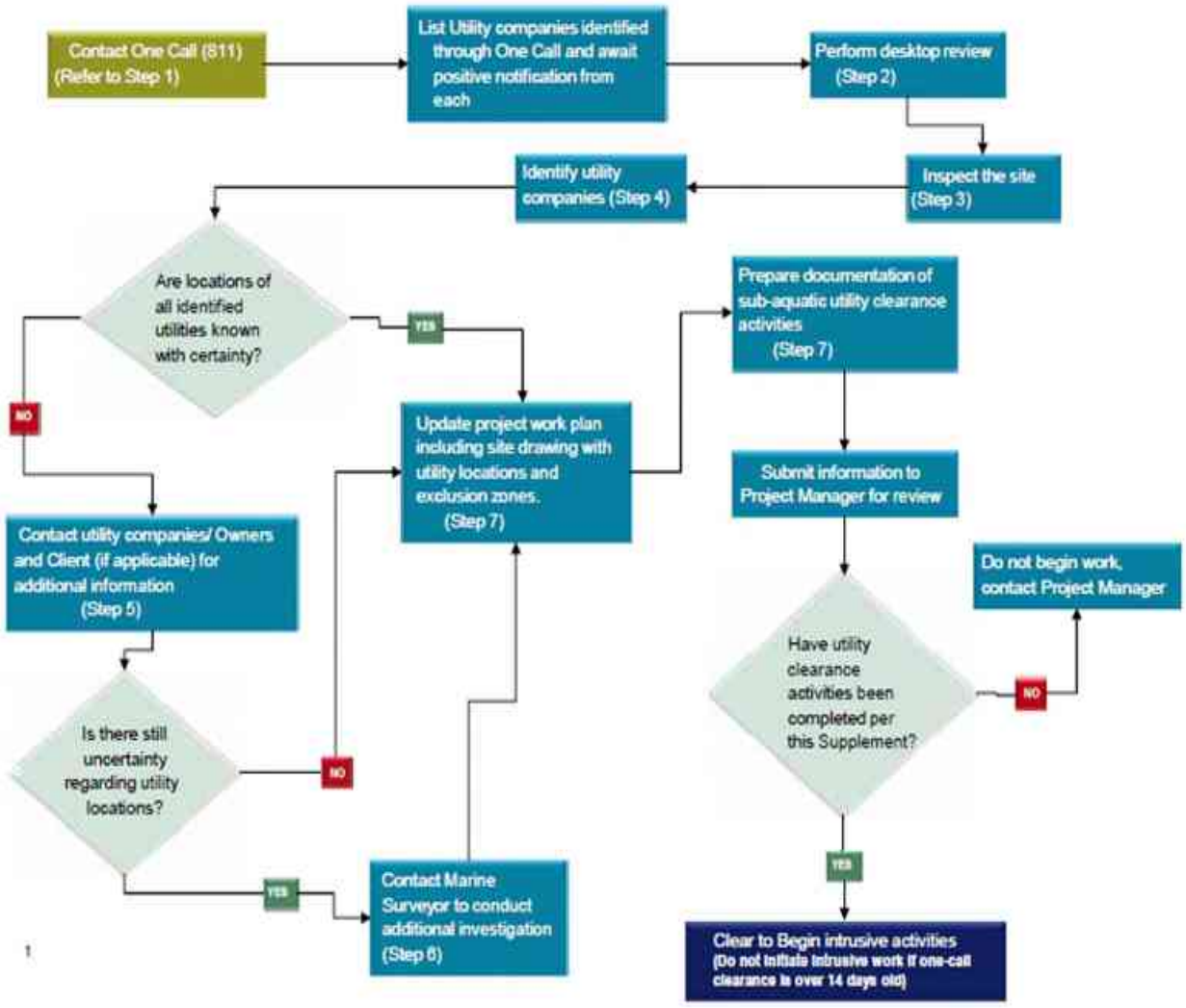
Utility locations must be surveyed.

Section 4 – List Known and Potential Utility Owners

Utility Owner	CDC Code	Name	Telephone	Address

If there is uncertainty in utility clearance than stop work until uncertainty is resolved

Section 5 – Contact the Utility Companies			
Utility Company Contacted	**Date of Correspondence**	**Type of Correspondence**	**Notes and Additional Information**
Was a site meeting(s) conducted with the utility owners? Yes No			
Date of meeting:	**Meeting attendees:**		
Date of meeting:	**Meeting attendees:**		
If utility locations are still uncertain, complete Section 6. If not, proceed to Section 7.			
Section 6 – Contact a Marine Surveyor			
Was a marine surveyor contacted? Yes No		**Date:**	
Was a survey completed? Yes No		**Date:**	
Was the survey provided to ARCADIS? Yes No		**Date:**	
Contractor:	**Contact person:**	**Telephone number:**	**Email address:**
Section 7 – Complete Subaquatic Utility Clearance Checklist and Update Project Work Plans and Site Maps			
The Project Manager must review and sign below when Submarine Utility Clearance Flowchart, Project Work Plans and site maps are completed.		**Date:**	
Project Manager Name		**Project Manager Signature**	


Contact One Call (811) (Refer to Step 1)
List Utility companies identified through One Call and await positive notification from each
Perform desktop review (Step 2)
Inspect the site (Step 3)
Identify utility companies (Step 4)
Are locations of all identified utilities known with certainty?
YES
NO
Prepare documentation of sub-aquatic utility clearance activities (Step 7)
Update project work plan including site drawing with utility locations and exclusion zones. (Step 7)
Submit information to Project Manager for review
Contact utility companies/ Owners and Client (if applicable) for additional information (Step 5)
Do not begin work, contact Project Manager
Have utility clearance activities been completed per this Supplement?
NO
Is there still uncertainty regarding utility locations?
NO
YES
Contact Marine Surveyor to conduct additional investigation (Step 6)
YES
Clear to Begin intrusive activities
(Do not initiate intrusive work if one-call clearance is over 14 days old)

ARCADIS Design & Consultancy for natural and built assets

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