United States Army Corps of Engineers
New England District

Final

Debris Removal Work Plan

Area of Contamination 50, 57, and 74

Former Fort Devens, Massachusetts

Contract No. W912WJ-19-D-0014

Contract Delivery Order No. W912WJ-20-F-0022

August 2021

Final
Debris Removal Work Plan

Areas of Contamination 50, 57, and 74
Former Fort Devens, Massachusetts
August 2021

Prepared By:
SERES-Arcadis 8(a) JV 2, LLC
669 Marina Drive, Suite B-7
Charleston, South Carolina 29492
Tel 843 216 8531

Prepared For:
United States Army Corps of Engineers,
New England District

CERTIFICATION
I hereby certify that the enclosed Report, shown and marked in this submittal, is that proposed to be incorporated with Contract Number W912WJ-19-D-0014. This document was prepared in accordance with the U.S. Army Corps of Engineers (USACE) Scope of Work and is hereby submitted for Government approval.

Reviewed By:

Andy Vitolins, PG
Project Manager

Heather Levesque, PMP
Deputy Project Manager

Contents

Figures

Tables

Appendices

Acronyms and Abbreviations

AOC	Area of Contamination
BCT	Base Realignment & Closure Team
Army	United States Army
DoD	Department of Defense
ELAP	Environmental Laboratory Accreditation Program
EMI	Electromagnetic Induction
EPH	Extractable Petroleum Hydrocarbons
GPR	Ground Penetrating Radar
GPS	Global Positioning System
IDW	investigation derived waste
KGS	KOMAN Government Solutions, LLC
MassDEP	Massachusetts Department of Environmental Protection
PCBs	Polychlorinated Biphenyls
RCRA	Resource Conservation and Recovery Act
PFAS	per- and polyfluoroalkyl substances
PID	photoionization detector
PPE	Personal Protective Equipment
QAPP	Quality Assurance Project Plan
QSM	Quality System Manual
RTC	Response to Comments
S-A JV	SERES-Arcadis 8(a) JV 2, LLC
SOPs	Standard Operating Procedures
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
VPH	Volatile Petroleum Compounds

1 Introduction

The SERES-Arcadis 8(a) JV 2, LLC (hereafter referred to as the S-A JV) is submitting this final Work Plan for the removal of surficial debris identified at Area of Contamination (AOC) 57 (Building 3713 Fuel Oil Spill), AOC 74 (Barnum Road Firefighting Exercise Site), and AOC 50 (Former Moore Army Airfield) (Work Plan). This Work Plan incorporates the previous draft Work Plan submitted by KOMAN Government Solutions, LLC (KGS)/Trinity on behalf of the U.S. Army Corps of Engineers – New England District (USACE) and the U.S. Army (Army) (KGS 2020), and the associated Responses to Comments (RTCs) from the United State Environmental Protection Agency (USEPA) and Massachusetts Department of the Environment (MassDEP). The S-A JV has prepared this Work Plan on behalf of the USACE under Contract Number W912WJ-19-D-0014. RTCs from the previous draft Work Plan are presented in **Appendix A**.

This work plan outlines the procedures to be used for:

1. Performing a ground penetrating radar (GPR) and metal detector survey to identify the extent of partially-buried/buried debris previously observed in portions of AOCs 50, 57, and 74 (as described herein).
2. Removal of the identified debris to visual limits.
3. Documentation of the debris removal actions.

2 Background

A background summary and description of debris observed at each AOC is provided below. At each of the debris area locations, the field inspection team walked in all directions to determine the surficial and visual extent of the debris. Debris that was observed was logged using a handheld Global Positioning System (GPS) unit. **Table 1** presents a summary of the debris identified during the site walks. Field photographs displaying examples of the observed debris are provided in **Appendix B**.

2.1 AOC 57

On March 18, 2019, while conducting temperature profiling along Cold Spring Brook, the United States Environmental Protection Agency (USEPA) identified areas of surface debris between AOC 57 Areas 2 and 3, in a wooded area between the walking trail and wetlands associated with Cold Spring Brook (**Figure 1**). These areas were discussed during the March 25, 2019 Base Realignment & Closure Team (BCT) meeting. On March 26, 2019, KGS conducted a field reconnaissance in this area to confirm and classify the suspected disposal areas. A supplemental field reconnaissance event was completed on March 20, 2020. The debris areas were characterized mostly as a deteriorated vehicle and associated parts (metal debris, tires, and bumpers), smaller piles of scrap metal (empty drums and containers), and some large concrete slabs (likely from former building foundations) (**Table 1**). The majority of the metal debris was rusted and located on the ground surface. Containers and drums found partially buried or at ground surface ranged in size from approximately 1-gallon to 55-gallons. The former contents of many of the drums and containers is unknown; however, some of the drum labels were legible enough to identify former bulk contents, with some labeled as containing antifreeze and gasoline. Additionally, some were noted to contain organic matter (i.e., soil, leaf matter).

2.2 AOC 74

Field reconnaissance was conducted at AOC 74 on June 4, 2020 in the vicinity of the walking trail and in wooded areas to the west and east of the footbridge (**Figure 2**). The scattered surface debris was characterized mostly as rusted metal (empty drums and cans) (**Table 1**). A pile of eight metal cans of various sizes was discovered scattered in a 5-foot by 15-foot area. The former contents of many of the drums and containers are unknown; however, some cans were identified as paint cans.

2.3 AOC 50

On March 30, 2020, two previously identified debris areas in AOC 50 (known herein as “Debris Field A” and “Debris Field B” were inspected (**Figure 3**). Both areas were observed to contain assorted empty metal drums, containers, and paint cans (**Table 1**). Some of the drum labels were legible enough to identify the former contents as gasoline and antifreeze. Most of the debris identified in both areas are located on semi-steep slopes away from roadway access and are therefore unlikely to be accessible for heavy equipment to assist the cleanup.

3 Proposed Field Activities

The following tasks will be performed to investigate and remove the identified debris areas:

1. Clearing vegetation as necessary to conduct the work.
2. Removing debris identified at the ground surface.
3. Conducting soil sampling if warranted based on field observations
4. Performing confirmatory geophysical survey.
5. Investigation-derived waste management

The work will be performed in compliance with an approved Accident Prevention Plan and Site Safety and Health Plan with site-specific activity hazard analyses. The S-A JV will follow the below Standard Operating Procedures (SOPs) provided in **Appendix C**:

1. Investigation Derived Waste Handling and Storage (S-A JV, May 2020, Rev #1)
2. Extraction/Preservation of Soil/Sediment for VOCs (S-A JV, May 2020, Rev #2)
3. Ground Penetrating Radar (S-A JV, May 2020, Rev #0)
4. Resource Conservation and Recovery Act (RCRA) Waste Characterization Sampling (S-A JV, May 2021, Rev #0)
5. Soil Description (S-A JV, February 2018, Rev #2)
6. Utility Locating Using Radio Frequency Methods (S-A JV, October 2018, Rev #0)

3.1 Vegetation Clearing

Vegetation clearing (including brush and small trees 4 inches or less in diameter) will be performed as necessary to access the surface debris, provide a clear working area for the geophysical survey, and minimize health and safety hazards.

Professional judgement will be used to determine the extent of the clearing. Prior to mobilizing and conducting geophysical survey activities, a 20-foot by 20-foot area will be cleared around the debris removal areas; chainsaws and other hand tools will be used as needed. If necessary, the vegetation clearing areas may extend outwards beyond the 20-foot by 20-foot areas. No clearing within wetland areas is anticipated and vegetation clearing is not considered a ground-disturbing activity that would require erosion control measures. If there are fallen trees present in the working area, then they will be cut and set aside. As previously requested by the Devens Enterprise Commission for other work at Fort Devens, if invasive plant species are identified within the immediate working area, then they will be removed and disposed offsite. Coordination with Devens Enterprise Commission and/or United States Fish and Wildlife Service will occur prior to vegetation clearing activities.

3.2 Surficial Debris Removal

Surficial debris removal activities are anticipated to be completed as detailed below:

- Modified Level D personal protective equipment (PPE) will be used during the surficial debris removal. Air monitoring readings will be recorded at each location to determine if PPE upgrades are necessary.
- Surficial debris (defined as debris within the top 6 inches of soil) that does not contain liquid will be removed manually or with equipment to reduce direct contact with the debris.
- Removed debris will be placed in roll-off containers until characterized (if required based on observations) and disposed off-site at a permitted facility by a licensed disposal company. The collected debris will be photographed and cataloged with written descriptions of type and dimensions.
- Partially buried drums and partially sealed containers will be removed if safely possible without releasing the contents (if present). Air monitoring using a photoionization detector (PID) will be performed around and inside partially-sealed containers before they are fully opened and at the general debris piles before removal.
- Debris containers identified as being sealed and containing liquid will be removed if accessible at surface and placed within a staging area for characterization. Sealed containers will not be opened during debris removal activities. If the sealed container is accessible at the surface, it will be moved to an approved staging area and then opened for characterization prior to disposal.
- If debris is believed to contain potentially hazardous waste, then the debris will be containerized at a temporary staging area lined with poly sheeting, and samples will be collected of the material. If laboratory analysis confirms the debris to be hazardous waste, then proper disposal procedures will be followed in accordance with Resource Conservation and Recovery Act (RCRA) and USEPA regulations. If laboratory analysis shows the debris to be non-hazardous waste, then standard solid waste disposal procedures will be followed.
- Buried debris that would require extensive excavation to remove, items that cannot be removed due to risk of rupture, and items that cannot be moved due to size/weight restrictions (as determined in the field) will be surveyed, flagged, and left in place.

3.3 Soil Sampling

Soil sampling will only be conducted at debris removal locations where field observations (i.e., visual observations of staining, odors, or PID readings) indicate that a potential release from the associated debris has occurred. Soil sampling locations will be flagged and field surveyed via GPS. Soil samples will be collected via hand auger from 0 to 1 foot below ground surface and submitted for analysis of VOCs, RCRA-listed metals (i.e., RCRA 8), EPH, VPH, PCBs, and per- and polyfluoroalkyl substances (PFAS). The soil samples for VOC/VPH analysis will be collected from undisturbed soil using a core body and plunger rod apparatus (e.g., Terra Core™ or En Core® sampler kit); the remaining soil will be subsequently composited for metals, EPH, PCB, and PFAS analysis. The soil sampling SOP is included in **Appendix C**.

Laboratory analysis of soil and waste characterization samples will be performed by Katahdin Analytical in Scarborough, ME and Alpha Analytical Laboratories, Westborough MA, which are certified under Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) Quality System Manual (QSM) for Environmental Laboratories, Version 5.3. Samples will be analyzed using the following methods:

- VOCs via Method SW846/8260
- RCRA-8 Metals via Method SW846/6010/7471
- EPH/VPH via Massachusetts Department of Environmental Protection (MassDEP) EPH and VPH methods
- PCBs via Method SW8082
- PFAS via Isotope Dilution Method.

Tier 2B data validation of soil sampling results (not waste characterization results) will be performed in accordance with the general procedures detailed in the KGS Quality Assurance Project Plan (QAPP) (KGS, 2020). The logic outlined in *USEPA National Functional Guidelines for Organic Superfund Methods Data Review* (January 2017) will be used to apply qualifiers to the soil chemistry data. Where specific guidance is not available, the chemistry data will be evaluated using professional judgement in a conservative manner consistent with industry standards.

3.4 Geophysical Survey

Following completion of the surficial debris removal and soil sampling effort, a geophysical survey will be conducted of the areas immediately surrounding each identified debris location, where feasible, to assess whether buried debris is present. The survey will consist of GPR (using a 350 or 400 MHz GPR antenna), magnetometry using a Schonstedt™ magnetic locator (or similar), and electromagnetic induction (EMI) using a EMP-400 profiler (or similar). Initially, the survey will encompass a 25-foot by 25-foot area surrounding each debris location. If debris is located at the edges of this boundary, the grid will be expanded until the extent has been identified. GPR and EMI survey activities will not be performed in areas with steep slopes due to safety concerns; for these areas, activities will be limited to a magnetic locator survey and visual observations. If near-surface debris is located, it will be uncovered to visually identify its nature and condition, and then removed if feasible in accordance with the procedures outlines in Section 3.2. Areas of potential buried debris (as identified from the geophysical survey results) that cannot be accessed due to depth, or removed due to other restrictions (see Section 3.2), will be surveyed and marked in the field.

3.5 Site Restoration

After the removal of surficial debris is completed, depressions or ruts created by equipment that are determined to pose a safety hazard will be regraded or backfilled with clean soil, as needed. No grass reseeding will be conducted.

3.6 Investigation-Derived Waste Management

Solid waste from debris removal will be placed in roll-off containers. Sealed containers encountered during debris removal that contain liquid will be flagged and will not be moved from the staging area until the liquid waste is characterized. Non-hazardous waste will be discarded as solid waste at the conclusion of debris removal activities. If hazardous waste is encountered, the removal from the staging area will be deferred until results of the geophysical survey are known and addressed in a work plan addendum. Investigation-derived waste (IDW) will be handled in accordance with the SOP (**Appendix C**). The results of waste characterization sampling (if required) will be provided to the USEPA/MassDEP.

4 Schedule

Field work is scheduled to begin in the late fall of 2021 when debris will not be obscured by vegetative growth. The exact field schedule will be provided at least two weeks prior to mobilization.

5 Reporting

A report summarizing the debris removal activities will be submitted within 60 days of the completion of field work or receipt of analytical results for any soil samples collected.

6 References

KGS 2020. Quality Assurance Project Plan, Former Fort Devens Army Installation, Devens, MA, Contract No. W912WJ-18-C-0011. 2020

KGS 2021. Work Plan for Debris Removal at AOC 57, AOC 74, and AOC 50, Former Fort Devens Army Installation, Devens, MA, Contract No. W912WJ-18-C-0011. KOMAN Government Solutions, LLC. 18 March 2021

Figures

Legend

- Monitoring Well
- Building Debris
- Buried Drum
- Car Parts
- Containers
- Drums
- Metal Debris
- Metal Piles
- Tires
- Staging
- Walking Trail

Aerial Source: USGS, MassGIS Orthoimagery 2019

Debris Pile Locations (AOC 57 Area 2 and Area 3)

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 40 80
Feet

Date:
02/03/2021

Figure
1

File: 0221_WP_F1_AOC57_DebrisAreas.mxd

Legend

- Monitoring Well
- Drums
- Metal Debris
- Stream
- Staging Area
- Walking Trail

Aerial Source: USGS, MassGIS Orthoimagery 2019

Debris Pile Locations (AOC 74)

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 50 100
Feet

Date: 02/03/2021

Figure 2

File: 0221_WP_F2_AOC74_DebrisAreas.mxd

Legend

- Debris Area
- Containers
- Metal Debris
- Monitoring Well/Piezometer
- Monitoring Well Converted to Injection Well
- Injection Well
- Staging Area

Aerial Source: USGS, MassGIS Orthoimagery 2019

Debris Pile A and B Locations (AOC 50)

Former Fort Devens Army Installation and Sudbury Annex
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 125 250
Feet

Date: 02/03/2021

Figure 3

Tables

Table 1
Type and Location of Identified Debris
Work Plan for Debris Removal at AOC 57, AOC 74, and AOC 50
Former Fort Devens Army Installation, Devens, MA

Point ID	Type	Quantity	Northing	Easting	Comments
AOC 57					
BD-1	Building Debris	unknown	3022937.3	633187.91	Cement slabs
BD-2		unknown	3022870.57	633070.45	Cement slabs
BD-3		1	3022750.68	632935.63	Cement slab
C-1	Containers	1	3022932.46	633139.5	Container
C-2		4	3022938.83	633112.23	Cans spaced approximately 9-10 ft apart
D-1	Drum	1	3022932.12	633082.48	Drum
DP-1		7	3022737.58	632906.69	5-gallon drums
D-2		1	3022869.9	633056.4	Drum lid
D-3		1	3022657.84	632812.16	
D-4		1	3022575.19	632675.81	
T-1	Tires	1	3022852.39	633048.58	Tires
T-2		1	3022808.64	633022.5	
T-3&4		2	3022716.36	632871.01	T-3&4 are located within 4 feet of each other
DB-1	Buried Drum	1	3022853.64	633049.74	Partially buried drum, potentially 55-gallon size
DB-2		1	3022852.47	633039.35	Partially buried drum, potentially 55-gallon size
DB-3		1	3022849.28	633032.73	Partially buried drum, potentially 55-gallon size
DB-4		1	3022836.86	633023.8	Partially buried drum, potentially 55-gallon size
DB-5		1	3022772.71	632943.28	Partially buried drum, potentially 55-gallon size
DB-6		1	3022671.59	632808.58	Partially buried drum, potentially 55-gallon size
CP-1	Vehicle and Parts	1	3022843.51	633050.98	Tires, fender, bumper, top half of a vehicle above ground
CP-2		1	3022833.13	633027.18	Tires, fender, bumper, top half of a vehicle above ground
M-1	Metal Piles	unknown	3022948.1	633091.5	Toolbox, metal sheet, and potential automobile
MP-2		unknown	3022758.48	632919.96	
MP-3		unknown	3022651	632737.26	Metal pile with construction debris
MD-1	Metal Debris	unknown	3022875.38	633044.79	
MD-2		unknown	3022707.35	632837.98	
AOC 74					
D-1	Drum	1	3023894.6	634005.27	
MD-1	Metal Debris	3	3024026.07	633956.78	Metal cans and concrete slabs present in area 10-ft x 10-ft
MD-2		1	3023994.07	633990.44	5-gallon can
MD-3		8	3023990.46	633993.93	Various sizes in debris field present in an area 5-ft wide x 15-ft long
MD-4		unknown	3023905.87	634035.08	
MD-5		unknown	3023898.98	634003.28	
AOC 50					
Debris Pile A	Debris Pile A	unknown	3033542.34	626970.24	Many paint cans (1-2-gal) and 1 tire. Debris observed along steep hill.
Debris Pile B	Debris Pile B	unknown	3035624.47	626644.29	Metal cans (one identified as a gas can)
CP-1	Containers	35	3033546.4	626985.77	Metal cans, glass bottles present in an area 20-30-ft wide x 70-100-ft long
CP-2		unknown	3033536.03	627071.66	Metal cans present in an area 10 -ft wide x 15-feet long
CP-3		7	3033536.95	627079.09	Metal cans, metal piping present in an area 10-ft wide x 15-feet long
MP-1	Metal Debris	4	3033558.91	627080.23	Metal pile present in an area 10-feet wide x 15-feet long

Table 2
Proposed Soil Sample Locations and Analysis
Work Plan for Debris Removal at AOC 57, AOC 74 and AOC 50
Former Fort Devens Army Installation, Devens, MA

Area of Contamination	Proposed Number of Soil Samples	Proposed Laboratory Analysis for Soil				
		VOCs	Metals	EPH/VPH	PCBs	PFAS
		Method SW846/8260	Method SW846/6010/7471	MassDEP Method for EPH/VPH	Method SW8082	Isotope Dilution Method
AOC 57 Area 2	1	X	X	X	X	X
AOC 57 Area 3	1	X	X	X	X	X
AOC 74	1	X	X	X	X	X
AOC 50 Area A	1	X	X	X	X	X
AOC 50 Area B	1	X	X	X	X	X

Note:
VOCs - volatile organic compounds
EPH/VPH - extractable petroleum hydrocarbon/volatile petroleum hydrocarbon
PCBs - polychlorinated biphenyls
PFAS - per- and polyfluoroalkyl substances
AOC - area of contamination

Appendix A

Responses to Comments

ARMY RESPONSES TO MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION COMMENTS ON THE WORK PLAN FOR DEBRIS REMOVAL AT AOC 57, AOC 74, AND AOC 50 FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MASSACHUSETTS

The following Army responses pertain to the Massachusetts Department of Environmental Protection (MassDEP) comments dated 8 January 2021 on the draft *Work Plan for Debris Removal at AOC 57, AOC 74, and AOC 50, Former Fort Devens Army Installation, Devens, MA*, dated 16 December 2020.

Page-Specific Comments

Comment 1. Page 4, Soil Sampling – Sample results should be screened against unrestricted use criteria (e.g., S-1 standards). In the event that an exceedance is reported, site specific, risk-based criteria could then be considered to reach a decision on the need for further action.

> **Response**: The work plan has been revised to state that soil samples will only be collected if there are field indications of a potential release to the environment from the debris. Accordingly, the analytical results for soil samples, if collected, will be compared to the applicable risk-based criteria.

Comment 2. Geophysical Survey – Please identify the instruments expected to be used to conduct the GPR, magnetic, and electromagnetic surveys.

> **Response**: Agree. The text has been revised to read as follows:
>
> > ***"****The survey will consist of ground-penetrating radar (using a 350 or 400 MHz GPR antenna), magnetometry using a Schonstedt™ magnetic locator (or similar), and electromagnetic induction (EMI) using Profiler EMP-400 (or similar)."*

ARMY RESPONSES TO ENVIRONMENTAL PROTECTION AGENCY COMMENTS ON THE WORK PLAN FOR DEBRIS REMOVAL AT AOC 57, AOC 74, AND AOC 50 FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MASSACHUSETTS

The following Army responses pertain to the Environmental Protection Agency (EPA) comments dated 25 January 2021 on the draft *Work Plan for Debris Removal at AOC 57, AOC 74, and AOC 50, Former Fort Devens Army Installation, Devens, MA*, dated 16 December 2020.

General Comments

GC #1. The Work Plan for Debris Removal listed above (Work Plan) references a Health and Safety Plan that will protect investigators but does not describe what steps, if any, will be taken to protect the public from encountering recovered objects in the staging areas or partially uncovered objects that may remain in place in the debris areas under certain circumstances, as described in the Work Plan. Work Plan descriptions of AOCs 57 and 74 reference walking trails and/or bridges, so presumably these areas are accessible to the public. Even if no known or potentially hazardous material is encountered, the recovered (or remaining) debris objects may present slip/trip/fall hazards, sharp edges, etc. that might endanger a member of the public who comes in contact with these. EPA recommends that yellow hazard tape be placed around all staging areas, especially those that may have objects that are not removed on the same day. Warning signs should also be erected. Also, within the debris piles themselves, Army should consider yellow tape and possibly signs at locations that have been disturbed but where objects remain in place (i.e. > 50 lb). The field team should use professional judgement (erring on the side of caution) as to whether the investigation has rendered or discovered any such debris object sufficiently obvious to arouse curiosity and pose a danger. At some point, in order to complete the RI, it is expected that sampling of bedrock groundwater will be necessary to define the full extent of vertical contamination and to determine if Devens source areas are responsible for PFAS contamination detected off site.

> **Response:** The site will be secured to prohibit the public from coming into contact with the debris. Staging areas will be created and surrounded by yellow tape or fencing. Debris that can be removed will be taken off-site for disposal. Bedrock sampling for PFAS is being evaluated in the Phase 2 RI Work Plan.

GC #2. The Work Plan describes sampling and analysis procedures for the soil samples but makes only the briefest mention of waste characterization sampling and procedures for known or potentially hazardous waste that may be found. An expanded description of what will be done in such a case (or attachment of an SOP) is warranted. EPA requests copies of waste characterization results and related documentation within thirty (30) days of their receipt. As data gaps are identified as the remaining proposed sampling is completed it will be necessary to establish additional investigation locations to address the data gaps to define the full extent of PFAS contamination both horizontally and vertically.

> **Response:** The work plan has been revised to state that waste characterization will be conducted if required for disposal. Results of the waste characterization will be provided to the agencies. If off-site disposal of waste (other than debris) is required, approval of the disposal facility will be coordinated with the USEPA Off-Site Rule Coordinator prior to disposal.

Page-Specific Comments

Comment 1. Page 1 of 7, ¶ 2 – The work plan states that "The Army and KGS conducted site walks in 2019 and 2020 to identify the extent of surficial debris..." but does not specify (i.e. provide dates) when/how the debris/disposal areas were discovered/identified or when the Devens BCT and/or Devens RAB were notified of such discoveries. Please provide this information in the amended work plan.

> **Response**: The Work Plan has been revised to provide additional details about the timeline of events, including the initial notification of discovery by the EPA, followed by the dates of the Army's follow-up field reconnaissance efforts.

Comment 2. Page 2 of 7, Summary of Observations – The reference to ROD-specified soil and groundwater COCs in the AOCs 50 and 57 paragraphs is unclear. Because this level of detail would typically be reserved for the post-investigatory report, does Army suspect that the debris/drum disposal areas are historic and/or continuing sources of groundwater contamination at these AOCs?

> **Response**: At this time, the Army does not expect the identified debris to be a source of groundwater contamination; therefore, the references to ROD-specified COCs have been removed. In addition, since the debris removal is being performed as a housekeeping measure, the Work Plan has been revised to state that soil sampling will only be conducted if field indications of a release are observed.

Comment 3. Page 3 of 7, 1st sentence on page – A word appears to be missing from this sentence.

> **Response:** The text has been revised to read as follows: *Vegetation clearing (including brush and small trees 4 inches or less in diameter) will be performed as necessary to access the surface debris, provide a clear working area for the geophysical survey, and minimize health and safety hazards.*

Comment 4. Page 3 of 7, Vegetation Survey – Why has 20 feet by 20 feet been selected for the area to be cleared? For most of the debris areas shown on the maps, the debris appears to cover a much larger area. The photos appear to show that much of the debris is not in areas that are already open (although hand digging may be feasible in between the trees). What criteria will be used to decide where to locate these 20 X 20 cleared areas? The text indicates that the cleared areas may be expanded if necessary. Is this intended to occur after some initial geophysics is done? Will the work proceed in phases? A bit more explanation of these field steps and related decisions should be provided.

> **Response:** A 20 x 20-ft area was selected based on previous experience with conducting utility clearing which normally was performed using a 10 x 10-ft grid. Most of these areas consist of clustered debris or are single debris (e.g., paint can). However as indicated in the work plan, the Army will expand the survey if necessary. Starting at a known location, the survey grid will expand outward.

Comment 5. Page 4 of 7, Soil Sampling – The proposed collection of a single soil sample from each AOC / AOC subarea is inadequate for purposes of assessing the presence or absence of hazardous substances released to the environment and/or existing contamination of the environment. Since currently available information is limited to that observed during reconnaissance walks conducted in 2019 and 2020, the scope of the sampling program must be expanded beyond the currently proposed "biased" (i.e. judgmental) approach, to ensure adequate evaluation/assessment of entire AOCs and/or AOC subareas and verify completion of the investigation/removal program.

Specifically, EPA recommends that a yet-to-be-specified number of soil samples, representative of the entire AOC and/or AOC subarea (i.e. area within "identified boundaries" established during the geophysical/metal detector surveys), be collected utilizing a systematic (i.e. grid- and/or transect) approach, prior to commencement of site restoration activities. The additional samples will ensure adequate assessment of the debris/disposal areas, reduce the probability of false negatives (by increasing the number of data collected), eliminate concerns regarding possible, undiscovered releases/sources of contamination, and current and/or potential future exposures/risks associated with hazardous substances that may be present in the environment.

> **Response**: Since the debris removal is being performed only as a housekeeping measure, comprehensive soil sampling is not required. However, in accordance with standard practice, field screening will be conducted at each debris removal location to assess whether a release has occurred. Soil sampling will be conducted if field screening indicates a potential release. The analytical results for soil samples, if collected, will be compared to the applicable risk-based criteria to make decisions about the need for additional characterization.

Comment 6. Page 4 of 7, Soil Sampling – Army should consider collecting discrete, grab samples from locations of visually stained soils and areas of suspected releases since they provide the most accurate information regarding hazardous substance variability and are best suited to investigate/assess observed releases.

> **Response**: See response to Comment 5 (above).

Comment 7. Page 4 of 7, Soil Sampling – The text describes sub-areas of debris and refers to Table 1, but the numbers of sub-areas listed in the text are not consistent with those shown on the figures. For example, the text says there are four debris areas at AOC 50, but Figure 3 only shows two areas (A and B). The text in this bullet appears to be counting the types of debris at each AOC, not the areas. Please correct/clarify.

> **Response**: This text has been deleted. The sub-areas in the text were referencing the "type" of debris.

Comment 8. Page 4 of 7, Soil Sampling – Soil samples results should also be compared to EPA's residential, industrial, and groundwater (leaching) Regional Screening Levels (RSLs) https://semspub.epa.gov/work/HQ/400431.pdf)

> **Response:** See response to Comment 5 (above).

Comment 9. Page 4 of 7, Soil Sampling – The text states that, "Soil samples will be collected via hand auger from 0-1 ft." Samples should also from 3-15 feet (construction worker exposure scenario) and within 2 ft of the water table to evaluate potential contamination leaching to groundwater.

> **Response:** If collected, soil samples will only be collected from 0-1 ft below ground surface in areas exhibiting field indications of a potential release. The need for additional sampling will be considered following review of these sampling results.

Comment 10. Page 4 of 7, Soil Sampling – The sixth sentence specifies that soil samples will be submitted for volatile organic compounds (VOCs), metals, extracted petroleum hydrocarbons (EPH), volatile petroleum hydrocarbons (VPH) and per- and polyfluoroalkyl substances (PFAS). However, the following sentence mentions soil sampling for PCBs. Please clarify.

> **Response:** The referenced sentence has been updated to include PCBs.

Comment 11. Page 4 of 7, Geophysical Survey - Please identify the instruments expected to be used to conduct the GPR, magnetic, and electromagnetic surveys.

Response: The text has been revised to read as follows:

> *"The survey will consist of ground-penetrating radar (using a 350 or 400 MHz GPR antenna), magnetometry using a Schonstedt™ magnetic locator (or similar), and electromagnetic induction (EMI) using Profiler EMP-400 (or similar)."*

Comment 12. Page 5 of 7, Metal Detector Survey – The text states that a metal detector will be used to assist in debris removal less than 6 inches below grade and to verify debris removal is complete. Should Army forego the additional sampling recommended in Comment 5 above and [pre-debris removal] soil sampling results reveal contaminant concentrations above applicable EPA and/or MassDEP screening levels in an area of subsequent debris removal, supplemental soil sampling will be conducted to verify that the removal is complete. The removal does not negate soil sample data/results**.**

Response: See response to Comments 5 and 9 (above).

Comment 13. Page 6 of 7, Schedule and Reporting – The proposed schedule for commencement/completion of debris/disposal investigation/removal work, specifically as it relates to AOC 57, is inconsistent with the milestone schedule set forth in EPA's September 29, 2020 Additional Work letter. Because the schedule for AOC 57 is the subject on ongoing informal dispute resolution negotiations between Army and EPA and will be resolved in the context of these discussions, EPA will refrain from formally commenting on the schedule and reporting portions of this document.

Response: The milestone schedules have been updated since the time of comment. The debris removal work is currently scheduled to be conducted in late fall 2021 to allow for vegetation die-back that will facilitate the work.

Comment 14. Figure 1 – Please add the outlines of AOC 57 Area 2 and Area 3 and consider labeling other site features or reference points. The text refers to a trail; that should be shown on the figure.

Response: Additional site features have been added to Figure 1.

Comment 15. Figure 2 – Please add the AOC 74 boundary and/or other monitoring wells or reference features. The text refers to a trail; that should be shown on the figure.

Response: Additional site features have been added to Figure 2.

Comment 16. Figure 3 – Although less critical for this figure because the former runways provide reference points, labeling of features such as the estimated 5ug/L PCE contour, nearest injection well profile, building, or another key feature would be helpful.

Response: Additional site features have been added to Figure 3.

Appendix B

Reconnaissance Photographs (KGS)

AOC 57 Areas 2 and 3 Debris Field Recon (typical)

Grease can (typical)

Rusted container

Metal debris (typical)

Buried drum (typical)

Tire (typical)

Surficial drum (typical)


Concrete slab (typical)


Rusted paint cans

Concentrated pile of cans

Antifreeze can (typical)

AOC 74 Debris Field Recon (typical)

Metal Can (typical)

Metal Can (typical)

Partially Buried Metal Can (typical)

Partially Buried Drum

Rusted Paint Can (typical)

Paint Can (typical)

AOC 50 Debris Field A Recon (typical)


Metal sheet


Tire

Cans, glass (typical)

Metal within steep slope

CP-1

CP-2&3 and MP-1

Metal sticking out of steep slope

Metals containers (typical)

AOC 50 Debris Field B Recon (typical)

Metal Container (typical)

Metal debris on steep slope (typical)

Old metal gas can

Steep Slope View

Appendix C

Project Standard Operating Procedures

TGI - EXTRACTION/ PRESERVATION OF SOIL/SEDIMENT FOR VOCS

Rev: 2

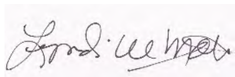
Rev Date: 05/11/2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
2	May 11, 2020	All	Conversion from SOP to TGI	Lyndi Mott/ Dennis Capria

APPROVAL SIGNATURES

Prepared by:



04/27/2020

Lyndi Mott

Date:

Technical Expert Reviewed by:

05/11/2020

Dennis Capria (Technical 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

Soil or sediment samples collected for volatile organic compound (VOC) analysis must be handled in a manner which will minimize the loss of contaminants due to volatilization and biodegradation. Based on experience and open literature, it has been concluded that field extraction and preservation must be conducted in a manner to ensure that contaminants do not degrade or volatilize during sample handling and transport. The following equipment and procedures summarize the method of field preservation of soil samples.

3 PERSONNEL QUALIFICATIONS

Arcadis field personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervision training, and site-specific health and safety training. At least one person on the sampling team must be trained per Department of Transportation (DOT) and (International Air Transportation Administration (IATA) requirements to prepare and offer shipments of samples by a commercial carrier and training in Materials of Trade when transporting this material in Arcadis or private vehicles for work-related purposes. Trained personnel will use the following shipping guides:

- Arcadis Hazardous Materials (aka Dangerous Goods) using Shipping Guide No. US-002 - Environmental Samples-Solids Known or Suspected of Being Hazardous per DOT Definition
- Arcadis Hazardous Materials (aka Dangerous Goods) using Shipping Guide No. US-012 – Environmental Samples solid containing Methanol and or Sodium Bisulfate Preservative (collected using TeraCore® Encore®, EazyDraw® Syringe Samplers).

In addition, Arcadis personnel overseeing, directing, or supervising soil collection will be versed in the applicable Quality Procedures (QPs), standard operating procedures (SOPs), and Technical Guidance Instructions (TGIs) to successfully complete the sample activities.

4 EQUIPMENT LIST

- portable balance, small electronic or manual scale calibrated with an appropriate certified weight;
- analyte-free water;
- Site specific Health and Safety Plan (HASP);
- personal protective equipment (PPE), per the HASP;
- 1¾ cm inside-diameter disposable soil coring device syringes (supplied by laboratory);
- coolers or transport containers with contained ice;
- large soil sampling device (e.g., split-spoon sampler);
- indelible ink pens;
- field logbook;
- duct tape;
- 1-gallon freezer bags;
- appropriate forms;
- preservative-free empty sample containers;
- EnCore™ (or equivalent, e.g. TerraCore®, EasyDraw®) samplers and cut plastic syringes; and/or sampling containers provided by the laboratory (dependent on the type of purge and trap unit that will be used to analyze the samples):
    - low-concentration containers with a magnetic stir bar and a solution of 1 gram of sodium bisulfate dissolved in 5 milliliter (mL) of organic-free water. Tare weight of container and contents should be recorded on the label.
    - high-concentration [greater than 200 micrograms per kilogram (ug/kg)] containers will contain 10 mL of methanol and also have the tare weight recorded on the label. Tare weight of the container and contents should be recorded on the label.

5 CAUTIONS

Once the proper weight has been contained within the syringe, the piston of the syringe is used to push the soil into the 40-mL sample vial. Care must be taken so as not to spill or splash the preservative already in the vials. Caution must also be used when recapping the vial, as even a small amount of soil on the rim of the vial may cause improper sealing and subsequently lead to loss of the preservative and surrogates. The samples must be placed in coolers and maintained at approximately 4°C. The soil sample vials will be weighed by the laboratory before extractions are completed. For this reason, extra labels or tape are not to be added to the vials. Containers or syringes that differ from the tare weight by more than 0.01 gram should not be used.

Avoid over tightening sample vials lids. Over tightened lids may damage the Teflon seal and integrity of the sample.

Samples unpreserved at 4°C have a holding time of 48-hours, from the time of collection and analysis or preservation. If samples are to be shipped unpreserved, plan to express mail via air and to ship on the same day as collection, unless performance data can be provided to support longer holding times. The 40 mL vials are unacceptable as unpreserved sample containers due to VOC loss via volatilization and biodegradation.

Freezing unpreserved samples in proper containers may be considered to extend holding times to 14 days from collection.

Soils are to be collected and contained in the least amount of time possible to minimize the loss of VOCs. Trimming of outer layer of the exposed the soil sample should be considered, if the sample has been exposed to the atmosphere for more than a couple of minutes.

6 HEALTH AND SAFETY CONSIDERATIONS

Care must be taken so as not to spill or splash the preservative already in the vials, when applicable. Sodium bisulfate is a strong acid and can cause severe burns. If the preservative makes contact, immediately flush with potable water. Immediately consult with a medical professional if any burning, pain, or irritation persists.

The 40-mL sample vials can shatter while tightening. Amber vials are more prone to breakage. Use appropriate cut resistant gloves to avoid possible laceration while tightening vials.

Refer to the site-specific health and safety plan (HASP) for further health and safety considerations.

7 PROCEDURE

Container Preparation

Container preservation may be done either in the field or in the laboratory. Procedures for both methods are provided in this SOP. Standard sample containers for laboratory preservation will include either TerraCore® EnCore®, or EasyDraw®.

Field preservation will depend on the soil concentration, if known.

For high concentration soils (greater than 200 ug/kg), laboratory-prepared 40-mL VOA vials filled with 5 mL to 10 mL of analyte-free purge and trap grade methanol (at a minimum of 5 mL methanol) to 5-gram soil/sediment. The sample container size may be dependent on the type of purge and trap unit that will be used to analyze the samples.

Containers for low VOC concentrations will include 1 gram of sodium bisulfate dissolved in 5 mL of organic-free water.

The analytical laboratory also adds the appropriate surrogate compounds to the methanol based on the analytical method quality assurance [e.g. 8015, 8021, 8260b, Massachusetts Compendium of Analytical Methods for Volatile Petroleum Hydrocarbons (VPH), or 8260b, USEPA, 2002; DEQE, 2000; MADEP, 2003]. The laboratory records the weight of each vial to the nearest 0.1 gram after both methanol and surrogates have been added. These containers must be stored in coolers and maintained at less than 6°C but not without freezing.

Sampling

Selection of a soil/sediment sampling interval will be determined based on a site-specific sampling plan and collected either via TerraCore® EnCore®, EasyDraw® or by preservation in the field with methanol and/or sodium bisulfate in containers pre-measured by the laboratory.

<u>Preservation in the Field (laboratory pre-filled sample containers)</u>

Soil/sediment is collected in-situ or from a larger sampling device (e.g., split-spoon, auger, or other sampling device) with a disposable coring device (syringe), also supplied by the laboratory, as soon as possible upon sample retrieval to avoid exposure to air and VOC loss. A coring device that may be used of amendable to soil/sediment type consists of a plastic syringe with the tip removed. It is essential that the diameter be suitable for injection into the sample container. A small electronic or manual balance is needed for weighing the syringe and soil.

1. Once the tare weight of the syringe is determined and a sample interval is selected, soil sample collection is accomplished by manually pushing a syringe into the soil/sediment with the piston withdrawn or collection with a stainless-steel spoon.

2. The soil sample weight is determined by subtracting the tared weight from the total weight of the soil and syringe.

3. Acceptable soil sample weight is 5 grams for a 40-mL vial sample container. However, the laboratory may supply larger sized sample containers and require a laboratory-specific weight of soil/sediment.

    - If a syringe is used and the sample weight is less than 5 grams, the syringe may be pushed into the soil again, with the piston withdrawn to gather additional soil.

    - If the sample weight is greater than 5 grams, a portion of soil may be extruded and removed from the syringe.

    - Weigh the containers in the field. Record the weight of each sample. Subtract the tare weight of the container and preservative to obtain the weight of sample. Record the weights on the sample labels and in the field notebook.

    - If the volatile concentrations of the sample are not known, two low-concentration vials and one high-concentration vial should be prepared. Additional vials are needed for samples to be used for laboratory quality control purposes.

- Note: Samples that contain carbonate minerals may effervesce upon contact with the acidic low-concentration preservative. If the effervescence is small, the loss of volatiles will be limited by quickly capping the vial. If large amounts of gas are generated, target analytes may be lost, and the vials may shatter. If this occurs, document the issue in the field notebook and collect another sample using a fresh container prepared with 5 mL (1 mL of water is equivalent to 1 gram of water) of analyte-free water and no preservative.

- Place samples on ice immediately after collection and ship or deliver to the laboratory as soon as possible.

- An additional sample fraction should be placed in a clean glass jar with no preservative for laboratory use to determine percent solids. Moisture content determination is required to report the sample results on a dry weight basis. Moisture content determination is required to report the sample results on a dry weight basis. If soil samples will be analyzed for other parameters, the moisture content can usually be taken from the other sample containers. However, when sampling for VOCs only, a small separate laboratory-supplied container must be filled.

<u>Laboratory Preservation (Encore™ or equivalent)</u>

1. Collect an approximate 5-gram sample using an EnCore™ sampler or cut plastic syringe.

2. Place samples on ice immediately after collection and ship or deliver to the laboratory as soon as possible. Samples in capped EnCore™ samplers should be delivered within 24 hours of collection to allow the sample to be preserved within 48 hours from collection and meet holding time.

3. In addition to the soil sample collected for VOC analysis, soil must be collected and placed into an empty container for moisture content analysis. Moisture content determination is required to report the sample results on a dry weight basis. If soil samples will be analyzed for other parameters, the moisture content can usually be taken from the other sample containers. However, when sampling for VOCs only, a small separate laboratory-supplied container must be filled.

Shipping Container Preparation

Use Arcadis Hazardous Materials (aka Dangerous Goods) using Shipping Guide No. US-012 – Environmental Samples solid containing Methanol and or Sodium Bisulfate Preservative (collected using TerraCore® EnCore®, EasyDraw® Syringe Samplers) for sample container preparation. Among other requirements depending on whether the samples are shipped by air verse by ground shipping containers must be marked with <u>**“This package conforms to 49 CFR 173.4.”**</u> <u>Note</u>: in order to comply with 49 CFR 173.4, the total volume of methanol mixture per shipping container must be less than 30 grams. In addition, other pertinent requirements of this reference are as follows:

- Each inner receptacle is securely packed in an inside packaging with cushioning and absorbent material. The inside packaging cannot react chemically with the material and needs to be capable of absorbing the entire contents of the receptacle. (Note: a foam container for the vials meets these requirements.)

- The inside packaging is securely packed in a strong outside packaging. (Note: a cooler meets this requirement.)

- The gross mass of the completed package does not exceed 64 pounds.

Consult Arcadis Hazardous Materials (aka Dangerous Goods) using Shipping Guide No. US-012 – Environmental Samples, Solid Containing Methanol and/or Sodium Bisulfate Preservative (collected using TerraCore® EnCore®, EasyDraw® Syringe Samplers) for appropriate packing and labeling for shipments via air and ground. In addition, consult the Chain-of-Custody SOP.

8 WASTE MANAGEMENT

Used methanol or sodium bisulfate, if any, will be contained in an airtight drum or container. Containers will be labeled with the project name, date, and contents. Appropriate client specified personnel will be notified for the transport of container to the appropriate on-site storage area for disposal at an appropriate facility. Any unused sample containers with methanol or sodium bisulfate will be shipped back to the laboratory using original packaging material per DOT or IATA procedures.

9 DATA RECORDING AND MANAGEMENT

Sampling activities, (i.e. location, depth, soil/sediment type, sample identification, sample container tare weight, sample weights, effervescence) will be recorded in the field logbook. Chain of custody (COC) will be prepared per the approved SOP and copies of the COC will be transmitted to the project manager and maintained in project files.

10 QUALITY ASSURANCE

Quality assurance activities will be completed to comply with the site-specific sampling plan and/or quality assurance project plan.

A methanol trip blank should accompany the sample containers at all times in the field and during transport. This consists of a sample container prepared in a similar manner as the soil sample containers. One trip blank should accompany each sample delivery group.

Field blanks and ambient air blanks are optional when sampling via the methanol preservation method.

Discrete blind duplicate samples may be collected in separate soil/sediment sample containers. Compositing or homogenizing multiple soil/sediment samples into one sample container is not acceptable for VOCs.

Site-specific matrix spike and matrix spike duplicate (MS/MSD) analyses, if required, may be collected from a single soil/sediment sample container; no additional sample volume is required

11 REFERENCES

Arizona Department of Environmental Quality (ADEQ), 2000. Implementation of EPA Method 5035-Soil Preparation of EPA Method 8015B, 8121B and 8260B, Arizona Revised Statues (A.R.S.) 49-104 (A). April 19, 2000.

Massachusetts Department of Environmental Protection (MADEP), 2003. Method for the Determination of Volatile Petroleum Hydrocarbons, MADEP-VPH-03-1.1, Revision 1.1. December 2003.

USEPA, 2002. *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition, Method 5035A – Closed System Purge and Trap for Volatile Organics in Soils and Waste Samples. July 2002.

Design & Consultancy for natural and built assets

TECHNICAL GUIDANCE INSTRUCTION

Ground Penetrating Radar

MAY 2020

CONTACTS

GREGORY BYER, P.E., L.P.G.
Technical Expert in Geophysics

dd 317 236 2853
m 317 989 8328
e gregory.byer@arcadis.com

Arcadis U.S., Inc.
150 W. Market Street
Suite 728
Indianapolis, IN 46204
United States

BRENT W. BARKER
Project Geophysical Specialist

dd 720 399 8681
m 720 591 3380
e brent.barker@arcadis.com

Arcadis U.S., Inc.
11001 W. 120th Avenue
Suite 200
Broomfield, CO 80021
United States

Approval Signatures

Prepared by: Date: 5/11/20

Reviewed/Approved by: Date: 5/11/20

VERSION CONTROL

Issue	Revision No.	Date Issued	Description of Revision: Page No.	Description of Revision: Comment	Reviewed by:
Initial Draft	001	March 2017	N/A	N/A	Grant Sprick
Review	002	March 22, 2017	N/A	See tracked changes	Brent Barker
Final Draft/Signatures	003	October 12, 2018	All	Modification to TGI format	Greg Byer, Brent Barker
Revision/ Signatures	004	May 11, 2020	All	Update of Technical Guidance	Brent Barker, Greg Byer

CONTENTS

I. SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) document outlines the applications, limitations, and methodology for acquiring and interpreting subsurface data using ground penetrating radar (GPR). GPR is a non-invasive and non-destructive tool that transmits high frequency (generally between 100 and 1000 Megahertz [MHz]) electromagnetic waves into the ground and detects and records the energy reflected back to the surface with a frequency-matched receiver. The GPR unit is generally pulled or pushed across the ground surface and data collection should be done in a methodical manner either in a series of parallel lines or a grid of lines crossing at right angles to allow subsequent computer processing and analysis. Energy is reflected from boundaries that possess contrasting dielectric constants or electrical conductivities. Reflections typically occur at lithologic contacts where there may be changes in water content and/or mineral composition. Where subsurface materials have extremely high electrical conductivity and magnetic susceptibility including metal objects such as underground storage tanks (USTs), steel drums, and metallic utility pipes extremely high amplitude reflections are generally observed. Non-metallic pipes and utilities often produce weaker GPR reflections due to a lower contrast in dielectric constant between non-metallics and soil. The two most common requirements of GPR investigations are the depth of penetration and required horizontal and vertical resolution. Both depth of penetration and vertical resolution are inversely related to the transmitter center frequency. Higher frequency will potentially yield better resolution, but a loss of total depth of penetration may result. Conversely, a lower frequency will yield less vertical resolution while offering deeper penetration. A key variable in signal loss is the degree of attenuation of the transmitted signal. As a rule, environments that are electrically conductive such as soils or rocks with high clay content or groundwater high in total dissolved solids tend to offer the greatest signal attention and may be so severe as to limit the success of the GPR survey, regardless of frequency chosen. Environments with little or no clay minerals or soil moisture, frozen ground, or massive non-conductive rock offer the greatest success to GPR surveys.

Choice of transmitter frequency can generally be matched with project objectives and limitations posed by geologic conditions and/or infrastructure. The following are examples of applications by frequency range:

Antenna Center Frequency (MHz)	Typical Applications
1000 or greater	Concrete studies (delaminations, condition of rebar, rebar dimensions, etc.), shallow void surveys (beneath pavement), bridge decking analysis, Subfloor utility investigations (floor drains, conduits, etc.)
500 to 1000	Ice and snow thickness mapping, forensics, search and rescue applications, shallow utility mapping
250 to 500	Search for underground storage tanks or other buried metals such as drums, utility mapping surveys, characterization of fill materials, search for excavations such as graves, roadway mapping, boring clearance work
100 to 250	Shallow geologic investigations, fracture mapping in rock quarries, stratigraphic analysis, fill and waste mapping
100 or less	Deep geologic investigations, permafrost investigations, glacial studies, mining applications

II. PERSONNEL QUALIFICATIONS

GPR investigations should be conducted by qualified and experienced operators, such as an experienced field technician and/or geophysicist. The GPR operator should be experienced in evaluating data quality in the field and be able to adjust data acquisition procedures in response to variable site conditions in order to identify anomalies and resolve target features. Inexperienced Arcadis personnel directing or supervising GPR data acquisition or interpreting processed GPR data should seek appropriate guidance and technical peer review from qualified and experienced personnel available from the Geophysics Practice Area.

III. EQUIPMENT LIST

The following equipment will be available, as required, during GPR surveys.

- Personal protective equipment (PPE), as required in the site Health and Safety Plan (HASP).
- Appropriate forms, Site plans, field notebook, spray paint and camera.
- Specific GPR systems matched to project objectives and site conditions. Each manufacturer has their range of products, many of which are designed with specific applications in mind. In general, Arcadis will require that GPR data be stored and downloaded in digital format for later processing. Not all manufacturers offer data storage. The most common acceptable GPR system manufactures include:
    - GSSI – https://www.geophysical.com
    - Sensors & Software – https://www.sensoft.ca
    - Mala - https://www.guidelinegeo.com/products/category/mala-ground-penetrating-radar-gpr/
- A primary and, preferably, a secondary antennae of appropriate signal frequency1 to match anticipated dimension and depth of objective(s).
- Non-conductive measuring tape or measuring wheel; and
- Optionally a GPS unit which can be mounted to the GPR system for integration of GPS position into GPR data files.
- Optionally data processing software. Arcadis has licenses to Radan (GSSI), Ekko_Project (Sensors & Software), and Reflex (a general seismic and GPR processing program capable of converting most manufacturer-specific formats to industry standard formats).

IV. CAUTIONS

The effectiveness of GPR is site-specific and subject to the skill level of the operator. Reliability and efficiency are enhanced when used in conjunction with other geophysical methods. Soils with higher electrical conductivity rapidly attenuate the radar energy, reducing the penetration depth and resolution. Clayey soils and saturated soils, particularly when high in soluble salts, limit the usefulness of GPR. Other potential interference sources include subsurface debris, rebar reinforced concrete, above ground reflective objects (cars, surface water, transmission lines), and electromagnetic generating apparatus (electrical generators, radio transmitters).

Both metallic and non-metallic utilities may be imaged by GPR. However, it should be noted that due to differences in the properties of materials, locating a non-metallic utility (plastic, vitrified clay tile, etc.) may be more difficult than a metallic pipe because of a lesser contrast in dielectric constant between non-metallics and soil. A guideline for effective locating depth for utilities is 1-inch (2.5 cm) diameter of utility can be discerned for each foot (0.3 m) of depth to a depth of 12 feet (3.7 m). For instance, one may expect to resolve a utility 10 inches (25 cm) in diameter at a depth of 10 feet (3 m). This is a general rule of thumb that can be applied to both metallic and non-metallic utilities but should be used cautiously as the type of material can affect the resolution.

Also, the presence of reinforcing bar (rebar) in concrete can limit the resolution of pipes present below the concrete. The resolution of smaller diameter pipes found within or just below the concrete may be completed masked by the high response caused by the rebar.

Working inside of buildings can be especially challenging due the multiple surfaces (walls and ceilings) and fixtures above ground. The operator must know how to account for unwanted data artifacts. Generally, the GPR velocity in air is about 3 to 4 times faster than the subsurface. As a result, a metallic ceiling located 12 feet above the floor will appear in the GPR data at a “depth” of about 3 to 4 feet.

Standing water is problematic. Typically, if a GPR unit is passed through a puddle of standing water a strong ringing response will be recorded, often obscuring subsurface information entirely.

V. HEALTH AND SAFETY CONSIDERATIONS

Minimize physical hazard exposure through use of proper PPE as prescribed in the HASP. Maintain awareness of other potential hazards associated with the physical location where the GPR investigation is being conducted and any ingress or egress conditions.

VI. PROCEDURE

1. Become familiar with the details of the applicability and limitations of GPR.
2. Evaluate site-specific soil information to determine suitability of soils (clay content, saturation) for GPR. In general, soils with greater than 35% clay content are considered restrictive, and soils with less than 10% clay content are considered favourable for deep penetration with GPR.
3. Evaluate meteorological information regarding recent or forecasted precipitation that could impact soil moisture content and GPR effectiveness. Schedule GPR surveys appropriately.
4. Perform site reconnaissance in advance to identify potential sources of surface interference such as reinforced concrete, large metal objects, or electrical generators).
5. Consider complimentary technologies to supplement GPR and provide multiple lines of evidence. Technologies may include radio frequency, magnetic, electromagnetic surveys, or electrical resistivity surveys.
6. Employ only qualified and experienced GPR operators. For utility locating and mapping applications, the GPR operator should be specifically experienced in evaluating data quality and identifying anomalies in the field requiring variations in data acquisition procedures to positively interpret and locate targets of concern.

7. Consider the depth and size of subsurface features that GPR will be used for identification. Attempt to match the signal frequency to the expected depth and size of the subsurface feature. Change antennae as necessary for variable depths and sizes of target objects. Consider the selection of a primary and secondary choice of antennae and use multiple antennae as necessary. Evaluate GPR for known utility locations and/or relative to EM results, as an indication of potential effectiveness. A guideline for effective locating depths for utilities is 1-inch (2.5 cm) diameter of utility can be discerned for each foot (0.3 m) of depth to a depth of 12 feet (3.7 m). Expect a much coarser resolution below 12 feet.
8. Establish a reference grid over the area to be investigated and identify traverse locations in the field notebook or on a site plan map.
9. Most GPR systems are equipped with an odometer to keep track of the distance moved. It is important to confirm the accuracy of the odometer calibration and adjust if necessary.
10. Select and input a dielectric constant or average velocity into the GPR unit based on knowledge of the type of subsurface materials. Bear in mind that the dielectric constant or velocity is an approximation based on assumed subsurface materials and may vary based on the variability of the subsurface materials. The dielectric constant or velocity is necessary to estimate the depth of a target but should be considered an approximation not an absolute. Multiple passes over a known utility may be necessary using different dielectric constants before an accurate depth to a target can be estimated. Some manufacturers include the ability to perform hyperbola fitting to estimate dielectric constant or velocity from data collected in the field.
11. Depending on the system and antenna frequency, the pace at which the GPR unit is moved along a traverse may affect the target resolution. It is recommended that an initial starting pace should be approximately 1.5 feet (0.5m) per second and modified if necessary, during field operations. Appropriate pacing can be determined in advance if the size of the smallest target is known.
12. Record GPR data while slowly pushing or pulling the antenna along each survey traverse. It is good practice to annotate periodic grid crossings using the system's ability to create fiducial markers. This is especially important for long traverses or locations where the ground surface is rough.
13. The data collection and storage approach is generally one of two types. One approach is to walk in a systematic pattern and mark out targets as they are found using paint or some other means. Once the area of interest is marked out, complete the survey by going back and storing key transects in the system memory for final reporting. The locations of the final stored traverses should be surveyed with GPR or taped to known locations via triangulation. This first approach is most appropriate for marking out USTs relatively simple utility patterns. The second approach is applicable to mapping large areas, complex utility layouts, fill mapping, or other geologic objectives. In such circumstances the best practice is to layout a control grid and using GPR mounted to the GPR system. The grid can either be a series of parallel lines at right angles to a known fabric, or if conditions are unknown, a grid of lines at orthogonal orientations. In this second approach it is important to start and end the GPR unit at marked out grid points and to keep good notes about the data collection process. Long lines should also be supplemented with fiducial marks at intermediate grid crossings. It is anticipated in this approach that data will be stored in memory and processed using appropriate GPR processing software.
14. For projects where a complete grid of data is stored, the results may be interpreted either as a series of horizontal slice maps or 3-dimensional data sets. Most contemporary software has the capability of digitizing discrete objects or horizons on a line by line basis, after which the interpretations can be exported to a vector drawing format such as DXF or SHP files in the form of 3D points and polylines.

VII. WASTE MANAGEMENT

GPR is a non-invasive procedure and should not result in the generation of derived wastes. Any trash or rubbish generated during the course of field activities should be disposed of in a proper trash receptacle.

VIII. DATA RECORDING AND MANAGEMENT

Conduct data processing and analysis in accordance with the manufacturer's recommendations and industry practice. Processed data is available in electronic form. A copy of the PDF files for each individual GPR traverse should be included in the project directory along with scans of the field notes. Electronic data (raw and processed) should be maintained in accordance with data management procedures as outlined in the project sampling analysis plan (SAP), quality assurance project plan (QAPP), data quality objectives plan, or other applicable plan or guidance document.

IX. QUALITY ASSURANCE

The following quality control procedures should be observed:

- Seek appropriate input prior to conducting a GPR survey to identify site-specific features (soil conditions/sources of interference) that may impact data acquisition.
- Operate all equipment in accordance with manufacturer's instructions and recommended procedures. Record all system components (Unit, antennae frequency, etc.) information in the field book or a pre-made field form.
- Regardless of which data collection approach is taken, data quality should always be checked in the field to identify factors that may require adjustment to the data acquisition procedures. Make appropriate adjustments to data acquisition methods to achieve survey objectives, as feasible.
- It is recommended that the operation and performance of the GPR equipment is field checked (if possible) by locating existing underground utilities or structures of known depth, size, and construction. These characteristics should be similar to that of unidentified target objects.
- Data interpretation should undergo peer review by appropriate qualified and experienced personnel.

X. REFERENCES

US Army Corps of Engineers, 1995. Geophysical Exploration for Engineering and Environmental Investigations, Engineering Manual (EM) 1110-1-1802.

TGI - INVESTIGATION-DERIVED WASTE HANDLING AND STORAGE

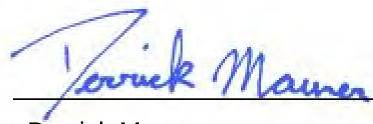
Rev #: 1

Rev Date: May 15, 2020

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	

APPROVAL SIGNATURES

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

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 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.

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.

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 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

- 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.

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 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.

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.

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.

TGI – Resource Conservation and Recovery Act (RCRA) Waste Characterization Sampling

Rev: 0

Rev Date: May 20, 2021

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
1	0	May 20, 2021	All	New TGI	Ryan Mattson

Approval Signatures

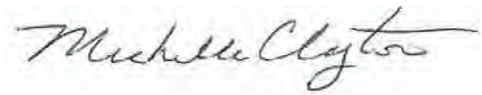
Prepared by:

05/20/2021

Ryan Mattson

Date:

Technical Expert Reviewed by:



05/21/2021

Michelle Clayton

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 objective of this Technical Guidance Instruction (TGI) is to provide field sampling personnel procedures for collecting waste characterization samples from materials which are subject to the Resource Conservation and Recovery Act (RCRA) definition of solid waste at 40 CFR §261.2. Solid wastes, which include liquid, solid, or sludge – phase wastes, typically encountered by Arcadis are contaminated environmental media (soil and groundwater), contaminated building materials, drilling fluids, decontamination liquids, contaminated personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials. Arcadis may also be hired to sample client industrial or manufacturing wastes.

This TGI specifically excludes the following sampling which should be covered by more specific TGIs: polychlorinated biphenyl waste sampling under the Toxic Substances Control Act, radioactive waste sampling under the Atomic Energy Act, naturally occurring radioactive material or technologically enhanced naturally occurring radioactive material waste sampling, asbestos sampling, lead paint sampling, medical waste sampling, National Pollution Elimination Discharge permit sampling and publicly owned treatment works discharge sampling.

Personnel utilizing this TGI should have a sampling plan, waste analysis plan or request that has been reviewed by a client or Arcadis hazardous waste Technical Expert and the sampler should understand location, scope, analytical testing laboratory, results timing, and data quality objectives for the particular sampling event prior to work. If this is not the case, stop work and contact the CPM for scope related questions or the hazardous waste Technical Expert for waste compliance questions. Arcadis hazardous waste Technical Expert advice is available by emailing regulatedwaste@arcadis.com.

This TGI describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures for waste characterization sampling. The procedures included in this TGI for waste characterizations sampling are based on the EPA's guidance document RCRA Waste Sampling Draft Technical Guidance (USEPA 2002). Waste characterization sampling provides data to help ensure the wastes are managed, transported and disposed in accordance with applicable federal, state, and local regulations. Although not comprehensive, the following laws and regulations pertaining to Hazardous Waste Management should be considered applicable. 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 (1976).
- Federal Hazardous Waste Regulations 40 CFR §260-261, Appendix I to §261, §264
- Department of Transportation (DOT) Hazardous Materials Transportation 49 CFR §171-173
- Occupational Safety and Health Administration (OSHA) Regulations 29 CFR §1910 and §1926

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

This 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 should be documented in the project work plans or reports. If changes to the sampling procedures are required due to unanticipated field conditions, the changes should 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 OSHA hazardous waste operations and emergency response (HAZWOPER) training, site supervisor training, site-specific training, first aid, and cardiopulmonary resuscitation (CPR), as needed. Personnel handling hazardous waste, including sampling, should have RCRA hazardous waste management training per 40 CFR §264.16. Additional state-specific hazardous waste management training may be required in certain states (i.e., California).

Arcadis personnel who ship samples that are subject to the definition of a DOT hazardous material (49 CFR 171.8) should have biennial DOT hazardous materials transportation training per 49 CFR § 172.704 (Arcadis requires every 2 years, DOT requires every 3 years). Arcadis field personnel should also comply with client-specific training. In addition, Arcadis field sampling personnel should 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. The project health and safety plan (HASP) and other documents may identify other training requirements or access control requirements.

4 Equipment List

The following equipment and materials, as required, should be available for waste characterization sampling:

All sampling events:

- Appropriate personal protective equipment as specified in the HASP
- Leather gloves
- Nitrile gloves
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as determined by the CPM and/or Technical Expert.
- Decontamination equipment/tools including Alconox®/Liquinox®-band detergent spray bottle, deionized or distilled water spray bottle, brushes, buckets.
- Indelible ink and/or permanent marking pens
- Appropriate sample containers, labels, and forms
- Digital camera
- Field logbook

Additional equipment/materials for Container Sampling – Solid Phase Waste

- Hammer
- 5/8” drum wrench/socket
- Stainless steel or disposable plastic hand spade
- Stainless steel scoop
- Stainless steel bucket auger

Additional equipment/materials for Container Sampling – Liquid Phase Waste

- Hammer
- 5/8” drum wrench/socket
- Step stool or ladder
- Disposable bailer, coliwasa sampler, or dipper

Additional equipment/materials for Process Waste Streams

- Process diagram
- Lockout/tagout information
- Step stool or ladder
- Stainless steel or disposable plastic hand spade
- Stainless steel scoop
- Disposable bailer, coliwasa sampler, or dipper

Additional equipment/materials for Uncontained Release Area

- Air monitoring equipment
- Underground utilities clearance checklist
- Long measuring tape or wheel
- Pin flags
- Stainless steel or disposable plastic hand spade
- Stainless steel scoop
- Stainless steel bucket auger

Additional equipment/materials for Destructive Building Material Sampling

- Plastic sheeting
- Hammer drill with appropriate bits
- Hammer
- Flathead screwdriver
- Chisel
- Putty knife
- Generator or other power source
- Zip seal plastic bags
- Paper plates

5 Cautions

This TGI does not provide procedures for sampling waste streams where there is no knowledge of waste origin or potential hazards. If such a situation arises, the sampler should stop work and consult the CPM and a Technical Expert.

6 Health and Safety Considerations

As determined by the site's known and suspected hazards, appropriate PPE should be worn by all field personnel within the designated work area. Exposure air monitoring may be required during certain field activities as stated in the Site HASP.

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.

Filled waste containers can be very heavy, become unbalanced, and/or spill contents. Waste containers stored for extended periods of time may be subject to deterioration. Personnel should attempt to sample waste containers without moving them and, if necessary, use appropriate moving techniques and equipment for safe handling. Container lids must be replaced after sampling to maintain RCRA compliance. Large containers such as rolloff bins and frac tanks may require climbing to access sampling ports. A second sampler is recommended as a spotter for such sampling events. Sampling wastes from active processes can involve opening valves or accessing confined spaces. Stop work and communicate with the CPM and process operator if there is any misunderstanding or change in scope of sampling. Destructive bulk sampling can generate projectiles, please make sure the area is clear of ancillary personnel and upgrade PPE as appropriate. Destructive sampling can also encounter hidden utilities. Sampling of uncontained wastes may result in exposure to airborne contamination or if the waste is in stockpiles may involve gravity hazards. Upgrade monitoring equipment and plan work in advance to minimize these hazards.

7 Procedure

Sampling Methodology

RCRA requires that waste characterization samples be representative of the waste stream. A representative sample is defined in 40 CFR 260.10 as a sample of a universe or a whole that can be expected to exhibit the average properties of the universe or whole. Arcadis personnel should work with the client, waste Technical Expert and disposal facility on an approach to collect representative waste characterization samples and prepare them for shipment for laboratory analysis. The laboratory used for waste characterization analysis should have the appropriate federal and state accreditations and may be required to be pre-approved by the Client.

<u>Sampling Containerized Solid Wastes</u>

1. Assess the integrity of the container for labels, bulging, leaks. If the container appears compromised or unlabeled, stop work and contact the CPM.
2. Open the container using appropriate tools.
3. Record visual appearance and volume of waste in field logbook.
4. Collect volatile constituent samples (volatile organic compounds, total petroleum hydrocarbons – gasoline range, etc.) as grab samples at a random location using a method to minimize the loss of volatiles, typically directly into laboratory provided sampling devices/containers.
5. Collect semi and nonvolatile constituent samples (semi-volatile organic compounds, etc.) as grab samples for 4-point composites from random locations in the accessible waste layer. The nonvolatile sample compositing should be performed by the laboratory. A disposable or stainless-steel sampling tool or bucket auger may be used if deep container sampling is requested. Decontaminate any tool used between sampling different locations.
6. Place samples in laboratory provided sample containers.
7. Close the container by replacing all components disassembled to open it.
8. Take a photograph of the container.
9. Note the container sampled, photo number and sample ID in the field logbook.

<u>Sampling Containerized Liquid Wastes</u>

1. Assess the integrity of the container for labels, bulging, leaks. If the container appears compromised or unlabeled, stop work and contact the CPM.
2. If the container is a tank, sampling from a hatch or opening at the top is preferred over a valve at the bottom because of potential waste stratification.
3. Open the container using appropriate tools.
4. Record visual appearance and volume of waste in field logbook and assess the waste for separate phases (non-aqueous phase liquid [napl], liquid, sediment) and record percentages by volume of each in field logbook. If there are separate phases, contact CPM to advise if discrete sampling of each phase is required.
5. Open an unused disposable liquid sampling tool (such as a bailer, coliwasa or dipper). If discrete phase sampling is required, choose a sampling tool that is capable of collecting the desired phase only and

insert the sampling end of the tool in the phase to be sampled. If discrete phase sampling is not required, choose a sampling tool, and stir the waste.

6. Collect a representative sample of the waste using the tool into laboratory provided sample containers.
7. If pH is requested by field test, apply some waste from the liquid sampler to pH paper/pH meter and photograph the paper result or equipment display screen showing the pH value for project records. Note if using pH paper, it must be capable of reading pH in the range of at least 1 to 13 pH units, with a larger range acceptable.
8. Close the container by replacing all components disassembled to open it.
9. Take a photograph of the container.
10. Note the container sampled, photo number and sample ID in the field logbook.

<u>Sampling Process Waste Streams</u>

Process waste streams typically have designated sample collection locations (built in sampling ports, covered pits, sumps etc.) to allow collection of waste characterization samples. The sampler should consult the process operator and receive authorization before collecting any samples from an active process.

1. Record the name of the sampling location in field notes and on sample labels.
2. Collect a sample directly from the sampling location into the laboratory-provided container, if possible. Some liquid processes may need to be sampled using a dipper which should be passed through the process waste in one continuous motion to collect the sample and transfer to laboratory-provided containers. A disposable flat scoop sampling tool can be used to collect solid process wastes off conveyors, etc. prior to transferring to laboratory-provided containers.
3. Take a photograph of the sample location.
4. Note the sample location, photo number and sample ID in the field logbook.

<u>Sampling Uncontained Release Areas</u>

Sampling of an uncontained release or spill area can be performed as follows:

New Releases:

1. Visually assess the horizontal boundaries of the spill. The first round of waste characterization is typically biased by collecting waste characterization samples that are most likely to be “worst case”, i.e., visually impacted and near the center of the spill. The samples should be collected as grab samples with ideally a minimum of four (4) grab samples to characterize a new waste stream to statistical significance.
2. Collect volatile constituent samples (volatile organic compounds, total petroleum hydrocarbons – gasoline range, etc.) semi and nonvolatile constituent samples (semi-volatile organic compounds, etc.) as grab samples centered on the release location. A disposable or stainless-steel sampling tool may be used or a bucket auger if deep sampling is requested. Volatile constituent samples should be collected using a method to minimize the loss of volatiles, typically directly into laboratory provided sampling devices/containers. Decontaminate any tool used between sampling different locations.
3. Place samples in laboratory provided sample containers.
4. Take a photograph of the sampling location.
5. Note the sampling location, photo number and sample ID in the field logbook.

Stockpiles:

1. Assess the size of the stockpile and work with the client, waste Technical Expert and disposal facility on an approach to collect an appropriate number of representative samples.

2. Collect volatile constituent samples (volatile organic compounds, total petroleum hydrocarbons – gasoline range, etc.) semi and nonvolatile constituent samples (semi-volatile organic compounds, etc.) as grab samples from randomly selected places in the stockpile. A disposable or stainless-steel sampling tool may be used for samples near the outer edge of the stockpile and a bucket auger can be used for sampling deeper into the stockpile. Volatile constituent samples should be collected from stockpile material inside the outer "shell" of the stockpile that has had less exposure to air for using a method to minimize the loss of volatiles, typically directly into laboratory provided sampling devices/containers. Decontaminate any tool used between sampling different locations.
3. Collect semi and nonvolatile constituent samples (semi-volatile organic compounds, etc.) as either grab samples from randomly selected places in the stockpile, if characterization samples will be used to separate the stockpile into different waste streams, or as grab samples for 4-point composites from random locations, if the stockpile will be disposed collectively as one waste stream. Nonvolatile sample compositing should be performed by the laboratory. A disposable or stainless-steel sampling tool may be used for samples near the outer edge of the stockpile and a bucket auger can be used for sampling deeper into the stockpile. Decontaminate any tool used between sampling different locations.
4. Place samples in laboratory provided sample containers.
5. Take a photograph of the sampling location.
6. Note the sampling location, photo number and sample ID in the field logbook.

Historical Releases:

Waste characterization for historical release areas subject to future remediation is typically performed in accordance with a site investigation work plan and is out of scope for this TGI.

<u>Destructive Sampling Building Materials</u>

1. Assess the building material and area to be sampled. Surface coatings and softer material such as sheet rock can be sampled with hand tools (hammer, chisel, putty knife, etc.). Harder materials such as wood, masonry and concrete may require a hammer drill with an appropriate bit. Confirm the volume/mass requirements for the sample with the analytical lab to collect a sufficient amount of sample for analysis while minimizing damage to the sample area.
2. Sampling Vertical Surfaces:
    - Place plastic sheeting under the sampling area.
    - If directed to collect a surface coating sample, scrape material into a labeled laboratory provided sampling container or, if necessary, a new plastic bag beneath the sampling area.
    - If directed to collect a representative sample of the entire building material, drill into the full thickness of the material to be disposed, collecting shavings on a labeled new paper plate beneath the sampling area. Move to an adjacent area and drill another full thickness hole if additional sampling volume/mass is needed.
3. Sampling Vertical Surfaces:
    - Place plastic sheeting around the sampling area.
    - If directed to collect a surface coating sample, scrape material, and transfer it to a labeled laboratory provided sampling container.
    - If directed to collect a representative sample of the entire building material, place a labeled new paper plate directly over the sampling area and drill through the plate into the full thickness of the material to be disposed. Shavings should collect on the paper plate. Move to an adjacent area

and drill another full thickness hole using a new paper plate each time if additional sampling volume/mass is needed.

4. Record visual appearance and volume of waste in field logbook.
5. Transfer samples from bags or plates to laboratory provided sample containers.
6. Take a photograph of the sampling location.
7. Note the sampling location, photo number and sample ID in the field logbook.

Sampling Frequency

The sampler should work with the client, waste Technical Expert and disposal facility on an approach to collect an appropriate number of representative samples. In the absence of any other frequency directive, waste characterization samples should be collected at the following frequencies:

- Large Volume Soil/Sludge Waste Steams (Uncontained, Stockpiles, Rolloff Bins, etc.): minimum one representative sample per 200 cubic yards.
- Large Volume Liquid Waste Streams (Tanks, Ponds, etc.): minimum one representative sample per waste stream.
- Small Volume Soil/Sludge Waste Streams (Drums, Totes, etc.):
  - 1-4 containers: one grab sample from one randomly selected container for volatile constituents; grab samples from each container to be combined by laboratory into 4-point composite for nonvolatile constituents.
  - More than 4 containers: grab samples for volatile constituents from randomly selected containers representing 20% of total number of containers; grab samples for nonvolatile constituents from the same 20% of total number of containers to be combined by laboratory into 4-point (or less) composites.
- Small Volume Liquid Waste Streams (Drums, Totes, etc.): minimum one representative sample from randomly selected containers representing 20% of total number of containers.

Waste Characterization Sample Analytical Parameters

Waste characterization should be conducted in accordance with the requirements of the client, waste handling facility, and local/state/federal governments. In general, wastewater should be analyzed by methods appropriate for the known or suspected contaminants in the waste stream. Solid phase waste characterization samples may be analyzed for toxicity characteristic leaching procedure (TCLP) VOCs, TCLP SVOCs, TCLP RCRA metals, and PCBs, as well as reactivity. Liquid and sludge phase waste characterization samples may be analyzed for TCLP VOCs, TCLP SVOCs, TCLP RCRA metals, and PCBs, as well as corrosivity (pH), reactivity and flammability (flashpoint). Project-specific constituents of concern including PCBs, herbicides and pesticides may require additional sampling. Please note that state- or local-specific regulations may require a different or additional sampling approaches such as total petroleum hydrocarbon sampling, fish bioassay sampling, etc.

Sample Handling and Shipping

All samples should be appropriately labeled, packed, and shipped in accordance with Arcadis sample cooler packing procedure/video available at the Arcadis Transportation Safety SharePoint site. The chain-of-custody should be filled out in accordance with current Arcadis sample chain of custody standard operating procedure (SOP) available from the Arcadis Virtual Library. Any sample compositing instructions for the laboratory should be included on the chain of custody. The Arcadis shipping determination form (Arcadis Transportation Safety SharePoint) should be completed prior to the first shipment of samples from a project site.

As noted under the qualifications section above, biennial training is required by Arcadis 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.

8 Data Recording and Management

Waste characterization sample handling, packing, and shipping procedures shold 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, Sampling and Analysis Plan, or Waste Analysis Plan. Copies of the chain-of-custody forms should 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.

9 Quality Assurance

The CPM should 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, WAP, HASP, etc. Deficiencies should be noted, tracked, and resolved. Upon correction, they should be noted for project documentation.

10 References

United States Environmental Protection Agency (USEPA). 2002. RCRA Waste Sampling Draft Technical Guidance. Office of Solid Waste. August.

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

ARCADIS Design & Consultancy for natural and built assets

TGI - SOIL DESCRIPTION

Rev: #2

Rev Date: February 16, 2018

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	May 20, 2008	17	Original SOP	Joe Quinnan Joel Hunt
1	September 2016	15	Updated to TGI	Nick Welty Patrick Curry
2	February 16, 2018	15	Updated descriptions, attachments and references in text	Nick Welty Patrick Curry

APPROVAL SIGNATURES

Prepared by:

June 30, 2017

Patrick Curry, PG

Date:

Technical Expert Reviewed by:

June 30, 2017

Nicklaus Welty, PG

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

This Arcadis Technical Guidance Instruction (TGI) describes proper soil description procedures. This TGI should be followed for unconsolidated material unless there is an established client-required specific procedure or regulatory-required specific procedure. In cases where there is a required specific procedure, it should be followed and should be referenced and/or provided as an appendix to reports that include soil classifications and/or boring logs. When following a required non-Arcadis procedure, additional information required by this TGI should be included in field notes with client approval.

This TGI has been developed to emphasize field observation and documentation of details required to:

- make hydrostratigraphic interpretations guided by depositional environment/geologic settings;
- provide information needed to understand the distribution of constituents of concern; properly design wells, piezometers, and/or additional field investigations; and develop appropriate remedial strategies.

This TGI incorporates elements from various standard systems such as ASTM D2488-06, Unified Soil Classification System, Burmister and Wentworth. However, none of these standard systems focus specifically on contaminant hydrogeology and remedial design. Therefore, although each of these systems contain valuable guidance and information related to correct descriptions, strict application of these systems can omit information critical to our clients and the projects that we perform.

This TGI does not address details of health and safety; drilling method selection; boring log preparation; sample collection; or laboratory analysis. Refer to other Arcadis procedure, guidance, and instructional documents, the project work plans including the quality assurance project plan, sampling plan, and health and safety plan (HASP), as appropriate.

3 PERSONNEL QUALIFICATIONS

Soil descriptions should only be performed by Arcadis personnel or authorized sub-contractors with a degree in geology or a geology-related discipline. Field personnel will complete training on the Arcadis soil description TGI in the office and/or in the field under the guidance of an experienced field geologist with at least 2 years of prior experience applying the Arcadis soil description method.

4 EQUIPMENT LIST

The following equipment should be taken to the field to facilitate soil descriptions:

- field book, field forms or PDA to record soil descriptions;
- field book for supplemental notes;
- this TGI for Soil Descriptions and any project-specific procedure, guidance, and/or instructional documents (if required);
- field card showing Wentworth scale;
- Munsell® soil color chart;
- tape measure divided into tenths of a foot;
- stainless steel knife or spatula;
- hand lens;
- water squirt bottle;
- jar with lid;
- personal protective equipment (PPE), as required by the HASP; and
- digital camera

5 CAUTIONS

Drilling and drilling-related hazards including subsurface utilities are discussed in other procedure documents and site-specific HASPs and are not discussed herein.

Soil samples may contain hazardous substances that can result in exposure to persons describing soils. Routes for exposure may include dermal contact, inhalation and ingestion. Refer to the project specific HASP for guidance in these situations.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with soil sampling and description will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Know what hazardous substances may be present in the soil and understand their hazards. Always avoid the temptation to touch soils with bare hands, detect odors by placing soils close to your nose, or tasting soils.

7 PROCEDURE

1. Select the appropriate sampling method to obtain representative samples in accordance with the selected sub-surface exploration method, e.g. split-spoon or Shelby sample for hollow-stem drilling, acetate sleeves for direct push, bagged core for sonic drilling, etc.
2. Proceed with field activities in required sequence. Although completion of soil descriptions is often not the first activity after opening sampler, identification of stratigraphic changes is often necessary to select appropriate intervals for field screening and/or selection of laboratory samples.
3. Set up boring log field sheet.
    - Drillers in both the US and Canada generally work in feet due to equipment specifications. Use the Arcadis standard boring log form (**Attachment A**).
    - The preferred boring log includes a graphic log of the principal soil component to support quick visual evaluation of grain size. The purpose of the graphic log is to quickly assess relative soil permeability. Note, for poorly sorted soils (e.g. glacial till), the principal component may not correlate to permeability of the sample. In this case, the geologist should use best judgement to graph overall soil type consistent with relative soil permeability. For example, for a dense sand/silt/clay till, the graphic log would reflect the silt/clay, rather than sand.
    - Record depths along the left-hand side at a standard scale to aid in the use of this tool. See an example completed boring log (**Attachment B**).
4. Examine each soil core (this is different than examining each sample selected for laboratory analysis), and record the following for each stratum:
    - depth interval;
    - principal component with descriptors, as appropriate;
    - amount and identification of minor component(s) with descriptors as appropriate;
    - moisture;
    - consistency/density;
    - color; and
    - additional description or comments (recorded as notes).
5. At the end of the boring, record the amount of drilling fluid used (if applicable) and the total depth logged.

The above is described more fully below.

DEPTH

To measure and record the depth below ground surface (bgs) of top and bottom of each stratum, the following information should be recorded.

1. Measured depth to the top and bottom of sampled interval. Use starting depth of sample based upon measured tool length information and the length of sample interval.
2. Length of sample recovered, not including slough (material that has fallen into hole from previous interval), expressed as fraction with length of recovered sample as numerator over length of sampled interval as denominator (e.g. 14/24 for 14 inches recovered from 24-inch sampling interval that had 2 inches of slough discarded).
3. Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.
4. Any observations of sample condition or drilling activity that would help identify whether there was loss from the top of the sampling interval, loss from the bottom of the sampling interval, or compression of the sampling interval. Examples: 14/24, gravel in nose of spoon; or 10/18 bottom 6 inches of spoon empty.

DETERMINATION OF COMPONENTS

Obtain a representative sample of soil from a single stratum. If multiple strata are present in a single sample interval, each stratum should be described separately. More specifically, if the sample is from a 2-foot long split-spoon where strata of coarse sand, fine sand and clay are present, then the resultant description should be of the three individual strata unless a combined description can clearly describe the interbedded nature of the three strata. Example: Fine Sand with interbedded lenses of Silt and Clay, ranging between 1 and 3 inches thick.

Identify principal component and express volume estimates for minor components on logs using the following standard modifiers.

Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

Determination of components is based on using the Udden-Wentworth particle size classification (see below) and measurement of the average grain size diameter. Each size grade or class differs from the next larger grade or class by a constant ratio of ½. Due to visual limitations, the finer classifications of Wentworth's scale cannot be distinguished in the field and the subgroups are not included. Visual determinations in the field should be made carefully by comparing the sample to the Soil Description Field Guide (**Attachment C**) that shows Udden-Wentworth scale or by measuring with a ruler. Use of field sieves is encouraged to assist in estimating percentage of coarse grain sizes. Settling test or wash method (Appendix X4 of ASTM D2488) is encouraged for determining presence and estimating percentage of clay and silt. Note that "gravel" is not an Udden-Wentworth size class.

Udden-Wenworth Scale Modified Arcadis, 2008			
Size Class	Millimeters	Inches	Standard Sieve #
Boulder	256 – 4096	10.08+	
Large cobble	128 - 256	5.04 -10.08	
Small cobble	64 - 128	2.52 – 5.04	
Very large pebble	32 – 64	0.16 - 2.52	
Large pebble	16 – 32	0.63 – 1.26	
Medium pebble	8 – 16	0.31 – 0.63	
Small pebble	4 – 8	0.16 – 0.31	No. 5 +
Granule	2 – 4	0.08 – 0.16	No.5 – No.10
Very coarse sand	1 -2	0.04 – 0.08	No.10 – No.18
Coarse sand	½ - 1	0.02 – 0.04	No.18 - No.35
Medium sand	¼ - ½	0.01 – 0.02	No.35 - No.60
Fine sand	1/8 -¼	0.005 – 0.1	No.60 - No.120
Very fine sand	1/16 – 1/8	0.002 – 0.005	No. 120 – No. 230
Silt (subgroups not included)	1/256 – 1/16	0.0002 – 0.002	Not applicable (analyze by pipette or hydrometer)
Clay (subgroups not included	1/2048 – 1/256	.00002 – 0.0002	

Identify components as follows. Remove particles greater than very large pebbles (64-mm diameter) from the soil sample. Record the volume estimate of the greater than very large pebbles. Examine the sample fraction of very large pebbles and smaller particles and estimate the volume percentage of the pebbles, granules, sand, silt and clay. Use the jar method, visual method, and/or wash method (Appendix X4 of ASTM D2488) to estimate the volume percentages of each category.

Determination of actual dry weight of each Udden-Wentworth fraction requires laboratory grain-size analysis using sieve sizes corresponding to Udden-Wentworth fractions and is highly recommended to determine grain-size distributions for each hydrostratigraphic unit.

Lab or field sieve analysis is advisable to characterize the variability and facies trends within each hydrostratigraphic unit. Field sieve-analysis can be performed on selected samples to estimate dry weight fraction of each category using ASTM D2488 Standard Practice for Classification of Soils for Engineering Purposes as guidance, but replace required sieve sizes with the following Udden-Wentworth set: U.S. Standard sieve mesh sizes 6; 12; 20; 40; 70; 140; and 270 to retain pebbles; granules; very coarse sand; coarse sand; medium sand; fine sand; and very fine sand, respectively.

PRINCIPAL COMPONENT

The principal component is the size fraction or range of size fractions containing the majority of the volume. Examples: the principal component in a sample that contained 55% pebbles would be “Pebbles”; or the principal component in a sample that was 20% fine sand, 30% medium sand and 25% coarse sand would be “Sand, fine to coarse” or for a sample that was 40% silt and 45% clay the principal component would be “Clay and Silt”. Shade the boxes on the graphic log (**Attachment A**) up to and including the box with the principal component. The purpose of the graphical log is to provide a relative estimate of permeability. As noted above, for poorly sorted soils such as glacial till, the principal component may not correlate to permeability of the sample. In this case, the geologist should use best judgement to graph overall soil type consistent with relative soil permeability.

Include appropriate descriptors with the principal component. These descriptors vary for different particle sizes as follows.

Angularity – Describe the angularity for very coarse sand and larger particles in accordance with the table below (ASTM D-2488-06). Figures showing examples of angularity are available in ASTM D-2488-06 and the Arcadis Soil Description Field Guide.

Description	**Criteria**
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Sub-angular	Particles are similar to angular description but have rounded edges.
Sub-rounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Plasticity – Describe the plasticity for silt and clay based on observations made during the following test method (ASTM D-2488-06).

- As in the dilatancy test below, select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
- Shape the test specimen into an elongated pat and roll by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation. Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble when the soil is near the plastic limit.

Description	Criteria
Non-plastic	A 1/8-inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Dilatancy – Describe the dilatancy for silt and silt-sand mixtures using the following field test method (ASTM D-2488-06).

- From the specimen select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material adding water if necessary, until it has a soft, but not sticky, consistency.
- Smooth the ball in the palm of one hand with a small spatula.
- Shake horizontally, striking the side of the hand vigorously with the other hand several times.
- Note the reaction of water appearing on the surface of the soil.
- Squeeze the sample by closing the hand or pinching the soil between the fingers, and not the reaction as none, slow, or rapid in accordance with the table below. The reaction is the speed with which water appears while shaking and disappears while squeezing.

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Note that silt and silt-sand mixtures will be non-plastic and display dilatancy. Clay mixtures will have some degree of plasticity but do not typically react to dilatancy testing. Therefore, the tests outlined above can be used to differentiate between silt dominated and clay dominated soils.

MINOR COMPONENT(S)

The minor component(s) are the size fraction(s) containing less than 50% volume. Example: the identified components are estimated to be 60% medium sand to granules, 25% silt and clay; 15 % pebbles – there are two identified minor components: silt and clay; and pebbles.

Include a standard modifier to indicate percentage of minor components (see Table on Page 6) and the same descriptors that would be used for a principal component. Plasticity should be provided as a descriptor for clay and clay mixtures. Dilatancy should be provided for silt and silt mixtures. Angularity should be provided as a descriptor for pebbles and coarse sand. For the example above, the minor constituents with modifiers could be: some silt and clay, low plasticity; little medium to large pebbles, sub-round.

SORTING

Sorting is the opposite of grading, which is a commonly used term in the USCS or ASTM methods to describe the uniformity of the particle size distribution in a sample. Well-sorted samples are poorly graded and poorly sorted samples are well graded. Arcadis prefers the use of sorting for particle size distributions and grading to describe particle size distribution trends in the vertical profile of a sample or hydrostratigraphic unit because of the relationship between sorting and the energy of the depositional process. For soils with sand-sized or larger particles, sorting should be determined as follows:

Well sorted – the range of particle sizes is limited (e.g. the sample is comprised of predominantly one or two grain sizes).

Poorly sorted – a wide range of particle sizes are present.

You can also use sieve analysis to estimate sorting from a sedimentological perspective; sorting is the statistical equivalent of standard deviation. Smaller standard deviations correspond to higher degree of sorting (see Remediation Hydraulics, 2008).

MOISTURE

Moisture content should be described for every sample since increases or decreases in water content is critical information. Moisture should be described in accordance with the table below (percentages should not be used unless determined in the laboratory).

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet (Saturated)	Visible free water, soil is usually below the water table.

CONSISTENCY or DENSITY

This can be determined by standard penetration test (SPT) blow counts (ASTM D-1586) or field tests in accordance with the tables below. When drilling with hollow-stem augers and split-spoon sampling, the SPT blow counts and N-value is used to estimate density. The N-value is the blows per foot for the 6" to 18" interval. Example: for 24-inch spoon, recorded blows per 6-inch interval are: 4/6/9/22. Since the second interval is 6" to12", the third interval is 12" to 18", the N value is 6+9, or 15. Fifty blow counts for less than 6 inches is considered refusal. In recent years, more common drilling methods include rotary-sonic or direct push. When blow counts are not available, density is determined using a thumb test. Note however, the thumb test only applies to fine-grained soils.

Fine-grained soil – Consistency

Description	Criteria
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated one inch by thumb.
Medium stiff	N-value 9-15 or indented about ¼ inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty

Coarse-grained soil – Density

Description	Criteria
Very loose	N-value 1- 4
Loose	N-value 5-10
Medium dense	N-value 11-30
Dense	N-value 31- 50
Very dense	N-value >50

COLOR

Color should be described using simple basic terminology and modifiers based on the Munsell system. Munsell alpha-numeric codes are required for all samples. If the sample contains layers or patches of varying colors this should be noted and all representative colors should be described. The colors should be described for moist samples. If the sample is dry it should be wetted prior to comparing the sample to the Munsell chart.

ADDITIONAL COMMENTS (NOTES)

Additional comments should be made where observed and should be presented as notes with reference to a specific depth interval(s) to which they apply. Some of the significant information that may be observed includes the following.

- Odor - You should not make an effort to smell samples by placing near your nose since this can result in unnecessary exposure to hazardous materials. However, odors should be noted if they are detected during the normal sampling procedures. Odors should be based upon descriptors such as those used in NIOSH “Pocket Guide to Chemical Hazards”, e.g. “pungent” or “sweet” and should not indicate specific chemicals such as “phenol-like” odor or “BTEX” odor.
- Structure
- Bedding planes (laminated, banded, geologic contacts).
- Presence of roots, root holes, organic material, man-made materials, minerals, etc.
- Mineralogy
- Cementation
- NAPL presence/characteristics, including sheen (based on client-specific guidance).
- Reaction with HCl - typically only used for special soil conditions, such as caliche environments.
- Origin, if known (Lacustrine; Fill; etc.).

EXAMPLE DESCRIPTIONS

51.4 to 54.0’ CLAY, some silt, medium to high plasticity; trace small to large pebbles, sub-round to sub-angular up to 2” diameter; moist, stiff, dark grayish brown (10 YR 4/2) NOTE: Lacustrine; laminated 0.1 to 0.2” thick, laminations brownish yellow (10 YR 4/3).

32.5 to 38.0’ SAND, medium to very coarse, sub-round to sub-angular; little granule and pebble, trace silt; poorly sorted, wet, grayish brown (10 YR 5/2).

Unlike the first example where a density of cohesive soils could be estimated, this rotary-sonic sand and pebble sample was disturbed during drilling (due to vibrations in a loose sand and pebble matrix) so no density description could be provided. Neither sample had noticeable odor so odor comments were not included.

The standard generic description order is presented below.

- Depth
- Principal Components
  - Angularity for very coarse sand and larger particles
  - Plasticity for silt and clay
  - Dilatancy for silt and silt-sand mixtures
- Minor Components
- Sorting
- Moisture
- Consistency or Density
- Color
- Additional Comments

8 WASTE MANAGEMENT

Project-specific requirements should be identified and followed. The following procedures, or similar waste management procedures are generally required.

Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal. PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures and soil sampling/handling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. Once full, the material will be analyzed to determine the appropriate disposal method.

9 DATA RECORDING AND MANAGEMENT

Upon collection of soil samples, the soil sample should be logged on a standard boring log and/or in the field log book depending on Data Quality Objectives (DQOs) for the task/project. The preferred standard boring log is presented below and is included as **Attachment A**.

The general scheme for soil logging entries is presented above; however, depending on task/project DQOs, specific logging entries that are not applicable to task/project goals may be omitted at the project manager's discretion. In any case, use of a consistent logging procedure is required.

Completed logs and/or logbook will be maintained in the task/project field records file. Digital photographs of typical soil types observed at the site and any unusual features should be obtained whenever possible. All photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or log book and a label showing this information in the photo is useful.

10 QUALITY ASSURANCE

Soil descriptions should be completed only by appropriately trained personnel. Descriptions should be reviewed by an experienced field geologist for content, format and consistency. Edited boring logs should be reviewed by the original author to assure that content has not changed.

11 REFERENCES

Arcadis Soil Description Field Guide, 2008.

Munsell® Color Chart – available from Forestry Suppliers, Inc.- Item 77341 "Munsell® Color Soil Color Charts.

Field Gauge Card that Shows Udden-Wentworth scale – available from Forestry Suppliers, Inc. – Item 77332 "Sand Grain Sizing Folder."

ASTM D-1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

United States Bureau of Reclamation. Engineering Geology Field Manual. United States Department of Interior, Bureau of Reclamation. http://www.usbr.gov/pmts/geology/fieldmap.htm.

Petrology of Sedimentary Rocks, Robert L. Folk, 1980, p. 1-48.

NIOSH Pocket Guide to Chemical Hazards.

Remediation Hydraulics, Fred C. Payne, Joseph A. Quinnan, and Scott T. Potter, 2008, p 59-63.

ATTACHMENT A

Arcadis Standard Soil Boring Log Form

ARCADIS Design & Consultancy for natural and built assets

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	

ARCADIS

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	

ATTACHMENT B

Example of Completed Arcadis Soil Boring Log

ARCADIS Design & Consultancy for natural and built assets

SOIL BORING LOG

Boring/Well SB-01 Project Example

Site Location Anytown, North America

Drilling Started 6/26/17

Total Depth Drilled 20 Feet Hole Diameter 4.5 inches Drilling Completed 6/26/17

Type of Sample or Coring Device Continuous Length and Diameter of Coring Device 5', 2.25" macrocore Sampling Interval 5 feet

Drilling Method Geoprobe Drilling Fluid Used NA

Drilling Contractor Fibertec Driller Ryan Brown

Prepared By A. DeGrandis Helper Grant Berger

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD: clay	MUD: silt	SAND: very fine	SAND: fine	SAND: medium	SAND: coarse	SAND: very coarse	GRAVEL: granular	GRAVEL: pebble	GRAVEL: cobble	GRAVEL: boulder	Udden-Wentworth Description: principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, additional comments
	0.3	1	X	X	X	X	X							(0.0-4.0) SAND, fine to medium, sub-rounded;
	0.1	2	X	X	X	X	X							little granules to small pebbles, sub-rounded
60"	0.0	3	X	X	X	X	X							to sub-angular; trace silt; poorly sorted, dry
(HA)	0.0	4	X	X	X	X	X							to moist, dark grayish brown (10YR 4/2).
	1.4	5	X	X										NOTE: Ablation till.
	1.7	6	X	X										
	0.9	7	X	X										(4.0-10.0) SILT, non-plastic, rapid dilatancy;
52"	1.2	8	X	X										dry to moist, soft to medium stiff,
	0.6	9	X	X										gray (10YR 5/1).
	0.2	10	X	X										
	0.0	11	X	X	X	X								(10.0-15.5) SAND, fine, sub-rounded; trace
	0.0	12	X	X	X	X								silt; well sorted, moist to wet, pale
60"	0.1	13	X	X	X	X								brown (10YR 6/3).
	0.0	14	X	X	X	X								
	0.0	15	X	X	X	X								NOTE: Wet at 12.0'
	0.2	16	X	X	X	X								
	0.0	17	X											(15.5-20.0) CLAY, high plasticity, no dilatancy;
58"	0.0	18	X											little silt; moist, soft to medium stiff,
	0.0	19	X											light gray (10YR 7/1) to dark gray (10YR 4/1).
	0.0	20	X											NOTE: Lacustrine, minor 0.1-0.25" lamination.
														End of boring - 20.0'

ATTACHMENT C

Arcadis Soil Description Field Guide

ON THE ORIGINAL DRAWING.
USE TO VERIFY FIGURE
REPRODUCTION SCALE

SOIL DESCRIPTION FIELD GUIDE (JUNE 30, 2017; REV. 2.0)

FINE-GRAINED SOILS

Description	Criteria
	Descriptor - Plasticity
Nonplastic	A 1/8-inch (3mm) thread cannot be rolled at any moisture content.
Low	Thread can barely be rolled, and lump cannot be formed when drier than plastic limit.
Medium	Takes considerable time and rolling to reach plastic limit. Thread cannot be rolled after reaching plastic limit. Lump crumbles when drier than plastic limit.
High	Thread is easy to roll and quickly reaches plastic limit. Thread can be rerolled several times after reaching plastic limit. Lump can be formed without crumbling when drier than plastic limit.
	Descriptor - Dilatancy
No Dilatancy	No visible change when shaken or squeezed.
Slow	Water appears slowly on the surface of soil during shaking and does not disappear or disappears slowly when squeezed.
Rapid	Water appears quickly on surface of soil during shaking and disappears quickly when squeezed.
Minor Components with Descriptors	
	Moisture
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
	Consistency
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated 1 inch by thumb.
Medium stiff	N-value 5-8 or indented about 1/2 inch by thumb with great effort.
Stiff	N-value 9-15 or indented about 1/4 inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty.
Color using Munsell	
Geologic Origin (if known)	
Other	

EXAMPLE OF SOIL DESCRIPTION AND PHOTO

10-15 feet CLAY, medium to high plasticity; trace silt; trace small to very large pebbles, subround to subangular up to 2" diameter; moist, stiff, dark grayish brown (10YR 4/2). NOTE: Lacustrine; laminated 0.1 to 0.2" thick, laminations brownish yellow (10YR 4/3).

DESCRIPTION ORDER

Depth Interval
Principal Components with Descriptors
Minor Components with Descriptors
Sorting
Field Moisture Condition
Density/Consistency
Color using Munsell
Geologic Origin (if known)
Other descriptions as NOTES:
- Odor
- Stratigraphy
- Structure
- Sphericity
- Cementation
- Reaction to acid

MINOR COMPONENTS % MODIFIERS

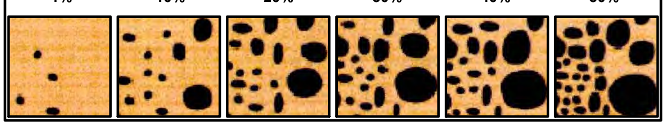
Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

UDDEN-WENTWORTH SCALE

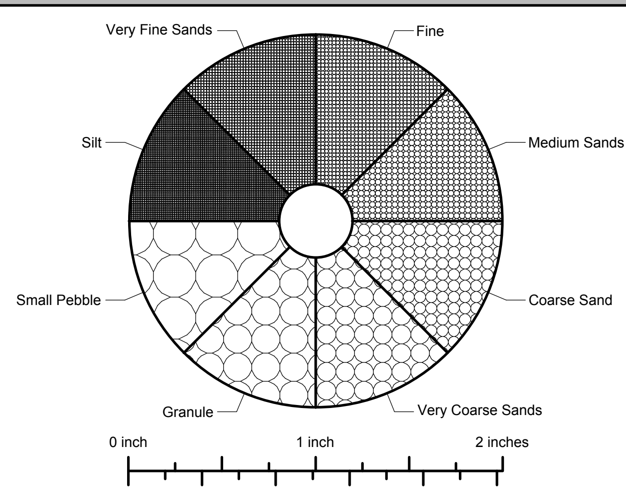
Fraction	Sieve Size	Grain Size	Approximate Scale
Boulder		256 - 4096 mm	Larger than volleyball
Large Cobble		128 - 256 mm	Softball to volleyball
Small Cobble		64 - 128 mm	Pool ball to softball
Very Large Pebble		32 - 64 mm	Pinball to pool ball
Large Pebble		16 - 32 mm	Dime size to pinball
Medium Pebble		8 - 16 mm	Pencil eraser to dime size
Small Pebble	No. 5+	4 - 8 mm	Pea size to pencil eraser
Granule	No. 10 - 5	2 - 4 mm	Rock salt to pea size
Very Coarse Sand	No. 18 - 10	1 - 2 mm	See field gauge card
Coarse Sand	No. 35 -18	0.5 - 1 mm	See field gauge card
Medium Sand	No. 60 - 35	0.25 - 0.5 mm	See field gauge card
Fine Sand	No. 120 - 60	0.125 - 0.25 mm	See field gauge card
Very Fine Sand	No. 230 - 120	0.0625 - 0.125 mm	See field gauge card
Silt and Clay. See SOP for description of fines	Not Applicable	<0.0625 mm	Analyze by pipette or hydrometer

PARTICLE PERCENT COMPOSITION ESTIMATION

1%	10%	20%	30%	40%	50%



GRAPH FOR DETERMINING SIZE OF PARTICLES



FOR COARSE-GRAINED SOILS

Description	Criteria
	Descriptor - Angularity
Angular	Particles have sharp edges and relatively planar sides withunpolished surfaces.
Subangular	Particles are similar to angular but have rounded edges.
Subround	Particles have nearly planar sides but have well-roundedcorners and edges.
Round	Particles have smoothly curved sides and no edges.
Minor Components with Descriptors	
	Sorting Cu= d60/d10
Well Sorted	Near uniform grain-size distribution Cu= 1 to 3.
Poorly Sorted	Wide range of grain size Cu= 4 to 6.
	Moisture
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
	Density
Very loose	N-value 1 - 4
Loose	N-value 5 - 10
Medium Dense	N-value 11 - 30
Dense	N-value 31 - 50
Very dense	N-value >50
Color using Munsell	
Geologic Origin (if known)	
Other	
	Cementation
Weak Cementation	Crumbles or breaks with handling or little finger pressure.
Moderate Cementation	Crumbles or breaks with considerable finger pressure.
Strong Cementation	Will not crumble with finger pressure.
	Reaction with Dilute HCl Solution (10%)
No Reaction	No visible reaction.
Weak Reaction	Some reaction, with bubbles forming slowly.
Strong Reaction	Violent reaction, with bubbles forming immediately.

EXAMPLE OF SOIL DESCRIPTION AND PHOTO

10 -15 feet SAND, medium to very coarse; little granules to medium pebbles, subround to subangular; trace silt; poorly sorted, wet, grayish brown (10YR5/2).

ON THE ORIGINAL DRAWING. USE TO VERIFY FIGURE REPRODUCTION SCALE

SOIL DESCRIPTION FIELD GUIDE (JUNE 30, 2017; REV. 2.0)

ARCADIS Design & Consultancy for natural and built assets

10 inches, 9 inches, 8 inches, 7 inches, 6 inches, 5 inches, 4 inches, 3 inches, 2 inches, 1 inch, 1/10in

0 mm, 10 mm, 20 mm, 30 mm, 40 mm, 50 mm, 60 mm, 70 mm, 80 mm, 90 mm, 100 mm, 110 mm, 120 mm, 130 mm, 140 mm, 150 mm, 160 mm, 170 mm, 180 mm, 190 mm, 200 mm, 210 mm, 220 mm, 230 mm, 240 mm, 250 mm

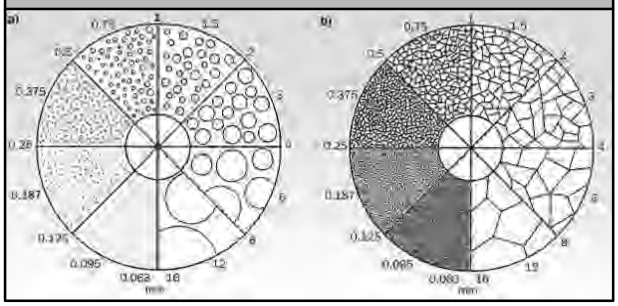
VARIATIONS IN SOIL STRATIGRAPHY

Term	Thickness of Configuration
Parting	0 - to 1/16-inch thickness.
Seam	1/16 - to 1/2-inch thickness.
Layer	1/2 - to 12-inch thickness.
Stratum	> 12-inch thickness.
Pocket	Small erratic deposit, usually less than 1 foot in size.
Varved Clay	Alternating seams or layers of sand, silt, and clay (laminated).
Occasional	≤ 1 foot thick.
Frequent	> 1 foot thick.

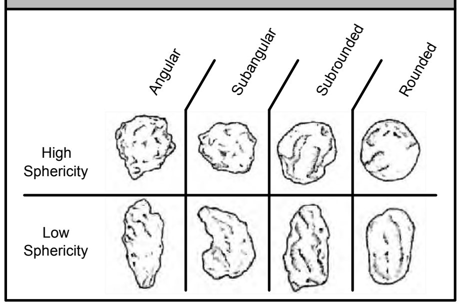
SOIL STRUCTURE DESCRIPTIONS

Term	Description
Homogeneous	Same color and appearance throughout.
Laminated	Alternating layers < 1/4 inch thick.
Stratified	Alternating layers ≥ 1/4 inch thick.
Lensed	Inclusions of small pockets of different materials, such as lenses of sand scattered through a mass of clay; note thickness.
Blocky	Cohesive soil can be broken down into small angular lumps, which resist further breakdown.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear to be polished or glossy, sometimes striated.

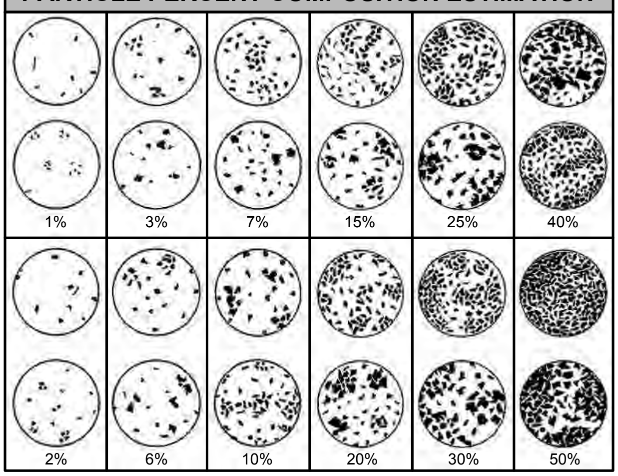
GRAPH FOR DETERMINING SIZE OF PARTICLES



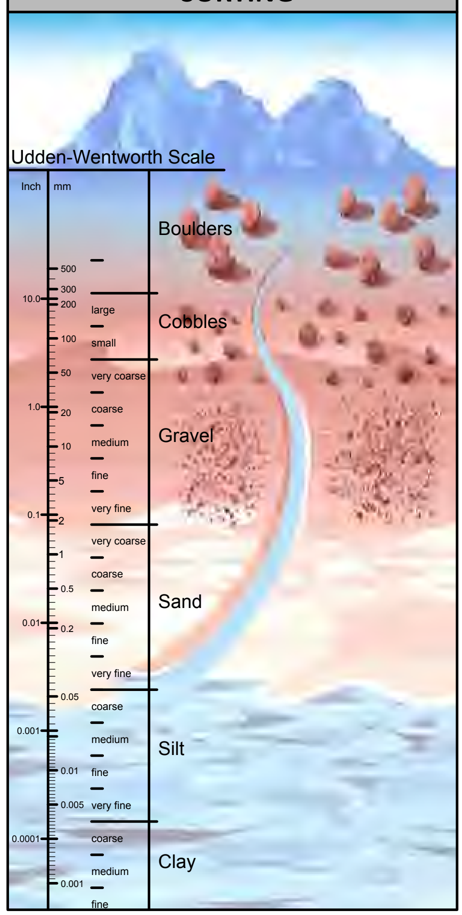
ANGULARITY CHART



PARTICLE PERCENT COMPOSITION ESTIMATION



SORTING



SETTLING TABLE (SILT/CLAY)

Diameter of Particle (mm)	<0.625	<0.031	<0.016	<0.008	<0.004	<0.002	<0.0005
Depth of Withdrawal (cm)	10	10	10	10	5	5	3
Time of Withdrawal	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec
Temperature (Celsius)							
20	00:00:29	00:01:55	00:07:40	00:30:40	00:61:19	04:05:00	37:21:00
21	00:00:28	00:01:52	00:07:29	00:29:58	00:59:50	04:00:00	
22	00:00:27	00:01:50	00:07:18	00:29:13	00:58:22	03:54:00	
23	00:00:27	00:01:47	00:07:08	00:28:34	00:57:05	03:48:00	
24	00:00:26	00:01:45	00:06:58	00:27:52	00:55:41	03:43:00	33:56:00
25	00:00:25	00:01:42	00:06:48	00:27:14	00:54:25	03:38:00	
26	00:00:25	00:01:40	00:06:39	00:26:38	00:53:12	03:33:00	
27	00:00:24	00:01:38	00:06:31	00:26:02	00:52:02	03:28:00	
28	00:00:24	00:01:35	00:06:22	00:25:28	00:50:52	03:24:00	31:00:00
29	00:00:23	00:01:33	00:06:13	00:24:53	00:49:42	03:10:00	
30	00:00:23	00:01:31	00:06:06	00:24:22	00:48:42	03:05:00	

ARCADIS Design & Consultancy for natural and built assets

TECHNICAL GUIDANCE INSTRUCTION

Utility Locating using Radio Frequency Methods

OCTOBER 2018

CONTACTS

GREGORY BYER, P.E., L.P.G.
Technical Expert in Geophysics

dd 317 236 2853
m 317 989 8328
e gregory.byer@arcadis.com

Arcadis U.S., Inc.
132 E. Washington
Suite 600
Indianapolis, IN 46204
United States

BRENT W. BARKER
Project Geophysical Specialist

dd 720 399 8681
m 720 591 3380
brent.barker@arcadis.com

Arcadis U.S., Inc.
11001 W. 120th Avenue
Suite 200
Broomfield, CO 80021
United States

Approval Signatures

Prepared by:  Date: 10/12/18

Reviewed by:  Date: 10/12/18

VERSION CONTROL

Issue	Revision No.	Date Issued	Description of Revision: Page No.	Description of Revision: Comment	Reviewed by:
Initial Draft	001	March 2017	N/A	N/A	Grant Sprick
Review	002	March 22. 2017	N/A	See tracked changes	Brent Barker
Final Draft/Signatures	003	October 12, 2018	All	Modification to TGI format	Greg Byer, Brent Barker

CONTENTS

I. SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) document outlines the applications, limitations, and methodology associated with the use of Radio Frequency Locators (RFLoc) using Direct Connect or Inductive Signal Transmission Methods to locate underground utilities. RFLoc methods utilize a radio frequency (RF) **transmitter** that applies a known frequency to an underground utility and a **receiver** that is able to detect this frequency along the length of the structure.

RFLoc methods can be useful in locating buried utility lines. The RF signal transmission is most commonly applied either by direct connection or by induction. In the direct-connection method, the signal is applied to an exposed segment of the utility of concern, such as an exposed conduit or segment of pipe, using clamp connectors or a coupling ring. Electrically conductive lines will “carry” or transmit the RF signal which can then be traced using the receiving unit. Examples of conductive lines commonly traced include telephone, electric, and water main utility lines. RFLoc is not effective in locating non-conductive lines, including materials composed of PVC, fiberglass, concrete or clay. In some cases, such as with natural gas supply lines to buildings and homes, the service line is coupled with a tracer wire to which the RF signal may be applied.

RFLoc methods are non-invasive and non-destructive. These tools transmit and receive radio frequency electromagnetic signals. Subsurface objects or material contacts can be located based on differences in their dielectric potential and/or electrical resistivity. Important constraints to consider are depth of penetration, resolution and signal transmission. Higher frequency signals will yield better resolution, but less depth of penetration as compared to a lower frequency signal. Signal transmission can be dampened out or limited by carry-over onto other utilities or lack of a good “connection” due to physical constraints.

II. PERSONNEL QUALIFICATIONS

Utility locating investigations should be conducted by qualified and experienced operators, such as an experienced field technician and/or geophysicist. The RFLoc operator should be experienced in the use of the instrument and its limitations. The operator should be able to adjust data acquisition procedures in response to variable site conditions in order to identify anomalies and resolve target features. Inexperienced personnel directing or supervising RFLoc investigations have the responsibility to seek appropriate guidance, training and technical peer review from qualified and experienced personnel prior to use.

In accordance with Utility Location TGI field personnel conducting subsurface work and/or investigation (SWI) activities where above ground or underground utilities are in the vicinity of the work have the responsibility to read, understand, and follow the ***Utility Location Policy and Procedure***. This procedure requires that any personnel assisting in the identification of underground utilities need to have previous related experience of a minimum of 1 year. Those implementing remote sensing technologies must complete training in those techniques and have 6 months experience operating and interpreting results. If utilities cannot be located to eliminate any reasonable concern, field personnel can use their Stop Work authority until utility locations can be identified. Field personnel must review this procedure onsite with subcontractors, and ensure they follow the procedures detailed in this document. Any Synergy/Arcadis subcontractor not following the Utility Location Policy and Procedures will be asked to stop work, and the project manager contacted.

III. EQUIPMENT LIST

The following equipment will be available, as required, during RFLoc utility locating surveys.

- Personal protective equipment (PPE), as required in the site Health and Safety Plan (HASP);
- Appropriate forms, Site plans, field notebook, spray paint and camera;
- RF Cable, Pipe, Utility Locator transmitter and receiver;
- Non-conductive measuring tape; and
- Spare batteries (typically 2 9-volt, and 6 to 8 C or D-sized alkaline).

IV. CAUTIONS

The effectiveness of locating buried utilities is site-specific and subject to the skill level of the operator. Reliability and efficiency is enhanced when used in conjunction with other lines of evidence, including detailed reconnaissance of the area, review of available site plans, and overall understanding of the Site area and types of buried facilities that may be expected at the Site.

Signal interferences can also occur. Facilities that are located in proximity to another facility, overlapping or in layers may appear as one unit. In some cases, segments of lines being traced may have been previously damaged/severed or partially removed and capped, which may cause a loss of signal transmission. Transmission signals can also “jump” from one utility line to another particularly with higher frequencies are used. Signals will generally follow the path of least resistance and in some will deviate from the line of interest or cause a shadow zone where one or more utilities are located in close proximity.

Also, as noted above, non-metallic and small diameter utilities are not conducive to locating using RFLoc methods. However, alternative methods can be considered such as tracing a transmitting lead, sonde or “mouse” which can in some cases be snaked into a non-conductive pipe and followed or traced at the surface using the receiving unit.

V. HEALTH AND SAFETY CONSIDERATIONS

Minimize physical hazard exposure through use of proper PPE as prescribed in the HASP. Maintain awareness of other potential hazards associated with the physical location where the RFLoc investigation is being conducted and any ingress or egress conditions. Special care should always be used whenever a direct connection is being made to a buried cable or when applying an induction loop to an exposed wire or cable. Never physically touch or connect to the equipment to exposed wires or cables that may carry electricity. Never connect directly to live or energized power cables.

VI. PROCEDURE

1. Become familiar with the details of the applicability and limitations of RF line locating equipment that has been selected for the project. Most commercially available RFLoc equipment have similar operating functions although operating menus and selections will vary from one make to another. Users must read all operating instructions and become familiar with any instrument prior to using the instrument to locate utilities.
2. Evaluate site-specific utility information to determine suitability of the equipment (e.g., depth, diameter and conductivity of the utilities).
3. Evaluate the Site conditions and select one or more of the potential signal transmission methods for optimal use, including direct connections, transmitter clamp, and/or inductive transmission.
4. **Direct Connection Method** is the most reliable method of signal application. This method is relatively free of interference. The greatest amount of signal strength can be achieved by this method. Low, mid, and high frequency signals may be used. The far end of the utility must be grounded. For most instruments, connect the RED test cord or clamp to an existing ground point or an exposed metallic section of the utility and place the GROUND ROD approximately 10 feet or as far as possible from this point, at an angle of 90º to the buried cable or pipe. Push the GROUND ROD into the ground 8 to 10 inches. Connect the BLACK test cord or clamp to the GROUND ROD. Plug the RED/BLACK test cords into the instrument. Press the FREQUENCY Button to select the desired frequency (e.g. 815 Hz, 8 kHz or 82 kHz, etc.). The Power Output Indicator and the Frequency light of the chosen frequency will light up.
5. **Transmitter Clamp Connection Method:** The transmitter clamp is very easy to use, fits around a pipe or cable and safely applies a signal to a live cable without interrupting or disconnecting the supply. The clamp applies a very discriminating signal to a target line with reduced coupling to other lines. A clamp can sometimes be a more effective method of applying the signal than direct connection. The red/black test cords and ground rod are not needed for this method. Successful coupler operation requires an insulated conductor that is grounded on both near and far ends.

   Put the clamp around the cable and ensure the clamp jaws are closed. It is important to connect the coupler around the cable needing to be traced. Connect the coupler around the wire closer to the outgoing cable not near the system ground. The result will be a stronger signal. By connecting near the grounding, the range will also be shorter, and difficulty may arise when trying to determine one cable from another. Plug the coupler test cord into the instrument and use the manufacture's specified frequency on the receiver and the transmitter. Attempt to trace the utility using the receiving unit.
6. **Inductive Signal Transmission Method:** This method is convenient to use and services are not interrupted. No test cords or connections are needed. The cable or pipe must have good insulation or non-conductive coating, or the operating range will be short. Turn the TRANSMITTER ON. Press the 82 kHz button. Place TRANSMITTER as close as possible to the path of the cable or pipe. Align the TRANSMITTER in line with the cable or pipe. First, locate the broad TRANSMITTER null (zero), and then move toward the expected cable path while looking for the signal carried by the cable. Start tracing the path with the RECEIVER 25 feet from the TRANSMITTER. Locate the cable or pipe, and follow the path. If the signal becomes weak, move the TRANSMITTER to a point 25 feet behind the last strong signal, and continue searching.
7. **Selecting the Tracing Signal Frequency:** The choice of signal frequency (e.g., 815 Hz, 8 kHz or 82 kHz) is dependent on the Site conditions, with each having their advantages. It is recommended to

begin by using the lowest available instrument signal frequency (e.g., 815 Hz) and continue as long as you are confident in the results. If the signal is very weak try to adjust the connection or grounding. If there is no improvement in signal then try increasing the frequency (e.g.,8 kHz). Repeat adjustments of ground and connection point again until switching to the highest frequency (e.g., 82 kHz). A lower frequency signal is usually preferred to the mid-range and high frequency signal, because it is much less susceptible to locating errors caused by nearby cables or pipes.

The lower frequency locating range will also allow for longer line traces than the higher frequency signal and will not travel well through disconnected shield bonds or insulated pipe bushings. The mid-range frequency averages the best of both high and low frequency and is not as susceptible to bleed off or coupling, but it can “jump” from one utility to another. It is still best to use the lower frequency when possible, but the mid-range is commonly used to locate coaxial cable and telecom pairs. The higher frequency is sometimes better for locating sharp corners in cables or pipes. The locating range is quite short for the high frequency signal so the transmitter must be repositioned more often during the tracing operation.

8. **Null and Peak Modes:** Most RFLoc instruments allow the Operator to select between NULL and PEAK modes. PEAK mode provides the most sensitive and accurate mode for location and depth measurement. It provides a sharp peak response with a corresponding small decrease in sensitivity. NULL mode gives a null response when it is directly over the line. The sharp, null response is easier to use than the peak response but is vulnerable to interference and should not be used for locating, except in areas where there is no interference present.
9. **SONDE Transmitter Methods:** A sonde transmitter is a small battery powered signal transmitter that can be inserted into non-metallic ducts, drains or sewers so they can be located and traced with a receiver. A wide range of transmitting sondes is available to suit different applications. Sondes can also be used to pinpoint joints in iron gas pipes, locate blockages in plastic water pipes and monitor the progress of horizontal boring tools. Sondes may be floated along drains at the end of a tether and floats are available for fitting to the sewer sonde and super sonde. Sondes can be strapped to high-pressure water jets or similar devices used for cleaning, maintaining and inspecting drains. Tracing the sonde along the pipe can then be accomplished using the transmitter and following the sonde. Care must be used to ensure the sonde does not become snagged which may prevent its recovery from the pipe.
10. Consider complimentary technologies to supplement RFLoc methods and provide multiple lines of evidence. Technologies may include Ground Penetrating Radar (GPR) magnetic and/or electromagnetic surveys, and air-knifing or vacuum explorations.
11. Employ only qualified and experienced RFLoc operators. For utility locating and mapping applications, the RFLoc operator should be specifically experienced in evaluating data quality and identifying anomalies in the field requiring variations in data acquisition procedures to positively interpret and locate targets of concern.
12. Complete appropriate mark-outs at the Site, such as spray painting traced lines. Consideration of use of paint colors should also be given. Standard colors for utility mark outs include: **RED-Electric: YELLOW-Gas; ORANGE-Communication: BLUE-Water; GREEN-Sewer and Drain; PURPLE-Reclaimed Water; PINK-Temporary Survey Marking; WHITE- Proposed Excavation.**

VII. WASTE MANAGEMENT

RFLoc is a non-invasive procedure and should not result in the generation of derived wastes. Any trash or rubbish generated during the course of field activities should be disposed of in a proper trash receptacle.

VIII. DATA RECORDING AND MANAGEMENT

Field notes should be taken to include a description of areas surveyed, areas that were not surveyed, interferences, equipment and methods used, location and type of utilities located (if known), photographs, and site sketch. Taped distance measurements should be taken to marked lines relative to existing permanent features for future reference. Project team personnel will be responsible for maintaining all mark outs for the duration of the project or have the lines remarked if lost due to weather or site activities.

IX. QUALITY ASSURANCE

The following quality control procedures should be observed:

- Seek appropriate input prior to conducting an RFLoc survey to identify site-specific features that may impact data acquisition.
- Operate all equipment in accordance with manufacturer's instructions and recommended procedures. Record all system component information in the field book.
- Data quality should be checked in the field to identify anomalies that may require adjustment to the data acquisition procedures. Make appropriate adjustments to data acquisition methods to achieve survey objectives, as feasible.
- It is recommended that the operation and performance of the RFLoc equipment be field checked by locating existing underground utilities or structures of known depth, size, and construction. These characteristics should be similar to that of unidentified target objects.
- Data interpretation should undergo peer review by appropriate qualified and experienced personnel.

X. REFERENCES

Radiodetection 7000, General Utility and Pipe Locator Operation Manual, July 2008; RYCOM Instruments 8869 Cable, Pipe and Fault Locator User's Manual.

Schonstedt Instrument Company February 2003. A Quick Course on Magnetic, Cable and Pipe Locating.