United States Coast Guard

Final Soil Confirmation Work Plan and Sampling and Analysis Plan

Burrows Island Light Station

Skagit County, Washington

Contract No 70Z05019DARCADI01
Task Order No. 70Z08821FPXA00300

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Final Soil Confirmation Work Plan and Sampling and Analysis Plan

Burrows Island Light Station, Skagit County, Washington

August, 2023

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Acronyms and Abbreviations

Arcadis	Arcadis U.S., Inc.
AST	aboveground storage tank
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
cy	cubic yards
DQI	data quality indicator
DQO	data quality objective
DRO	diesel-range organics
Ecology	Washington State Department of Ecology
GPS	global positioning system
GRO	gasoline range organics
HASP	Health and Safety Plan
HO	heavy oil
IDW	investigation-derived waste
mg/kg	milligrams per kilogram
MS	matrix spike
MSD	matrix spike duplicate
MTCA	Model Toxics Control Act
NTCRA	Non-Time Critical Removal Action
OIC	Officer in Charge
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCB	polychlorinated biphenyl
PPE	personal protective equipment
QA	quality assurance
QC	quality control
RAOs	Remedial Action Objectives
RD	remedial design
Site	Burrows Island Light Station, located in Skagit County, Washington

SOP	Standard Operating Procedure
TGI	Technical Guidance Instruction
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
UST	underground storage tank
Work Plan	Soil Confirmation Work Plan
XRF	x-ray fluorescence

1 Introduction

On behalf of the United States Coast Guard (USCG), Arcadis U.S., Inc. (Arcadis) prepared this Soil Confirmation Work Plan and Sampling and Analysis Plan (Work Plan) in partial fulfillment of the requirements of Contract 70Z0501DARCADI01, Task Order 70Z08821FPXA00300. The Work Plan was prepared in support of a non-time critical removal action (NTCRA) at the Burrows Island Light Station, located in Skagit County, Washington (Site). The NTCRA consists of the removal and off-island disposal of lead, petroleum, and polychlorinated biphenyl (PCB) impacted soil, encapsulation of surfaces with deteriorated paint, removal of asbestos-containing roofing materials, and repair of the access stairs from the boat landing to the light station, to allow safe access by authorized personnel. Details of the NTCRA are provided in the Remedial Design (Arcadis 2020b) and Final Action Memo (USCG 2021).

The purpose of the NTCRA is to protect human health and the environment by eliminating an unacceptable risk from lead, PCBs, and petroleum in surface and near-surface soil from previous operations at the Site, as documented in the Remedial Investigation and Focused Feasibility Study Report (Arcadis 2020a). Implementation of this NTCRA is intended to achieve Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) § 120(h) certification and a no further action determination by the USCG, with concurrence from the Washington State Department of Ecology (Ecology). In addition, encapsulation of lead-based paint will mitigate a potential future risk of soil recontamination, replacement of the asbestos roof on the duplex with an approved-non asbestos material will eliminate the risk of a potential future release of friable asbestos to the environment, and repair of the damaged stairs is necessary to allow safe access to the Site by remedial contractor workers and other authorized persons.

This Work Plan describes the data quality objectives (DQOs), analytical procedures, field sampling procedures, and quality assurance (QA) and quality control (QC) procedures for remedial construction monitoring and confirmation soil sampling.

2 Background

2.1 Site Description

The site is located on the western tip of Burrows Island, approximately ¼ mile southeast of Anacortes, Washington on Rosario Strait within the western portion of Section 32, Township 35 North, Range 1 East, Willamette Meridian (Figure 1). The latitude and longitude for the site are 48º 28’ 40” North and -122º 42’ 48” West (North American Datum of 1983). Primary access to the site is by boat via the fixed concrete dock located on the north side of the site. A helicopter pad is also located onsite.

The site is located on USCG-owned property identified as Parcel Number P32494 in Skagit County records (Skagit County 2018). The USCG property is approximately 8.2 acres; 2 acres is cleared land and the remainder is heavily forested. The Skagit County designated land use for Parcel P32494 is (740) Recreational Activities. Parcels adjacent to the USCG property are owned by Washington State Parks and Recreation and have similar land use designations as the USCG property. The adjacent parcels are undeveloped and heavily forested. Several parcels of land on Burrows Island are owned by private

individuals: Parcels P32502, P32500, P32503, P32452, P99308, and P99309. The privately-owned parcels are located on the opposite (eastern) side of Burrows Island from the USCG property.

The site is located on a rocky outcropping with no shoreline access. The cleared area is encompassed by the tree line on the south and east, and the cliff edge on the north and west. Soil is present at greater thickness moving east from the bluff with intermittent bedrock outcroppings. Soil tends to be well-graded with some organic content from surface vegetation. Topography of the site generally slopes to the Rosario Strait.

2.2 Site History

The site is an active USCG light station and was first developed for that purpose in 1906. The light signal was automated in 1972 and no dedicated USCG personnel have occupied the site since that time. Infrastructure was developed to support operation of the light station, including residential and operational buildings, fuel storage tanks and underground pipelines, and electrical generation and transmission equipment. The following structures were associated with site operations:

- Boathouse – operational building located on the north side of the site near the dock.
- Duplex – former residential building located on the south side of the site. Sidewalks are present around the perimeter and a fence runs around a portion of the yard on the east side of the building.
- Light and Fog Signal Building – operational building located on the southwestern portion. Houses the automated light signal.
- Former Officer in Charge (OIC) Quarters – residential building located north of the Duplex and south of the Boathouse. Structure has been demolished, but portions of the foundation are present in the footprint of the former building.
- Former Oil and Paint Storage Building – operational and storage structure located north of the Light and Fog Signal Building. Structure has been demolished and the concrete footing remains in place.
- Former Firehouse Pump Building – operational structure located east of the Duplex. Structure has been demolished and the concrete footing remains in place.

Fuel oil was historically used at the site for heat and to generate electricity. Based on historical documentation, multiple tanks were present while the site was operational, including the following:

- 10,000-gallon fuel oil aboveground storage tank (AST) located southeast of the Duplex.
- Two 675-gallon fuel oil ASTs located east of the Duplex and connected to the furnaces and gas ranges in the building via underground piping.
- One 675-gallon fuel oil AST located on the southeast corner of the Light and Fog Signal Building.
- One 200-gallon fuel oil underground storage tank (UST) located on the east side of the former OIC Quarters.
- One gasoline storage tank located west of the former Oil and Paint Storage Building.
- Two fuel oil ASTs (690 and 540 gallons) located southeast of the Light and Fog Signal Building.

The fuel oil tanks were connected via underground piping to a ship to shore connection located east of the Boathouse. Additional underground piping connected the tanks to the buildings and the main fuel oil line. All tanks have been removed (AGI Technologies 1999). Remaining infrastructure includes concrete support structures and underground piping.

A power transformer that supported onsite electrical generation was previously located southeast of the lighthouse and fog signal building (USCG 1980a, USCG 1980b). Oil in the transformer is known to have contained PCBs. A spill of approximately 5 to 50 gallons of transformer oil occurred on February 22, 1980 (USCG 1980b). Approximately 86 cubic yards (cy) of soil were removed from around the transformer and transformer pad (USCG 1980b). The transformer and electrical equipment are no longer present at the site.

The locations of current and historical structures are shown on Figure 2.

2.3 Removal Action

Contaminants of concern (COCs) present in soil are lead, PCBs, diesel range organics (DRO), and heavy oil (HO). The selected remedy includes removal of soil with concentrations of COCs above Model Toxics Cleanup Act (MTCA) Method A clean-up levels for unrestricted land use (Arcadis 2020b). The objectives of the activities covered in the Work Plan are to verify that the remedial action achieves the following Remedial Action Objectives (RAOs):

- Prevent exposure of humans and ecological receptors to COCs in soil at concentrations greater than the MTCA Method A clean-up levels.
- Comply with applicable or relevant and appropriate requirements at the site as summarized in the Remedial Investigation and Focused Feasibility Study (Arcadis 2020a) and Final Action Memo (USCG 2022).

Confirmation samples will be collected to verify that performance criteria related to the remedial action have been met. Applicable MTCA Method A clean-up levels are summarized in Table 1. The estimated removal areas and quantities are presented in Table 2.

3 Project Data Quality Objectives

USEPA's seven-step DQO process (USEPA 2006) was used to guide the design rationale for the study. The overarching project objectives and each step in the DQO process are described below.

3.1 Project Objectives and Problem Definition

The overarching objective is to protect human health and the environment and to obtain CERCLA § 120(h) certification to achieve a no further action determination from the USCG, with concurrence from Ecology. This will eventually allow divestiture of the light station by the USCG in accordance with the National Lighthouse Preservation Act of 2020. To achieve this objective, the USCG will implement a soil removal action as described Action Memo (USCG 2021). Confirmation soil sampling is required to document that the remedy has met the RAOs.

3.2 Data Quality Objectives

The USEPA's seven-step DQO process (USEPA 2006) was used to guide the design rationale for the study. Each step is described below.

3.2.1 Step 1: State the Problem

A remedial action is being completed at the site to address soil that contains COCs above MTCA Method A clean-up levels.

3.2.1.1 Team Members and Roles

Team members and their roles are as follows:

- USCG – lead agency and owner for the project.
- Arcadis – consultant, responsible for implementation of confirmation soil sampling, including collecting confirmation soil and waste characterization samples and coordinating analysis.
- Removal Contractor – responsible for implementation of soil removal action.

3.2.2 Step 2: Identify Goals of the Study

The primary goal of this study is to generate data of acceptable quality to verify that the RAOs have been achieved through confirmation soil sampling.

3.2.3 Step 3: Identify Information Inputs

The third step of the DQO process requires consideration of the following:

- Types and potential sources of information (e.g., site characteristics or variables) that should be measured to provide estimates or resolve decisions
- Information to provide a basis for specifying performance or acceptance criteria
- Information on the performance of appropriate sampling and analysis methods.

Information needed to answer the above questions include:

- Remedial Design (Arcadis 2020b)
- Historical maps and reports
- Field documentation and XRF screening data.
- Laboratory analytical data.

3.2.4 Step 4: Define Boundaries of the Site

The Site is located entirely within USCG-owned property on Burrows Island and includes all areas where hazardous substances (e.g., lead, petroleum, PCBs) were released from operation of the Burrows Island Light Station and have been located.

3.2.5 Step 5: Define the Analytical Approach

The sampling scheme will utilize 5-point composite samples collected from the excavation bottom and sidewalls to verify that soil remaining after the removal action is below MTCA Method A clean-up levels. Samples will also be collected from soil utilized as backfill from onsite and offsite sources. Samples will be collected using the methods described in Section 4 and submitted to a Washington state certified analytical laboratory. Confirmation samples will be analyzed for constituents that were detected above MTCA Method A clean-up levels in each removal area based on the RI (Arcadis 2020a). Backfill samples will be analyzed as described in Section 4.5. Additional details on sampling and analytical methods are provided in Section 4. A summary of the confirmation sampling plan is provided in Table 3.

3.2.6 Step 6: Specify the Performance Criteria

The goal of Step 6 is to define performance or acceptance criteria to minimize the possibility of making erroneous conclusions or failing to keep uncertainty in estimates to within acceptable levels (USEPA 2006). For this study, performance and acceptance criteria will apply to generating appropriate and acceptable data for establishing if COCs in soil exceed applicable MTCA Method A clean-up levels. Reporting limits for analytical testing will be less than the applicable MTCA Method A clean-up levels.

3.2.6.1 Data Quality

Sampling and analysis of soil will be conducted using standard USEPA or state-approved methods. QC measures will include:

- *Field duplicates*. Field duplicates measure sampling precision and will be collected at a minimum of 10 percent of the discrete sample locations.
- *Matrix spike (MS), and matrix spike duplicates (MSDs)*. MS and MSD samples are analyzed to measure interference from the sample matrix on the recovery of the target analytes. MS and MSDs will be performed in the laboratory at a frequency of one sample per batch or one sample per 20 samples, whichever is more frequent.
- *Field rinsate blanks*. Equipment rinsate samples will be collected daily from decontaminated reusable equipment (e.g., hand trowel, hand auger) to identify possible contamination from the sampling environment or equipment. These blanks will be collected by pouring laboratory-provided distilled water over (or through) decontaminated sampling equipment and into a jar.

3.2.7 Step 7: Develop the Plan for Obtaining Data

The last step in the DQO process is to develop a design for collecting the proposed samples in a manner that will meet the specified performance criteria. The rationale for selecting the sample locations and sampling procedures is discussed in Section 4 and field sampling procedures are described in Section 6.

3.3 Data Quality Indicators

The QA objective is to generate analytical data of known and appropriate quality that are acceptable and useful for decision making (e.g., determining if soil remaining after excavation is below MTCA Method A clean-up levels). Data quality indicators (DQIs), comprising statistics and data descriptors, are used to help achieve this objective. The principal DQIs are precision, accuracy, representativeness, comparability, and completeness (PARCC) and bias and sensitivity, as described in Table 3.

3.4 Data Review and Validation

Arcadis staff not involved with the data collection will review field documents and perform a level II data review of all the analytical data reports. The data review will be in accordance with the Superfund Contract Laboratory Program National Functional Guidelines for Data Review (USEPA 2017a and USEPA 2017b) and the QA/QC criteria specified in this Work Plan. Data will be reviewed and, if appropriate, flagged with data qualifiers. Based on laboratory data validation/review, a qualified Arcadis scientist will determine if the QA criteria have been met and will establish and document data usability.

3.5 Data Management

Arcadis will maintain a consistent project file system for project documents. The contract laboratory will electronically submit the laboratory report in PDF and electronic data deliverable formats.

3.6 Assessment Oversight

Confirmation sampling will be implemented by an experienced Arcadis Field Team Leader, who will be in daily contact with the Arcadis Project Manager and USCG. Daily field reports will be submitted by the Arcadis Field Team Leader to the Arcadis Project Manager for review. The Arcadis Project Manager will provide the daily field report to the USCG Project Manager in a timely manner (typically the next day) and will alert the USCG Project Manager to any identified issues during the removal action (if necessary). The Arcadis Field Team Leader may contact the USCG directly to resolve time-sensitive matters that may arise during the removal action.

4 Sampling Plan

The sampling approach is designed to confirm removal of COCs in soil. As discussed in Section 3.1, the confirmed COCs in soil are lead, petroleum hydrocarbons, and PCBs. This section discusses soil

sampling procedures for screening and collection of excavation confirmation samples, and evaluating suitable backfill sources. A conceptual layout of soil removal areas is shown on Figure 3.

4.1 X-Ray Fluorescence Field Screening for Lead

A portable x-ray fluorescence (XRF) unit will be used to screen soil in-situ during excavation and to inform selection of laboratory soil samples. Laboratory samples will be used to document compliance with the established cleanup levels for the site. In-situ XRF screening will be completed in accordance with the TGI for Screening Soil for Metals with Portable X-Ray Fluorescence Analyzer (Appendix A).

4.2 Confirmation Sampling

Confirmation soil samples will be collected from the excavation bottom and sidewall to evaluate post-excavation soil concentrations for laboratory analysis. Samples will be collected in accordance with the Washington State Department of Ecology Guidance for Remediation of Petroleum Contaminated Sites (Ecology 2016). Five-point composite samples will be collected from the exposed bottom of each excavation area at a frequency of 1 sample per 400 square feet. Five-point composite sidewall samples will be collected between the exposed bottom and top of sidewall at the outer limits of the excavation areas (not inclusive of interior sidewalls), at a frequency of 1 sample per 20 linear feet of sidewall. Internal sidewalls between removal areas are expected to be sloped and will be included in the excavation bottom samples. At least one sidewall and one excavation bottom sample will be collected from each excavation area. Soil samples will also be collected from areas that are used for transporting or staging contaminated materials following completion of handling activities. Composite samples will be collected to be representative of the excavation bottom or sidewall area and include equal volumes of soil from each discrete point. Samples will be collected using decontaminated equipment, placed into a plastic bag, and thoroughly homogenized by hand. A preliminary layout of confirmation soil sampling locations is shown on Figure 4. The locations of confirmation samples may be adjusted in the field based on excavation sequencing.

Samples will be collected using manual methods from surface intervals using a decontaminated hand auger or trowel in accordance with the TGI for Soil Drilling and Sampling Collection (Appendix A). Sample locations will be recorded using a handheld GPS. Soil will be placed into laboratory-provided containers, placed on ice, and shipped or transferred to Onsite Environmental for analysis. Reusable sampling equipment will be decontaminated between sampling locations in accordance with the TGI for Groundwater and Soil Sampling Equipment Decontamination (Appendix A).

Confirmation samples will be analyzed for the following constituents that were previously identified above MTCA Method A clean-up levels in each excavation area.

- Lead by USEPA Method 6010
- PCBs by USEPA Method 8082
- Diesel range organics (DRO) and heavy oil (HO) by NWTPH-Dx

Analytical results will be compared to MTCA Method A clean-up levels to determine if the RAOs have been achieved. If confirmation sample results from the excavation bottom exceed applicable MTCA

Method A clean-up levels, additional excavation will be completed in 6-inch increments and confirmation samples will be collected following removal. In the event a sidewall sample exceeds MTCA Method A clean-up levels, the excavation area will be expanded laterally based on field conditions and additional confirmation samples will be collected. If obstructions limit the vertical or lateral limits of an excavation area, the presence of any remaining soil with concentrations above MTCA Method A clean-up levels will be documented. MTCA Method A clean-up levels are presented in Table 1. A summary of the confirmation sampling plan is provided in Table 3.

4.3 Waste Characterization

Additional samples for waste profiling or confirmation of waste characteristics will be collected as needed based on the requirements of the disposal facility. Analytes and sampling frequency will be confirmed with the disposal facility, but may include the following:

- Total metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) by USEPA Method 6010 and 7471.
- Leachable metals by USEPA Method 6010/7471 and 1312.
- PCBs by USEPA Method 8082.
- Gasoline range organics (GRO) by NWTPH-Gx.
- Volatile Organic Compounds by USEPA Method 8260.

Samples will be collected from stockpiled materials as five-point composite using decontaminated sampling equipment in accordance with the TGI for Soil Drilling and Sample Collection (Appendix A). Equal volumes of soil will be collected from each of the five composite sample points, placed into a plastic bag, homogenized by hand, placed into laboratory provided containers, and stored on ice. Samples will be shipped or transferred to Onsite Environmental for analysis.

4.4 Bulk Density Sampling

Up to four soil samples will be collected from locations that represent typical soil conditions for bulk density. Samples will be collected from undisturbed soil prior to or during excavation using a manually driven core sampler and transferred to Onsite Environmental for analysis. Sample locations will be recorded using a handheld GPS and documented in the daily log.

4.5 Backfill Sampling

Onsite and offsite backfill sources will be sampled and analyzed for site COCs prior to approval for use as fill. Offsite backfill sources will also be analyzed for the following:

- Resource Conservation and Recovery Act (RCRA) 8 metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) by USEPA Methods 6010 and 7471;
- Polycyclic aromatic hydrocarbons by USEPA Method 8270;
- Volatile organic compounds by USEPA Method 8260; and

- Pesticides by USEPA Method 8081.

A minimum of two composite samples will be collected from each type of backfill material. The backfill materials will also be visually inspected for invasive plant species or other deleterious materials. Analytical results will be compared to MTCA Method A cleanup levels or Method B cleanup levels if there are no published Method A cleanup levels.

4.6 Sample Identification and Handling

This section discusses sample identification and handling procedures.

4.6.1 Sample Identification

Each confirmation sample will be assigned a unique identification (ID) number based on the location within each excavation area. Confirmation sample IDs will consist of the following codes to identify the type, location, depth, and replicate number.

- Sample type
  - Excavation Bottom = EB
  - Excavation Sidewall = SS
  - Investigation derived waste samples = IDW
  - Waste Characterization samples = WC
  - Bulk Density = BD
  - Borrow Source = BS
- Excavation Area, A through P (applicable for excavation confirmation samples)
- Waste drum, stockpile area, or other identifier (applicable for waste characterization and investigation derived waste samples)
- Unique, three-digit sequential number assigned to each sample.
- Date – MMDDYY

QA/QC samples will be identified as follows:

- Sample type
  - Rinsate blank – RS
  - Duplicate – DUP
- Unique, three-digit sequential number assigned to each sample type
- Date - MMDDYY

Examples of potential sample IDs:

- EB-C-002-102321 = Excavation bottom sample, Area C, unique number 002, collected on October 23, 2021.
- DUP-001-102321 = Duplicate sample, unique number 001, collected on October 23, 2021.

Sample locations and IDs will be recorded using a handheld GPS and recorded in an appropriate field form or the daily log.

4.6.2 Sample Handling

Samples will be placed in laboratory-supplied containers and will be handled according to the chain of custody protocol described in the TGI for Chain of Custody, Handling, Packing, and Shipping (Appendix C). The laboratory will provide new and certified precleaned sample containers appropriate to the list of analytes. Soil samples requiring temperature control preservation and will be placed on ice. Sample coolers that are shipped will be properly labeled and handled in accordance with U.S. Department of Transportation requirements.

4.7 Quality Control Samples

DQOs were developed using the USEPA's DQO process (USEPA 2006) to describe data and data quality needs. Data quality indicators such as PARCC parameters and analytical sensitivity will be used to assess conformance of data with QC criteria (USEPA 2002).

4.7.1 Field Duplicates

Field duplicates will be used to assess variability attributable to collection, handling, shipment, storage, and/or laboratory handling and analysis. Field duplicates will be collected from a minimum of 10 percent of the confirmation sample locations. Field duplicates samples will be co-located with the primary sample and will be processed by the laboratory using the same methods as the primary sample. The field duplicates will be submitted to the laboratory "blind" (i.e., not identified as a QC sample, but labeled with a different site identification than the regular sample.

4.7.2 Matrix Spike and Matrix Spike Duplicates

MS and MSDs will be used to assess the accuracy of the analytical method. MS and MSD samples will be selected by the laboratory and analyzed at a frequency of one sample per 20 samples or one per batch, whichever is more frequent, per laboratory SOPs. Adequate sample volume will be obtained for MS and MSD analysis.

4.7.3 Equipment Rinsate Blanks

Equipment rinsate blanks are used to identify potential contamination from the sampling environment, sampling equipment, or sample shipment. After equipment decontamination is complete, an equipment rinsate sample will be collected by running distilled water over the cleaned sampling equipment. The sample will be collected in clean laboratory-supplied containers. Equipment blanks will be collected at a frequency of once per day of field activities where reusable sampling equipment is used. Equipment blanks will not be collected for non-reusable sampling equipment.

4.7.4 Laboratory Quality Control Samples

Method blank and laboratory control samples will be analyzed at a frequency of one per 20 samples or per batch, or as identified by the method guidance for the media samples, whichever is greater.

5 Surveying

Confirmation surveys will be completed to verify the excavation limits and depths described in the RD have been achieved. A Washington State licensed professional land surveyor will mobilize to the Site and complete a topographic survey of the post-excavation surface. The excavation may be surveyed in sections as they are completed after confirmation sampling results indicate the RAOs have been met and prior to backfilling. The surveyor will establish vertical and horizontal control at the Site within a tolerance of 1-inch. Final surveys will be stamped and provided to the Removal Contractor and USCG.

6 Archaeological Monitoring

Archaeological monitoring will be conducted in accordance with the Monitoring and Discover Plan that was appended to the Final Action Memo (USCG 2022). An archaeological monitor from Willamette Cultural Resources Associates will be present onsite during construction activities to conduct monitoring.

7 Dust Monitoring

Dust monitoring will be conducted by the Arcadis Field Lead while onsite to evaluate potential exposures to site workers in accordance with the HASP. If visible levels of dust are present for prolonged periods of time (e.g., more than a few minutes), the Arcadis Field Lead will notify the Removal Contractor and dust control measures will be implemented (e.g. stop or slow down work, stand upwind from dust, where personal protective equipment). Dust monitoring and results will be documented in an appropriate field form or the daily log.

8 Field Equipment

Equipment to support field sampling will be calibrated and maintained according to the manufacturer's recommendation prior to and during use. Prior to field sampling, equipment will be inspected to confirm it is operational and able to function as intended. If any equipment malfunctions or needs service, it will be replaced or serviced as quickly as practical. Field equipment that will be required for confirmation sampling includes, but is limited to, the following items:

- Hand augers, shovels, and hand trowels
- GPS unit
- Tablet personal computer (connected to GPS unit)
- Laboratory supplied coolers and sampling containers

- Digital cameras
- Cell phones (no satellite phone is necessary due to confirmed cell phone coverage)
- XRF instrument
- Personal protective equipment (PPE [nitrile gloves, steel toe boots, safety glasses, high visibility vests, personal floatation devices, hard hats])
- First aid kit and emergency eyewash
- Fire extinguisher
- Decontamination supplies (spray bottles, potable water, buckets with lids, scrub brushes, nonphosphate detergent)
- Garbage bags, zip-type plastic bags
- Tape measure/wheel
- Field notebooks and pens (indelible ink).

9 Investigation-Derived Waste

Investigation-derived waste (IDW) that may be generated during the field activities, including excess soil, decontamination water, and disposable PPE. IDW will be handled in accordance with the TGI for Investigation-Derived Waste Handling and Storage (Appendix A). Soil IDW will be hauled off the island with the other soil. Liquid IDW from decontamination of sampling equipment is expected to be minimal and will be disposed with other soil. Disposable sampling equipment and PPE will be collected in plastic garbage bags and disposed with soil and other waste or off-site as municipal solid waste.

10 Field Documentation

This section summarizes field document procedures that will be used during the removal action.

10.1 Field Logbook

Daily field activities will be documented using a digital field form in accordance with the Quality Procedure for Field Activities Documentation (Appendix A). Recorded information may include, but is not limited to, the following:

- Site name and location
- Date and time of arrival and departure
- Name and signature of person maintaining the log
- Names of all persons at the Site
- Purpose of visit
- Level of PPE used

- Field instrument identification and calibration information
- Location of sampling points
- Results of field measurements made
- Number of samples collected
- Methods of sample collection and any factors that may affect quality
- All sample identification numbers
- Description of samples, including (as applicable) the depth at which the sample was collected, field duplicate samples collected, and/or other QA/QC samples collected
- Weather conditions on the day of sampling and any field observations
- Deviations or changes to the procedures established in this work plan and discussion with and direction from the Arcadis Project Manager.

10.2 Chain of Custody

Chain of custody procedures will be followed to document sample possession from the time of sample-to-sample analysis. The chain of custody form will contain the unique ID for all samples, date and time of sample collection, description, sample type, preservation (if any), and analyses required. The chain of custody form will remain with the samples at all times. Chain of custody procedures are described in the Standard Operating Procedure (SOP) for Sample Chain of Custody in Appendix A.

11 Field Variances

Deviations encountered in the field will be recorded in notes as appropriate. The types of expected changes and required actions and documentation for the change event are described in Table 4. TGIs and SOPs relevant to the field work are included in Appendix C.

12 Health and Safety

Field sampling will be conducted in accordance with the requirements of the Occupational Safety and Health Administration Hazardous Waste Operations and Emergency Response standard pursuant to Code of Federal Regulations 1910.120 and applicable Washington State Department of Labor and Industry Standards. The work will be conducted in accordance with a site-specific Health and Safety Plan (HASP) that describes site specific hazards and mitigation measures to reduce risks to workers. A copy of the HASP is included as Appendix B.

13 References

AGI Technologies. 1999. Removal of Heating Oil UST at Burrows Island Light Station, Project #DTCG88-99-C-623039, Anacortes, Washington. June.

Arcadis. 2020a. Final Remedial Investigation and Focused Feasibility Study, Burrows Island Light Station, Skagit County, Washington. June.

Arcadis. 2020b.Final Remedial Design Report, Burrows Island Light Station, Skagit County, Washington. June.

Ecology. 2016. Guidance for Remediation of Petroleum Contaminated Sites, Publication No. 10-09-057. Toxics Cleanup Program. June.

Skagit County. 2018. Parcel Map Viewer. Internet source: www.skagitcounty.net/search/Property/?id=P32494. December 6.

USCG. 1980a. PCB Decontamination Plan, Burrows Island Light Station, Anacortes, Washington. 13th District, Civil Engineering. Drawing Number 60.8001.

USCG. 1980b. Transformer Oil (PCB) Spill, Soil/Sample Concentration, Burrows Island Light Station, Anacortes, Washington. 13th District, Civil Engineering. Drawing Number 60.8002. March 26.

USCG. 2022. Final Removal Action Memorandum, Burrows Island Light Station. June 20.

USEPA. 2002. Guidance on environmental data verification and validation. EPA QA/QC-8. U.S. Environmental Protection Agency, Office of Environmental Information, Washington D.C.

USEPA. 2006. Guidance on systematic planning using data quality objectives process (EPA QA/G-4). EPA/240/B-06/001. U.S. Environmental Protection Agency, Washington, D.C.

USEPA. 2017a. National Function Guidelines for Inorganic Superfund Methods Data Review. EPA-540-R-2017-001. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation (OSRTI), Washington D.C. January.

USEPA. 2017b. National Function Guidelines for Organic Superfund Methods Data Review. EPA-540-R-2017-002. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation (OSRTI), Washington D.C. January.

Tables

Table 1
Soil Cleanup Levels
United States Coast Guard
Burrows Island Light Station
Skagit County, Washington

Constituent	MTCA Method A Cleanup Level[1]
Lead	250 mg/kg
Total Petroleum Hydrocarbons - Diesel Range Organics	2,000 mg/kg
Total Petroleum Hydrocarbons - Heavy Oil	2,000 mg/kg
Polychlorinated Biphenyl Mixtures	1 mg/kg

Notes
mg/kg = milligrams per kilogram
MTCA = Model Toxics Control Act
1. Cleanup levels based on unrestricted land use in accordance with WAC 173-340-900 Table 740-1

Table 2
Estimated Removal Areas and Quantities
United States Coast Guard
Burrows Island Light Station
Skagit County, Washington

Removal Area	Constituents above MTCA Method A Clean-Up Levels	Estimated Removal Depth (feet bgs)	DU Surface Area (SF)	Estimated Removal Volume (CY)	Estimated External Sidewall (feet)
A	Lead	0.5	2,320	43	150
B	Lead	1.5	1,030	57	0
C	Lead	2	600	44	32
D	Lead	3	380	42	0
E	Lead	1	3,670	136	193
F	Lead	0.5	1,140	21	171
G	Lead	0.5	740	14	140
H	Lead	0.5	6,500	120	427
I	Lead	2	3,250	241	202
J	Lead, PCB	2	2,860	212	96
K	Lead, PCB	3	2,440	271	132
L	Lead, DRO, HO	1	520	19	121
M	Lead, HO	0.5	1,010	19	137
N	Lead	0.5	80	1	36
O	Lead	0.5	370	7	88
P	Lead	0.5	110	2	47
Total			**27,020**	**1,250**	
Contingency for Stepout Excavations (20%)				**1,500**	

Notes:
CY = cubic yard
bgs = below ground surface
GRO = gasoline range organics
HO = heavy oil
MTCA = Model Toxics Control Act
PCBs = polychlorinated biphenyl
SF = square feet

1. Contingency applied to account for additional removal required based on results from sidewall and excavation bottom samples.

Table 3
Confirmation Soil Sampling Plan
United States Coast Guard
Burrows Island Light Station
Skagit County, Washington

Removal Area	Confirmation Sampling Analytes			Excavation Bottom Confirmation Samples	Excavation Sidewall Confirmation Samples
	Lead by USEPA Method 6010	PCBs by USEPA Method 8082	DRO/HO by NWTPH-Dx		
A	X			6	10
B	X			3	0
C	X			2	2
D	X			1	0
E	X			9	12
F	X			3	11
G	X			2	9
H	X			17	25
I	X			8	13
J	X	X	X	7	7
K	X	X	X	7	8
L	X		X	2	9
M	X		X	3	6
N	X			1	4
O	X			1	6
P	X			1	5
Subtotal				73	127
Duplicates				8	13
MS/MSDs				4	7
Total Sample Quantity				**85**	**147**

Notes:
DRO = diesel range organics
HO = heavy oil
MS/MSD = matrix spike/matrix spike duplicate
NWTPH-Dx = northwest total petroleum hydrocarbons, diesel range
PCBs = polychlorinated biphenyl
USEPA = United States Environmental Protection Agency
X = samples collected and analyzed for the constituent
1. Additional confirmation samples will be collected as needed in areas where the excavation is expanded laterally or vertically to remove any remaining impacts identified based on analytical results.

Table 4
Data Quality Indicators
United States Coast Guard
Burrows Island Light Station
Skagit County, Washington

Data Quality Indicator	Definition	Methodologies	Corrective Actions
Precision	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates (discrete) and field triplicates (incremental sampling methodology). Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field duplicates. Precision will be reported as relative percent difference.	Use same laboratory and equipment, if possible. Use consistent and approved laboratory methodology. Acquire replicate field samples.	If duplicate data do not meet the objective: - Evaluate apparent cause (e.g., sample heterogeneity) - Request reanalysis or remeasurement - Qualify the data before use.
Accuracy	Accuracy is the closeness of a measured result to an accepted reference value. It is usually measured as a percent recovery. Quality control analyses to be used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze matrix spike, matrix spike duplicates, laboratory control samples, and surrogates	If recovery does not meet objective: - Qualify the data before use - Request reanalysis or remeasurement.
Representativeness	Sample representativeness is the degree to which data accurately and precisely represent the environmental condition.	Follow approved plans and document changes or deviations.	If results are not representative of the system: - Identify cause - Flag for further review - Review for usability - Take corrective action.
Comparability	Comparability represents the degree of confidence with which one dataset can be compared to another.	Use identical or similar sample collection and handling methods, sample preparation, and analytical methods.	If data are not comparable to other datasets (e.g., RIFFS): - Identify discrepancies and discuss with the United States Coast Guard.

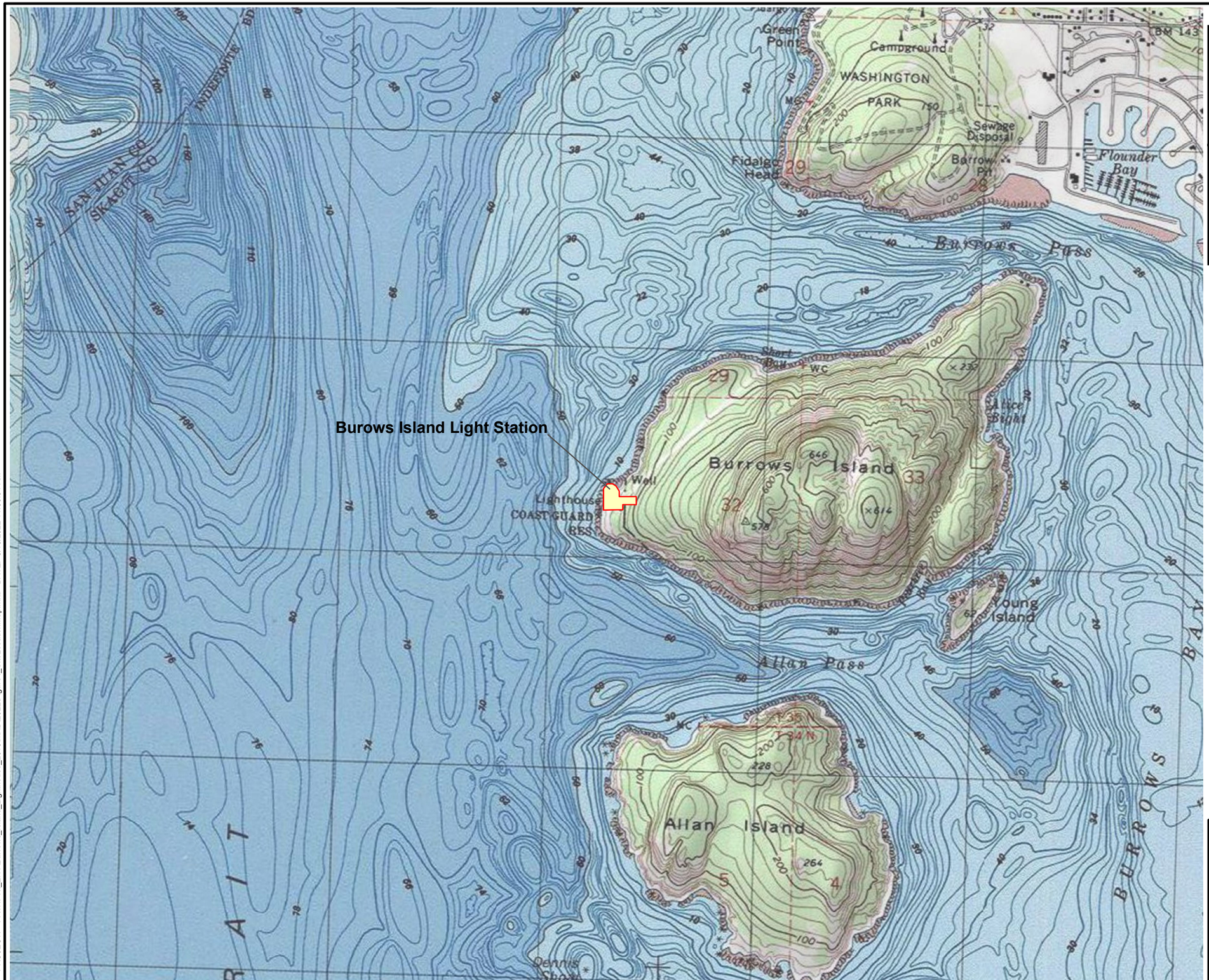
Table 4
Data Quality Indicators
United States Coast Guard
Burrows Island Light Station
Skagit County, Washington

Data Quality Indicator	Definition	Methodologies	Corrective Actions
Completeness	Completeness is a measure of the amount of valid data collected compared to the amount planned. Field completeness is a measure of the number of samples collected versus planned. Laboratory completeness is a measure of the number of valid measurements compared to the number planned.	Follow approved plan and document any changes or discrepancies.	If the data does not meet the completeness objective: - Identify appropriate changes; - Resample or collect additional samples; - Revise plan.
Bias	Bias is a distortion of a measurement that causes error in one direction (consistent low or high).	Perform matrix and matrix spike duplicates.	If data are biased: - Qualify/reject data - Assess usability - Identify problem; if possible, correct and reanalyze sample.
Sensitivity	Sensitivity refers to an instrument's or method's minimum concentration that can be reliably measured.	Ensure practical quantitative limits, method detection limits, and/or reporting limits (RLs) are appropriate. RLs should at least be less than applicable Model Toxics Control Act Method A or B cleanup levels.	If detection limits do not meet objective: - Qualify/reject data - Assess usability - Identify problem; if possible, correct and reanalyze sample.

Table 5
Change Control
United States Coast Guard
Burrows Island Light Station
Skagit County, Washington

Type of Change	Description	Action	Documentation
Deviation	Minor change that does not affect the technical accuracy of the project or work schedule.	The person recognizing the change will consult with field team leader.	Minor field changes will be documented in field logbook and deviation form. Field team leader to provide details to project team, including the USCG, in daily report.
Change	Change has a considerable effect on performance or cost but still allows for meeting DQOs.	Field team leader to notify Arcadis PM. Arcadis PM to notify the USCG. The USCG will determine if there is a need to revise document and/or notify others.	Changes will be documented in field logbook and change form. This documentation is to be provided in daily report.
Fundamental Change	Change has a significant effect of the project and does not meet DQO requirements.	Notify the USCG immediately. The USCG will determine if change requires a revision to the document and/or notification of the USEPA, Ecology, or others.	Document in field logbook. If change is identified after field work is completed, the Arcadis PM will provide written documentation to the USCG.

Figures



Legend

Site Location

Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp. Copyright:© 2013 National Geographic

0 1,500 3,000

SCALE IN FEET

UNITED STATES COAST GUARD
BURROWS ISLAND LIGHT STATION
SKAGIT COUNTY, WASHINGTON
SOIL CONFIRMATION WORK PLAN AND SAMPLING AND ANALYSIS PLAN

Site Location Map

ARCADIS

FIGURE 1

DIV/GROUP: ENV/IMDV DB: KGPeters LD: PIC: PM: TM:
PROJECT: PATH: T:_ENV\Burrows_Island_Lighthouse_2018\MXD\2022\Figure1_SiteLocationMap.mxd DATE: 5/16/2022 11:33:34 AM

LEGEND

- Light and Fog Signal Building
- Oil and Paint Storage Building Foundation
- Duplex
- Former Officer In Charge Quarters
- Boathouse
- Pumphouse and Spring Cistern
- Firehouse Pump Building Foundation
- Saltwater Flushing Pumphouse
- Concrete/Sidewalks
- Concrete Fill
- Former Fog Signal Structure
- Solar Panel
- Former Fuel Oil Tanks
- Former Transformer Oil Spill Excavation Area
- Transformer Pad
- Helicopter Pad
- Debris Pile
- Water Tanks/Platforms
- Septic Tank
- Concrete Cistern
- Former Gasoline Storage Tank
- Landing/Dock
- 3-foot Utility Line Buffer
- Active Electric Utility Line
- Water Line
- Septic Line
- Fuel Line
- Fence

Note:
1. Ground surface and existing site features are based on survey completed by OTAK on March 10 and 11, 2020. Historical site features are based on USCH historical drawings No. 60.5804 (December 1960) and No. 60.5805 (June 1958). Electrical transformer is based on USCG drawings No. 60.8001 and 60.8002 (March 1980). Additional former utility features are based on utility locates completed by Arcadis on March 6, 2015 and February 26, 2019.

0 50 100

SCALE IN FEET

UNITED STATES COAST GUARD
BURROWS ISLAND LIGHT STATION
SKAGIT COUNTY, WASHINGTON
SOIL CONFIRMATION WORK PLAN AND SAMPLING AND ANALYSIS PLAN

Site Plan with Current and Historical Features

ARCADIS

FIGURE
2

CITY: SAN FRANCISCO DIV/GROUP: ENV/IM DB: KGPeters LD: PIC: PM: TM:
PROJECT: PATH: T:\ ENV\Burrows Island Lighthouse 2018\MXD\2022\Fig2 Site Plan with Current and Historical Features.mxd DATE: 5/16/2022 11:35:14 AM

LEGEND

- A Excavation Areas
- Polychlorinated Biphenyl Area

Structures

- Light and Fog Signal Building
- Oil and Paint Storage Building Foundation
- Duplex
- Former Officer In Charge Quarters
- Boathouse
- Firehouse Pump Building Foundation
- Saltwater Flushing Pumphouse
- Water Tanks/Platforms
- Concrete/Sidewalks
- Concrete Fill
- Former Fog Signal Structure
- Solar Panel
- Water Tanks/Platforms
- Former Gasoline Storage Tank
- Landing/Dock
- 3-foot Utility Line Buffer

Excavation Depth (feet bgs)

- 0.5 foot
- 1.0 foot
- 1.5 feet
- 2.0 feet
- 2.5 feet
- 3.0 feet

Notes:

1. Ground surface and existing site features are based on survey completed by OTAK on March 10 and 11, 2020. Historical site features are based on USCH historical drawings No. 60.5804 (December 1960) and No. 60.5805 (June 1958). Electrical transformer is based on USCG drawings No. 60.8001 and 60.8002 (March 1980). Additional former utility features are based on utility locates completed by Arcadis on March 6, 2015 and February 26, 2019.
2. Removal depths and extents based on ISM and discrete data and are estimated where delineation with samples below the applicable Model Toxics Control Act Method A Cleanup Levels is not available.
3. bgs - below ground surface
4. Soil will be excavated to the target depths indicated or to refusal if bedrock is encountered before the target depth.
5. Obstructions present within the excavation areas, including trees, rocks, hard surfaces, or other natural features will be maintained to the extent possible and soil removal may be less than target depths.
6. Structures, trees or other features, including fencing, sidewalks, and stairs, will be maintained. Soil may be sloped or offset from structures implemented to protect.
7. PCB soils may be segregated based on disposal facility requirements.

0 60 120

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UNITED STATES COAST GUARD
BURROWS ISLAND LIGHT STATION
SKAGIT COUNTY, WASHINGTON
SOIL CONFIRMATION WORK PLAN AND SAMPLING AND ANALYSIS PLAN

Remediation Area Plan View

ARCADIS

FIGURE 3

CITY: SAN FRANCISCO DIV/GROUP: ENV/IM DB: KGPeters LD: PIC: PM: TM:
PROJECT: PATH: T:_ENV\Burrows_Island_Lighthouse_2018\MXD\2022\Figure 3 - Remediation Area Plan View.mxd DATE: 5/16/2022 11:36:15 AM

LEGEND

- Excavation Bottom Sample
- Sidewall Sample
- A — Excavation Areas
- Polychlorinated Biphenyl Area

Structures

- Light and Fog Signal Building
- Oil and Paint Storage Building Foundation
- Duplex
- Former Officer In Charge Quarters
- Boathouse
- Firehouse Pump Building Foundation
- Saltwater Flushing Pumphouse
- Water Tanks/Platforms
- Concrete/Sidewalks
- Concrete Fill
- Former Fog Signal Structure
- Solar Panel
- Water Tanks/Platforms
- Landing/Dock

Notes:

1. Ground surface and existing site features are based on survey completed by OTAK on March 10 and 11, 2020. Historical site features are based on USCH historical drawings No. 60.5804 (December 1960) and No. 60.5805 (June 1958). Electrical transformer is based on USCG drawings No. 60.8001 and 60.8002 (March 1980). Additional former utility features are based on utility locates completed by Arcadis on March 6, 2015 and February 26, 2019.
2. Removal depths and extents based on ISM and discrete data and are estimated where delineation with samples below the applicable Model Toxics Control Act Method A Cleanup Levels is not available.
3. Confirmation sampling frequency based on Washing State Department of Ecology Guidance for Remediation of Petroleum Contaminated Sites (June 2016).
4. Number and location of samples is subject to change based on field conditions and sample results.
5. Sidewalls that are adjacent to current buildings are assumed to not require sampling as foundations are present along the boundary where samples would be collected.

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UNITED STATES COAST GUARD
BURROWS ISLAND LIGHT STATION
SKAGIT COUNTY, WASHINGTON
SOIL CONFIRMATION WORK PLAN AND SAMPLING AND ANALYSIS PLAN

Confirmation Sampling Plan

ARCADIS

FIGURE 4

CITY: SAN FRANCISCO DIV/GROUP: ENV/IM DB: KGPeters LD: PIC: PM: TM:
PROJECT: PATH: T:_ENV\Burrows_Island_Lighthouse_2018\MXD\2022\Figure 4 - Confirmation Sampling Plan.mxd DATE: 5/16/2022 11:39:23 AM

Appendix A

Technical Guidance Documents and Standard Operating Procedures

TGI – Sample Chain of Custody

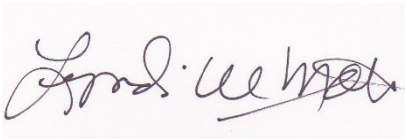
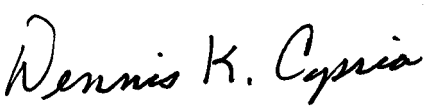
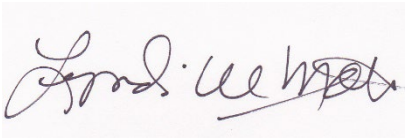
Rev: 3

Rev Date: March 28, 2022

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
	0	April 19, 2017	All	Re-write to COC only	Richard Murphy
	1	May 23, 2017	4,7,9	Add: Guidance on use of previous version of TGI. Add: Info on COCs for multiple shipping containers Modify: Move letter i. to letter m. and change to “when appropriate”	Peter Frederick
	2	April 29, 2020	4, 11	Remove obsolete link	Lyndi Mott
	3	December 28, 2022	All	Updated Arcadis format Added to 6c. Collection time between COC and container must match. Added to 6o. Add name of overnight courier when relinquishing samples. Updated reference documents and added internet links.	Lyndi Mott

Approval Signatures

Prepared by:		3/28/2022
	Lyndi Mott (Preparer)	Date
Reviewed by:		3/28/2022
	Dennis Capria (Chain of Custody Reviewer)	Date
Reviewed by:		12/22/2021
	Lyndi Mott (Subject Matter Expert)	Date

1 Introduction

This Technical Guidance Instruction (TGI) provides the procedure for Arcadis field personnel for required documentation during the collection of environmental field samples and transfer of custody to a laboratory. It provides direction for completion of the Chain of Custody form that must accompany collected field samples for analysis by a laboratory.

2 Intended Use and Responsibilities

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

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

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

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

3 Scope and Application

This TGI describes the general Chain of Custody (COC) procedures and guidance instructions for samples collected from project sites that are relinquished from Arcadis' possession.

COC is defined as the maintenance of an unbroken record of possession of an item from the time of its collection through some analytical or testing procedure. COC is typically documented by a written record of the collection, possession, and handling of samples collected from a project location. Each sample will be tracked by a documented record that efficiently documents the individuals who were responsible for the sample during each successive transfer of that sample to various recipients beyond Arcadis' possession. This information can be used to legally establish the integrity of the samples and therefore the analytical results derived from the samples. This

information can be used in addition to other records and documentation regarding the samples, such as field forms, field logs, and photographs.

A sample is considered under custody if:

- It is in your possession; or
- It is in your view, after being in your possession; or
- It was in your possession and then you then locked it up to prevent tampering; or
- It is in a designated secure area.

Continued use of previous version of TGI:

Although not recommended, Arcadis program-, project-, and client-teams may be able to use the previous version of this TGI provided that it meets all of the quality expectations of Arcadis and client and meets applicable regulatory requirements. It is up to the program, project, and/or client-team leader to determine whether it is appropriate to adopt the current TGI or to continue using the previous version.

However, all new work not associated with the previous version of this TGI must be performed with the current version of the TGI.

When adopting this new TGI, users of the previous versions must be aware that specific handling, packing, and shipping procedures and guidance has been removed and that those should be addressed within program or project plans (e.g., Quality Assurance Project Plans (QAPP), Work Plans, Sampling and Analysis Plans (SAPs), etc.) or in a more detailed TGI specific to that sampling activity, whether related to media, constituent/analyte, client, state, etc.

In addition, adopting this new TGI will require users to refer to the Arcadis Department of Transportation (DOT) Safety Program for procedures and guidance on the determination and handling, packing, and shipping of samples that are or may be considered hazardous materials.

4 Personnel Qualifications

Arcadis personnel performing work under the purview of this TGI will have received appropriate training and have field experience regarding the collection of samples from project locations. Arcadis personnel will have all other applicable and appropriate training relevant to the sampling work and project site.

5 Equipment List

The following list provides materials that may be required for each COC. Project reporting and documentation requirements must be reviewed with the CPM prior to execution of work. Additional materials, tools, equipment, etc. may be required, and project staff are required to verify with the CPM and/or Technical Expert what specific equipment is required to complete the COC.

- Indelible ink pen (preferably either black or blue ink);
- COC form **(Appendix A)** from either Arcadis, laboratory receiving and analyzing the samples, or other applicable and appropriate entity for the work performed;
- When appropriate, such as for litigation or expert testimony work, custody seals or tape.

6 Cautions

One way in which the law tries to ensure the integrity of evidence is by requiring proof of the chain of custody by the party who is seeking to introduce a particular piece of evidence.

A proper chain of custody requires three types of affirmations: (1) affirmation that a sample is what it purports to be (for example, soil collected from a specified location and depth); (2) affirmation of continuous possession by each individual who has had possession of the sample from the time it is collected until the time it is analyzed or held by a laboratory; and (3) affirmation by each person who has had possession that sample remained in substantially the same condition and not contaminated or affected by outside influences from the moment one person took possession until the moment that person released the evidence into the custody of another (for example, affirmation that the sample was stored in a secure location where no one but the person in custody had access to it).

Proving chain of custody is necessary to "lay a foundation" for the samples in question, by showing the absence of alteration, substitution, or change of condition.

Ensure that appropriate sample containers with applicable preservatives, coolers, and packing material are planned for and provided at the site at the time of sample collection.

Understand the offsite transfer requirements of the samples for the facility at which samples are collected.

If overnight courier service is required schedule pick-up or know where the drop-off service center is located and the hours of operation.

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

The person relinquishing possession of the samples or other member of the project team should contact the final recipient of the samples to confirm receipt and review any special provisions on the COC or questions that they may have.

7 Health and Safety Considerations

Follow the health and safety procedures outlined in the project/site Health and Safety Plan (HASP) as well as other applicable H&S requirements, such as:

- Arcadis Hazardous Material/DOT handling, packaging, and shipping training
- Project site-specific H&S training
- Client-specific H&S training
- Constituent-specific H&S training
- Media-specific H&S training

8 Procedure

Collected samples must be uniquely identified, and properly documented, containerized, labeled with unique identifier, possessed in a secure manner during remainder of sampling event, packaged, and shipped to recipient laboratory.

Sample Identification

The method of sample identification depends on the type of measurement or analyses performed. In some cases, in-situ measurements of existing conditions and/or sample location must be made during sample collection.

These data will be recorded directly on field forms, logbooks, or other project record data sheets used to permanently retain this information for the project file. Examples of location identification information includes: latitude/longitudinal measurements, compass directions, well number, building number, floor number, room name, or proximity to a site feature unique to the site. Examples of in-situ measurements are pH, temperature, conductivity, flow measurement, or physical condition of the media being sampled. Physical samples collected are identified by a unique identifying number or code on a sample tag or label. These physical samples are removed from the sample location and transported to a laboratory for analyses.

In some cases, before samples are placed into individual containers and labeled as individual samples, samples may be separated into portions depending upon the analytical methods and required duplicate or triplicate analyses to be performed.

When completing a COC for samples, personnel must complete the following:

1. Written COCs must be completed with indelible ink (preferably either black or blue colored ink).
2. Written COCs must be completed using legible printed writing, and not cursive writing.
3. All entry fields on the COC form must be completed. If information is not applicable for a specific entry field, personnel will either put “N/A” or use a strike-out line or dash like “----------“ to indicate no applicable information is needed for that field.
4. Use of quotation marks or lines/down arrows to represent repetitive/duplicative text in similar fields.
5. Regardless of the type or specific COC form, the following pertinent information must be provided on the COC form:
    a. Arcadis project number
    b. Arcadis project name
    c. Project location, including street address, city, state, building number, providing as much detail as appropriate
    d. Recipient laboratory contact and sample receiving shipping location information
    e. Entities’/persons’ contact information for who will be receiving analytical results
    f. Name of sampler, i.e., person collecting sample and relinquishing possession of samples to the next entity in the chain of custody
    g. Date of sample collection
    h. If appropriate for the sample media, contaminant/constituent of concern, or analytical method, document time of sample collection using standard military time
    i. Sample analytical method(s)

j. Turnaround time required for analyses and/or reporting

k. Instructions to laboratory regarding handling, timing, analyses, etc. as applicable and appropriate.

l. Printed name and signature of the individual person who collected the samples and relinquishing possession of the samples

m. If appropriate or when documentation of the specific sample collection method will influence how the laboratory handles, prepares, or analyzes the samples, document the sample collection methodology used for collecting the samples (e.g., ASTM D5755)

6. The following additional specific information will be entered on the COC form, regardless of what type of COC is being used:

a. Unique Sample Identifier – The sample identifier (ID) must be unique to the individual sample it is applied to. The information in which the sample ID conveys is determined by the CPM, Technical Expert, and/or other project team members in advance of sample collection so that sample identification is consistently applied for the project. The sample nomenclature may be dictated by a specific client, program, or project database and require unique identification for each sample collected for the project. Consult with the CPM and/or Technical Expert for additional information regarding sample identification.

The sample ID could convey specific information regarding the sample to aid personnel in recognizing what the sample represents, or they may be arbitrary so as to facilitate the anonymity of the sample location, media, constituent of concern, project site, etc.

Examples of unique identifiers include:

1. Well locations, grid points, or soil boring identification numbers (e.g., MW-3, X-20, SB-30). When the depth interval is included, the complete sample ID would be “SB-30 (0.5-1.0) where the depth interval is in feet. Please note it is very important that the use of hyphens in sample names and depth units (i.e., feet or inches) remain consistent for all samples entered on the chain of custody form. DO NOT use the apostrophe or quotes in the sample ID.

2. Sample names may also use the abbreviations “FB,” “TB,” “FD” and “DUP” as prefixes or suffixes to indicate that the sample is a field blank, trip blank, or field duplicate, respectively.

b. List the date of sample collection. All indicated dates must be formatted using either mm/dd/yy (e.g., 03/07/09) or mm/dd/yyyy (e.g., 03/07/2009).

c. List the local time that the sample was collected. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15. The time listed on the COC form must match the sample collection time on the sample container(s).

d. Samples should be indicated to be either “Grab” or “Composite”. Grab samples are collected from only one unique location at one specific point in time.

e. Composite samples are a group of individual samples that are combined for analysis in their totality. Composite samples need to be documented if they are either collected from a number of different locations over a broader area to be representative of the entire area being sampled, or if they are representative of a single location over an extended period of time.

f. If used, preservatives for the individual sample will be noted.

g. The requested analytical method(s) that the samples are being analyzed for must be indicated. As much detail, as necessary, should be presented to allow the analytical laboratory to properly analyze the samples. For example, polychlorinated biphenyl (PCB) analyses may be represented by entering "EPA Method 8082 – PCBs" or "EPA PLM 600-R93-116." In cases where multiple analytical methods and/or analytical parameters are required for an individual sample, each method should be indicated for the sample (e.g., EPA 8082/8260/8270 or EPA PLM/400-point count).

h. If there are project-specific sample analytes to be reported, they should be specifically listed for each individual sample (e.g., 40 CFR 264 Appendix IX).

i. The total number of containers for each analytical method requested should be documented. This information may be included under the parameter or as a total for the sample.

j. When necessary, note which samples should be used for site specific matrix spikes in the Remarks or Comments field.

k. Indicate special project-specific requirements pertinent to the handling, shipping, or analyses. These requirements may be on a per sample basis such as "extract and hold sample until notified," or may be used to inform the laboratory of special reporting requirements for the entire sample delivery group (SDG).

l. Indicate turnaround time (TAT) required for samples on COC. If individual samples have differing TATs, the different TATs for each sample or groups of samples must be clearly indicated.

m. Provide contact name and phone number in the event that problems are encountered when samples are received at the laboratory. The person relinquishing possession of the samples or other member of the project team should contact the final recipient of the samples to confirm receipt and review any special provisions on the COC or questions that they may have.

n. If available, attach the Laboratory Task Order or Work Authorization forms.

o. The "Relinquished By" field must contain the signature of the Arcadis person who relinquished custody of the samples to the next entity in the chain of custody, which may be another person, the shipping courier, or the analytical laboratory. If a courier, enter the shipping courier in the "Received by" such as FedEx. The date/time relinquished should be when the person signs the COC and seals the cooler or shipping container for pick-up by the shipping courier.

p. Dates and times must be indicated using the following format:

   1) Date: either mm/dd/yy e.g., 01/01/17 OR mm/dd/yyyy e.g., 01/01/2017

   2) Time: use military format, e.g., 9:30 a.m. is 0930 and 9:30 p.m. is 2130

q. The "Received By" section is signed by sample courier or laboratory representative who received the samples from the sampler. The laboratory will sign upon laboratory receipt from the overnight courier service.

7. When more than one page of the COC form is required to complete the total number of samples, use as many sheets as necessary to accurately and clearly, document the samples and information. Some COCs may have a standard first page/cover page, and subsequent pages may not contain all the detailed fields as

the first page/cover page. Ensure that any subsequent pages convey all of the necessary and pertinent information for each individual sample as required in this procedure document.

8. Pages of the COC must retain a page count of the total number of pages; e.g., Page 1 of 3, Page 2 of 3, Page 3 of 3.
9. Upon completing the COC forms, forward the original signed COC with the sample package. Ensure that the original COC form is secured with the sample package so that it remains with the physical samples for the duration of transport and handling to its final destination and ensure that the COC form will not be become damaged or rendered unreadable due to sample breakage/leakage if stored inside the sample shipping container or outside influences if COC is stored in an outside plastic pouch to the container.
10. If you've collected enough samples that would require more than one container to ship them all to the same laboratory or location, then each separate/individual container that contains any number of samples must have a separate COC representing only those samples contained within that specific container. For example, if you have 3 total shipping containers for all of your samples, you must have a total of 3 separate, individual COCs for each of the 3 containers representing only those samples in their representative container. Thus, every container holding samples must have its own, individual COC.
11. If electronic chain of custody (eCOC) forms are utilized, ensure that the requirements of this procedure and guidance instructions are followed to the extent possible. Verify that proper signature and COC procedures are maintained with the CPM and/or Technical Expert when using eCOC.

9 Waste Management

Not Applicable.

10 Data Recording and Management

The original signed COC shall be submitted with the samples. Copies of COC records will be transmitted to the CPM or designee at the end of each day unless otherwise directed by the CPM. The sampling team leader retains copies of the chain of custody forms for filing in the project file. Record retention shall be in accordance with client- and project-specific requirements and Arcadis policies, the most stringent will apply.

The option to use the Electronic Chain of Custody (eCOC) form in conjunction with the appropriate sample application(s) may be available through the FieldNow® program but is currently limited to a select list of approved analytical laboratories. Use of the eCOC application is intended to reduce common transcription errors both by field staff and laboratory staff on a conventional handwritten paper COC. Once the eCOC form is completed and approved on the field tablet by field staff, a PDF version of the form is automatically emailed to each assigned team member. In addition, a dedicated or mobile printer is recommended for printing a hard copy of the completed eCOC to be included in each sample cooler to meet laboratory requirements.

11 Quality Assurance

COC forms will be legibly completed in accordance with this procedure and guidance instruction document, as well as other applicable and appropriate project documents such as SAP, Quality QAPP, Work Plan, or other project guidance documents.

COC records will be reviewed by the CPM or their appropriate designee for completeness and accuracy to the applicable requirements. Non-conformances will be noted and corrected in a timely manner on the copies retained by Arcadis as well as contacting the ultimate receiving entity for correction to the originally signed COC in their possession.

12 References

Arcadis Transportation Safety Program requirements, procedures, and guidance instructions.

EPA Samplers' Guide – Contract Laboratory Program Guidance for Field Samplers, EPA document EPA-540-R014-013 October 2014 https://www.epa.gov/sites/default/files/2015-03/documents/samplers_guide.pdf.

EPA Region III – Sample Submission Procedures for the Office of Analytical Services and Quality Assurance (OASQA) Laboratory Branch revision 14.0 October 18, 2018, https://www.epa.gov/sites/default/files/2018-12/documents/sample-submission-procedures-rev14.pdf.

EPA Region IV Science and Ecosystem Support Division Operating Procedure for Sample and Evidence Management May 25, 2016, https://www.epa.gov/sites/default/files/2015-06/documents/Sample-and-Evidence-Management.pdf.

Attachment A

Chain of Custody and Laboratory Analysis Request Form

ARCADIS

ID#

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ____ of ____

Lab Work Order #

Send Results to:

Contact & Company Name:

Telephone:

Address:

Fax:

City State Zip

E-mail Address:

Project Name/Location (City, State):

Project #:

Sampler's Printed Name:

Sampler's Signature

SAMPLE ID	Collection Date	Collection Time	Type (✓) Comp	Type (✓) Grab	Matrix

Preservative									
Filtered (✓)									
# of Containers									
Container Information									
PARAMETER ANALYSIS & METHOD									
									REMARKS

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: _____
G. Other: _____
H. Other: _____

Containment Information Key
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: _____
10. Other: _____

Matrix Key:
SO - Soil
W - Water
T - Tissue
SE - Sediment
SL - Sludge
A - Air
NL - NAPL/Oil
SW - Sample Wipe
Other: _____

Special Instructions/Comments

☐ Special QA/QC Instructions (✓)

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Last Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt	Firm:	Firm:	Firm:	Firm:
Shipping Tracking #:	Condition/Cooler Temp:_____	Date/Time:	Date/Time:	Date/Time:	Date/Time:

SOP – Sample Chain of Custody Rev1_May 23, 2017

Arcadis U.S., Inc.
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TGI – Soil Drilling and Sample Collection

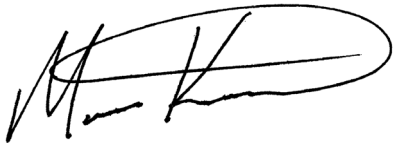
Rev: #2

Rev Date: April 8, 2022

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
	0	October 11, 2018	All	Updated and re-written as a TGI	Marc Killingstad
	1	May 12, 2020	None	Review – no changes necessary	Marc Killingstad
	2	April 8, 2022	All	Updated to new format and minor content (e.g., PFAS)	Chris Shepherd/Marc Killingstad

Approval Signatures

Prepared by:		4/8/2022
	Chris Shepherd (Preparer)	Date
Reviewed by:		4/8/2022
	Marc Killingstad (Subject Matter Expert)	Date

1 Introduction

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

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

This document is not considered to be all inclusive nor does it apply to 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. All deviations or omissions should be documented.

2 Intended Use and Responsibilities

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

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

3 Scope and Application

This Technical Guidance Instruction (TGI) describes general drilling procedures and the methods to be used to field screen and collect soil samples for laboratory analysis in unconsolidated or weakly consolidated sediments. For soil description procedures, please refer to the *TGI - Soil Description*. For monitoring well installation in granular aquifers, please refer to the *TGI - Monitoring Well Installation*. For per- and polyfluoroalkyl substances (PFASs) drilling and soil sampling procedures, please refer to: *TGI – PFAS-Specific Drilling and Monitoring Well Installation, TGI – Per- and Polyfluoroalkyl Substances (PFAS) Field Sampling Guide*, and *TGI – Equipment and Reagent Blank Sample Collection for PFAS Analysis*.

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

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

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

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

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). Some lubricants (e.g., vegetable oil-based lubricants) may be acceptable, if the constituents won't interfere with the analyses.

4 Personnel Qualifications

Arcadis field personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or state/federal regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as identified in the site-specific Health and Safety Plan (HASP) which may include first aid,

cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. The HASP will also identify any access control requirements.

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

Arcadis field personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Personnel responsible for overseeing drilling operations will have at least 16 hours of prior training overseeing drilling activities with an experienced geologist, environmental scientist, or engineer with at least 2 years of prior experience.

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

Additionally, the Arcadis field team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

5 Equipment List

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

- Site-specific HASP and health and safety documents identified in the HASP
- FIP/work plan that includes site map with proposed boring locations, fieldsampling plan (with corresponding depths, sample analyses, sample volume required, and sample holding time), and previous boring logs (as available)
- Appropriate personal protective equipment (PPE), as specified in the HASP
- Including but not limited to disposable chemical resistant gloves and Level D PPE
- Traffic cones, delineators, and caution tape as appropriate for securing the work area as specified in the Traffic Safety Plan (TSP)
- Photoionization detector (PID), flame ionization detector (FID) or other air/soil screening equipment, asneeded, in accordance with the HASP or workplan
- Sampling equipment:
- Drilling equipment required by *ASTM D1586*, when performing split-spoon sampling including clean sample sleeves
- Disposable plastic liners, when drilling with direct-push equipment
- Stainless steel hand auger and stainless-steel spade if using manual methods
- Appropriate soil sampling equipment (e.g., stainless steel spatulas/spoons/bowls, knife)
- Sealable plastic bags (e.g., Ziploc®)

- Air-tight sample containers and 8-oz. glass Mason jars or driller's jars
- Aluminum foil
- Appropriate sample blanks (trip blank supplied by the laboratory), as specified in the FSP
- Soil sample containers and labels (supplied by the laboratory) appropriate for the analytical method(s) with preservative, as needed (parameter-specific)
- Sample labels
- Indelible ink pens
- Engineer's ruler or survey rod
- Plastic sheeting (e.g., Weatherall Visqueen)
- Appropriate transport containers (coolers) with ice and appropriate labeling, packing, and shipping materials
- Decontamination equipment (buckets, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels) in accordance with the *TGI for Groundwater and Soil Sampling Equipment Decontamination*
- Forms/notes:
    - Tablet with digital forms, etc., if appropriate
    - Appropriate soil boring log (**Attachment 1**)
    - Chain-of-custody forms
    - Field notebook
    - Digital camera (or smart phone with camera)
- Drums or other containers appropriate for soil and decontamination water, as specified by the site investigation-derived waste (IDW) management plan, and appropriate drum labels

6 Cautions

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

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

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

drilling plan.

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

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

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions. Water used for drilling, decontamination of drilling/sampling equipment, or grouting boreholes uponcompletion will be of a quality acceptable for project objectives. Testing of water supply will be considered.

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

Store and/or stage empty and full sample containers and coolers out of direct sunlight. Sample container threads should be wiped down with a clean, nonabrasive material (e.g., paper towels) to better ensure the sample container is properly sealed. Be careful not to over-tighten lids with Teflon® liners or septa. Over-tightening can impair the integrity of the seal and cancause the glass to shatter and create a risk for hand injuries.

NOTE: *Field logs and some forms are considered to be legal documents. All field logs and forms will therefore be filled out in indelible ink. Do not use permanent marker or felt-tipped pens for labels on sample container or sample coolers. Permanent markers could introduce volatile constituents into the samples.*

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

7 Health and Safety Considerations

The HASP will be followed, as appropriate, to ensure the safety of field personnel. Review all site-specific and procedural hazards as they are provided in the HASP, and review Job SafetyAnalysis (JSA) documents in the field each day prior to beginning work.

Prior to drilling, utility clearance must be performed (see Section 5). Appropriate personal protective equipment (PPE) will be worn at all times in line with the task and thesite-specific HASP.

Working outside at sites with suspected contamination may expose field personnel to hazardous materials such as contaminated groundwater or NAPL (e.g., oil). Other potential hazards include biological hazards (e.g., stinging insects, ticks in long grass/weeds, etc.), and potentially the use of sharp cutting tools (scissors, knife). Only use non-toxic peppermint oil spray for stinging insect nests. Review client-specific health and safety requirements, which may preclude the useof fixed/folding-blade knives

and use appropriate hand protection.

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

8 Procedure

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

8.1 Drilling Procedures

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

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area.
    a. Verify utilities were cleared (see Section 5) and use soft dig technique to clear borehole, if applicable
    b. Clean sampling equipment in accordance with the FIP/work plan prior to drilling
2. Advance boring to target depth:
    a. Collect soil samples at appropriate interval as specified in the FIP/work plan (or equivalent) using the appropriate tooling (e.g., split-barrel sampler) and sample containers
        i. Split-barrel or drive-ahead samples are obtained during drilling
        ii. A common sampling method that produces high-quality soil samples with relatively littlesoil disturbance is described in *ASTM D1586 – Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils* (ASTM D1586).
    b. Always change disposable gloves before handling the sampling equipment
    c. Collect, document, and store samples for laboratory analysis as specified in the FIP/work plan (or equivalent; see below for additional details on sample collection procedures)
    d. Field screen samples as specified in the FIP/work plan (or equivalent; see below for additional details on field screening procedures)
    e. Rotasonic drilling produces soil cores that, for the most part, are relatively undisturbed, but note that when drilling in consolidated or finer-grained sediment the vibratory action during core barrel advancement may create secondary fractures or breaks. The core is retrieved by vibrating the soil/rock into a separate core bag, typically in 5-foot or 10-foot increments. The soil cores may consolidate or expand during retrieval, depending on soils, etc.
    f. Dual-rotary removes cuttings by compressed air or water/mud and allow only a

generalassessment of geology unless separate coring tools and techniques are used

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

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

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

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

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

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

    e. If soils are screened with a PID/FID or another instrument, document the measurement in accordance with the work plan

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

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

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

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

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

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

8.1.2 Direct-Push Method

The direct-push drilling method may also be used to complete soil borings. Examples of this technique include Geoprobe®, Diedrich Environmental Soil Probe (ESP) System, or AMS PowerProbe.

Environmental probe systems typically use a hydraulically operated percussion hammer.

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

(dual tube sampling system).

The outside diameter (OD) of the outer casing ranges from 2.25 to 6 inches and the OD of the inner sampling tube diameter ranges from 1.4 to 4.5 inches. The outer casing isolates overlying soil and permits the unit to continue to probe at depth. The dual tube sampling system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, a single rod system may be used that does notprovide a cased boring and which limits tremie-grouting from the bottom up.

Direct-push drilling can generally achieve target depths 100 feet or less depending on the site geology. The known or expected site conditions (e.g., presence of NAPL) will be evaluated when selecting the typeof direct-push sampling system to be employed.

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area
    a. Verify utilities were cleared (see Section 5) and use soft dig technique to clear borehole, if applicable
    b. Clean sampling equipment in accordance with the FIP/work plan prior to drilling
2. Advance soil boring to target depth.
    a. Collect soil samples at appropriate interval as specified in the FIP/work plan (or equivalent) using clean/disposable sampling equipment (plastic liners)
    b. Always change disposable gloves before handling the sampling equipment
    c. Collect, document, and store samples for laboratory analysis as specified in theFIP/work plan (or equivalent; see below for additional details on sample collection procedures)
    d. Field screen samples as specified in the FIP/work plan (or equivalent; see below for additional details on field screening procedures)
3. Decontaminate equipment between samples in accordance with the FIP/work plan (or equivalent)
4. Describe samples in accordance with the procedures outlined in **Step 3** under ***Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods*** above (refer to the description procedures outlined in the *TGI - Soil Description*)

8.1.3 Manual Methods

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

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area
2. Clear the ground surface of brush, root mat, grass, leaves, or other debris
3. Use a spade, spoon, scoop, hand auger, or slide hammer to collect a sample of the required depth interval
4. Use an engineer's ruler or survey rod to verify that the sample is collected to the correct depth and

record the top and bottom depths from the ground surface

5. To collect samples below the surface interval, remove the surface interval first; then collect the deeper interval
    a. To prevent the hole from collapsing, it may be necessary to remove a wider section from the surface or use cut polyvinyl chloride (PVC) pipe to maintain the opening
    b. Collect soil samples at appropriate interval as specified in the FIP/work plan (or equivalent) and transfer to the appropriate, laboratory-supplied container
    c. Collect, document, and store samples for laboratory analysis as specified in the FIP/work plan (or equivalent; see below for additional details on sample collection procedures)
    d. Field screen samples as specified in the FIP/work plan (or equivalent; see below for additional details on field screening procedures)
6. Decontaminate equipment between samples in accordance with the FIP/work plan (orequivalent)
7. Describe samples in accordance with the procedures outlined in **Step 3** under ***Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods*** above (refer to the description procedures outlined in the *TGI - Soil Description*)

8.2 Field Screening Procedures

8.2.1 PID and FID Screening

Soils are typically field screened with a PID or FID for a relative measure of the total VOCs at sites where VOCs are known or suspected to exist. PIDs and FIDs require calibration in accordance with the work plan(s) and manufacturer's specifications and PIDs should be calibrated based on the target chemicals. The PID employs an ultraviolet lamp to measure VOCs and the ionizationenergy (IE) of the site constituents need to be considered when selecting the type of lamp (e.g., 10.6 eV, 11.7 eV) that will be used. In general, any compound with an IE lower than that of the lamp photons canbe measured. The FID has a wide linear range and responds to almost all VOCs.

Field screening is performed using one (or both) of the following two methods:

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

Prior to usage, the PID or FID must be calibrated according to the manufacturer's specifications at a minimum frequencyof once per day prior to collecting PID or FID readings. The PID will be calibrated to a benzene-related compound (isobutylene) or other appropriate gas, while the FID will be calibrated to methane. The time, date, and calibration procedure must be clearly documented in the field notebook and/or the calibration form.

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

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

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

For the second method, a representative portion of the sample will be placed in a pre-cleaned air-tight container (as quickly as possible to avoid loss of VOCs), filling the container half full to allow for the accumulation of vapors above the soil. An aluminum foil seal will be placed between the glass and cap and the cap will be screwed on tightly. Unless the screening will be performed immediately after the sample is placed in the container, the sample containers will be stored in a cooler chilled to approximately4ºC until screening can be performed.

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

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

8.2.2 NAPL Screening

To screen for the potential presence of non-aqueous phase liquid (NAPL) in soil, drilling procedures must allow for high-quality porous media samples to be taken. Split-barrel samplers or direct-push samplers will be collected continuously ahead of the auger, drill casing/rods, or probe rods. Upon opening each split-barrel sampler or direct-push plastic liner sleeve, the soil will immediately be evaluated for the presence of visible NAPL and odors. If suspected NAPL is immediately visible in the sample, its depth will benoted.

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

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

- Evaluation for Visible NAPL Sheen or Free-Phase NAPL in Soil Sampler
    - NAPL sheen will be a colorful iridescent appearance on the soil sample
    - NAPL may also appear as droplets or continuous accumulations of liquid with a color typically ranging from yellow to brown to black, depending on the type of NAPL
    - Creosote DNAPL (associated with wood-treating sites) and coal tar DNAPL (associated with manufactured gas plant [MGP] sites) are typically black and have a characteristic, pungent odor
    - Pure chlorinated solvents may be colorless in the absence of hydrophobic dye. Solvents mixed

with oils may appear brown

- Particular care will be taken to fully describe any sheens observed, staining, discoloration, droplets (blebs), or NAPL saturation

- Soil-Water Pan Test
  - A portion of the selected soil interval with the highest PID or FID reading above 100 ppm will be placed in a disposable polyethylene dish along with a small volume of potable or distilled water
  - The dish will be gently tilted back and forth to mix the soil and water, and the surface of the water will be viewed in natural light to observe the development of a sheen, if any
  - A small quantity of Oil Red O or Sudan IV hydrophobic dye powder should be added in accordance with the work plan, and the soil and dye will be manually mixed for approximately 30 to 60 seconds and smeared in the dish tocreate a paste-like consistency
  - A positive test result will be indicated by a sheen on the surface of the water and/or a bright red color imparted to the soil following mixing with dye
- Soil-Water Shake Test
  - A small quantity of soil (up to 15 cc) will be placed in a clear, colorless, jar containing an equal volume of potable or distilled water (40-mL vials are well suited to this purpose, but not required)
  - After the soil settles into the water, the surface of the water will be evaluated for a visible sheen under natural light
  - The jar will be closed and gently shaken for approximately 10 to 20 seconds
  - Again, the surface of the water will be evaluated for a visible sheen or a temporary layer of foam
  - A small quantity (approximately 0.5 to 1 cc) of Oil Red O or Sudan IV powder will be placed in the jar in accordance with the work plan
  - The sheen layer, if present, will be evaluated for a reaction to the dye (change to bright red color)
  - The jar will be closed and gently shaken for approximately 10 to 20 seconds
  - The contents in the closed jar will be examined under natural light for visible bright red dyed liquid inside the jar

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

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

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

8.3 Soil Sample Collection for Laboratory Procedures

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

1. Their position in relation to identified source areas
2. The visual presence of source residues (e.g., NAPL or staining)
3. The relative levels of total VOCs based on field screening measurements
4. The judgment of the field coordinator
5. Moisture content or relative position with regard to apparent groundwater table/saturation

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

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

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

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

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

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

The small diameter core samplers will be used according to the manufacturer's instructions (e.g., En Novative Technologies). Some regulatory agencies have specific requirements regarding VOC sample

collection. Determine whether the oversight agency has specific requirements prior to commencing sampling and collect samples at appropriate interval as specified in the FIP/work plan (or equivalent). Samples may require homogenization across a given depth interval, or several discrete grabs (usually five) may be combined into a composite sample.

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

The procedure for mixing samples is provided below.

1. Mix the materials in a stainless steel (or appropriate non-reactive material) bowl using a stainless-steel spoon (or disposable equivalents)

a. When dealing with large sample quantities, use disposable plastic sheeting and a shovelor trowel

b. NOTE: *When preparing samples for metals analyses, do not use disposable aluminum(or metal tools or trays other than stainless steel), as it may influence the analytical results*

2. Flatten the pile by pressing the top without further mixing

3. Divide the circular pile by into four equal quarters by dividing out two diameters at right angles

4. Mix each quarter individually using appropriate non-reactive bowls, spoons and/or sheeting

5. Mix two quarters (as described above) to form halves, then mix the two halves to form a composite orhomogenized sample

6. Place composite or homogenized sample into specified containers

7. Remaining material will be disposed of in accordance with project requirements and applicableregulations

8. Sample containers will be labeled with sample identification number, date, and time of collection andplaced on ice in a cooler (target 4° Celsius)

9. Samples selected for laboratory analysis will be documented (chain-of-custody forms), handled, packed, and shipped in accordance with the procedures outlined in the FIP/work plan (or equivalent).

8.4 Soil Boring Abandonment

All soil borings need to be abandoned in accordance with ***TGI for Monitoring Well and Soil Boring Decommissioning***. See Attachment E of the TGI for specifics.

9 Waste Management

Investigative-Derived Waste (IDW) generated during drilling activities, including soil and excess drilling fluids (if used), and decontamination liquids, will be stored on site in appropriately labeled containers and disposed of properly. Disposable materials will be stored and disposed of separately. Containers must be labeled at the time of collection and will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, PPE). Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage,* the procedures identified in the FIP/work plan or QAPP as well as

state-, federal- or client-specific requirements. Be certain that waste containers are properly labeled and documented in the field log.

10 Data Recording and Management

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

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

In general, drilling activities will be documented on appropriate field/log forms as well as in a proper field notebook. All field data will be recorded digitally or with indelible ink. Field forms, logs/notes (including daily field and calibration logs), digital records, and chain-of-custody records will be maintained by the field team lead. Any deviations or omissions from this TGI should be documented.

Initial field logs and chain-of-custody records will be transmitted to the Arcadis CPM and Technical Lead at the end of each day unless otherwise directed by the CPM. The field teamleader retains copies of the field documentation.

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

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

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

11 Quality Assurance

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

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

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

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

12 References

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

13 Attachments

Attachment 1. Soil Boring Log Form

Attachment 1

Soil Boring Log Form

BORING LOG

Boring ID:		**Project Name:**		**Page:**	
Permit ID:		**Date Started:**		**Ground Elevation:**	
Site Address:		**Date Completed:**		**Vertical Datum:**	
City, State:		**Total Depth:**		**Northing:**	
Drilling Co:		**Depth to Water:**		**Easting:**	
Driller:		**Hole Diameter:**		**Horizontal Datum:**	
Drilling Method:		**Core Device:**		**Prepared by:**	
Boring Status:		**Drilling Fluid:**		**Reviewed by:**	

Drilling Information				Primary Texture											Soil Description (Udden-Wentworth System)	Field Notes
				Fines		Sand					Gravel					
Drilling Depth (ft bgs)	Core Interval (ft)	Core Recovery (inches)	PID Reading (ppm)	clay	silt	very fine	fine	medium	coarse	very coarse	granule	pebble	cobble	boulder	Depth interval (ft), Moisture, PRIMARY TEXTURE, Modifier/Minor Texture, Sorting, Angularity, Consistency, Plasticity, Color - Only Record Sand Density with Standard Penetration Tests Minor Texture Modifiers: Trace (<10%), Little (10 to 20%), Some (21 to 35%), And (36 to 50%)	Driller's Observations, Particle Size Percentages, Geologic Formation, Field Screening Results, Sample Interval etc.

BORING LOG

ARCADIS

Boring ID: ____________ **Project Name:** ____________ **Page:** ____ / ____

Drilling Information				Primary Texture											Soil Description (Udden-Wentworth System)	Field Notes
				Fines		Sand					Gravel					
Drilling Depth (ft bgs)	Core Interval (ft)	Core Recovery (inches)	PID Reading (ppm)	clay	silt	very fine	fine	medium	coarse	very coarse	granule	pebble	cobble	boulder	Depth interval (ft), Moisture, PRIMARY TEXTURE, Modifier/Minor Texture, Sorting, Angularity, Consistency, Plasticity, Color - Only Record Sand Density with Standard Penetration Tests Minor Texture Modifiers: Trace (<10%), Little (10 to 20%), Some (21 to 35%), And (36 to 50%)	Driller's Observations, Particle Size Percentages, Geologic Formation, Field Screening Results, Sample Interval etc.

BORING LOG

ARCADIS

Boring ID: ______________________ **Project Name:** ______________________________ **Page:** _____ / _____

Drilling Information				Primary Texture											Soil Description (Udden-Wentworth System)	Field Notes
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TGI – Groundwater and Soil Sampling Equipment Decontamination

Rev: 2

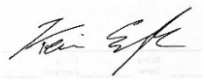
Rev Date: June 14, 2022

Version Control

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

Approval Signatures

Prepared by: 6/14/2022



Name (Preparer) Date

Reviewed by: 6/14/2022

Marc Killingstad (Subject Matter Expert) Date

1 Introduction

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

2 Intended Use and Responsibilities

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

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

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

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

3 Scope and Application

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

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

4 Personnel Qualifications

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

5 Equipment List

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

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

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

6 Cautions

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

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

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

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

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

7 Health and Safety Considerations

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

8 Procedure

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

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

Cleaning Sampling Equipment

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

Decontaminating Submersible Pumps

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

9 Waste Management

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

10 Data Recording and Management

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

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

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

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

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

Containers with decontamination fluids will be labeled.

11 Quality Assurance

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

12 References

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

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

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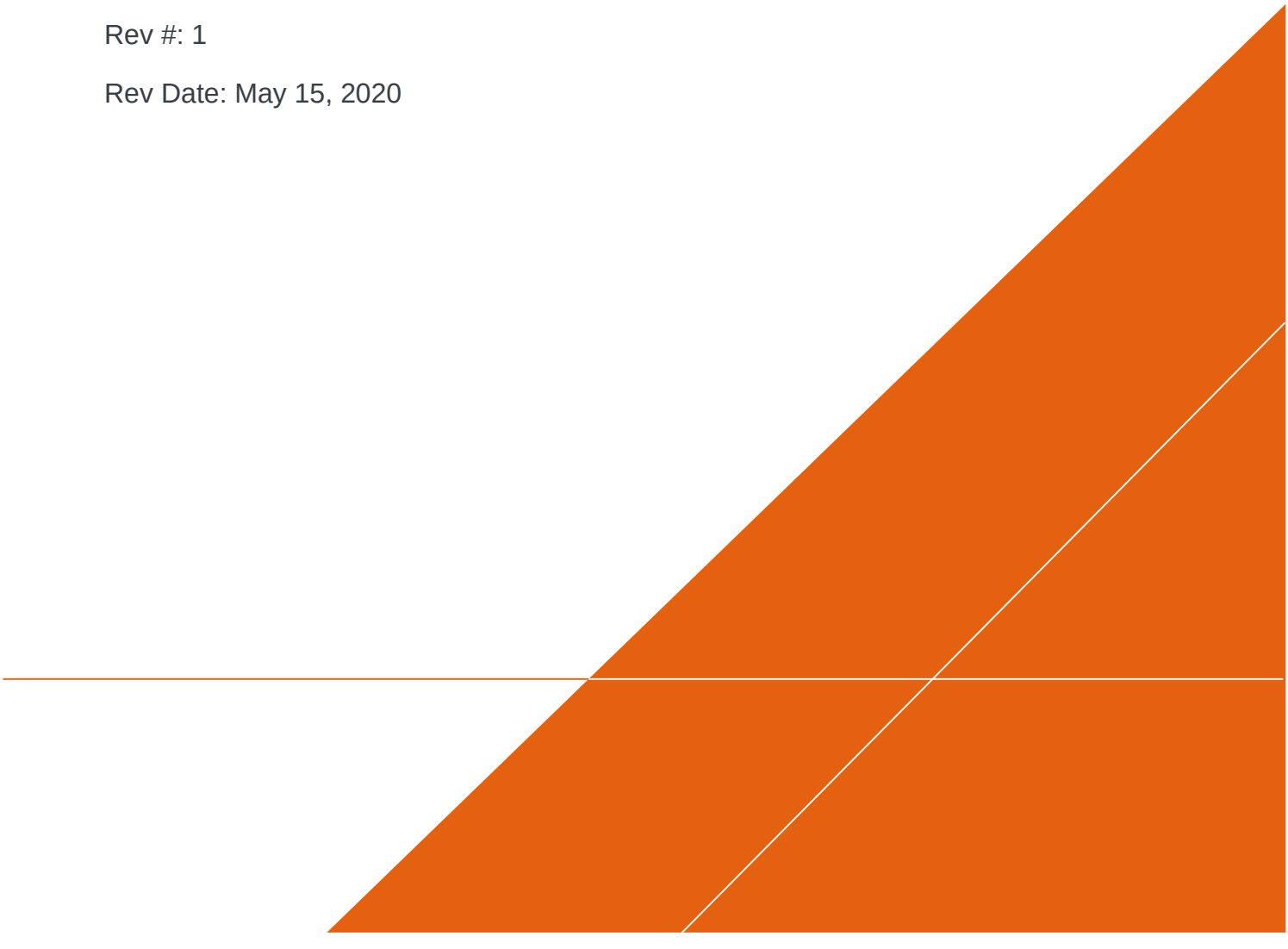
ARCADIS Design & Consultancy for natural and built assets

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.

ARCADIS Design & Consultancy for natural and built assets

TGI – Soil Description

Rev: 4

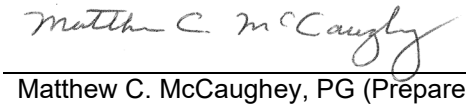
Rev Date: June 14, 2022

Version Control

Issue	Revision No.	Date Issued	Page No.	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
	3	April 15, 2022		Minor description edits, intro of grain-size K analysis, revised boring log template	Matt McCaughey Patrick Curry
	4	June 14, 2022		Updated date on cover page and header. Updated revision number from 3 to 4. Updated reference throughout document from ASTM D2488-06 to ASTM D-2488.17 . Change “25% silt and clay; 15% pebbles” to “20% silt and 20% clay” on page 10 of 23. Updates made to Section 8.2.1 Changed reference to Appendix B to Appendix A	

Approval Signatures

Prepared by: 6/14/2022



Matthew C. McCaughey, PG (Preparer) Date

Reviewed by: 6/14/2022

Patrick Curry, PG (Subject Matter Expert) Date

1 Introduction

This Arcadis Technical Guidance Instruction (TGI) describes proper soil description procedures based on visual inspection and testing of soil cores and samples. This document 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.

2 Intended Use and Responsibilities

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

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

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

3 Scope and Application

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 incorporates elements from various standard systems such as ASTM D-2488-17, Unified Soil Classification System, Burmister and Udden 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 includes the following attachments:

- **Attachment A –** Field Soil Description Guide
- **Attachment B –** Particle Size System Comparison
- **Attachment C –** Description of Logging Terms
- **Attachment D –** Blank Boring Log
- **Attachment E –** Completed Boring Log

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.

4 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.

5 Equipment List

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

- Field book, field forms or digital devices 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
- 4-ounce glass jars with lids (for collecting soil core samples)
- Personal protective equipment (PPE), as required by the HASP
- Digital camera

- Folding table

6 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.

7 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.

8 Procedure

8.1 General Procedures

- 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.
- 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.
- Set up boring log field sheet.
    - Determine the proper units of measure. Drillers in both the US and Canada generally work in feet due to equipment specifications. Field geologists typically record drilling depths, core recovery, and sample intervals in feet and grain size in millimeters
    - Use the Arcadis standard boring log form (**Attachment D**). *Note that as of April 2022, several digital logging applications are available through the FieldNow™ program and the Fulcrum app. A future revision of this TGI, likely in early 2023, will emphasize digital logging methods and field boring log forms will no longer be acceptable. FieldNow is discussed further in Section 10.*
    - The boring log template includes a graphic log of the primary soil texture 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.
- Examine each soil core (this is different than examining each sample selected for laboratory analysis) and record the soil conditions in accordance with guidelines provided in Section 8.2.
- At the end of the boring, record the amount of drilling fluid used (if applicable) and the total depth logged.
- At a minimum, a written or digital boring log should be prepared with the following information:
    - Describe type of surface material (asphalt, grass, topsoil, gravel, etc.)
    - Describe the type of fill or non-native soils and estimated depth to native soils
    - Record sample intervals (soil cores, environmental and/or geotechnical samples)
    - Describe soil conditions in accordance with this TGI
    - Record moisture content and estimated depth to water table or saturated zone
    - Record the total depth and document why drilling was stopped (refusal, target depth achieved, etc.)

8.2 Soil Description Procedures

The standard soil description order is presented below.

- Depth
- PRIMARY TEXTURE
- Principal and Minor Components with Descriptors
    - % Modifiers and grain size fraction
    - Angularity for coarse sand and larger particles
    - Consistency or Density
    - Plasticity for silt and clay
    - Dilatancy for silt and silt-sand mixtures
- Sorting
- Moisture Content
- Color
- Notes

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

- 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.
- 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., 36/60 for 36 inches recovered from 5-ft [60-inch] sampling interval).
- Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.
- 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 36/60 bottom 12 inches of core 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: SAND, fine; 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 class differs from the next larger 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 A**) that shows Udden-Wentworth scale or by measuring with a ruler.

The following table summarized the modified Udden-Wentworth Scale for grain size classification. Note that gravel is a size category encompassing the granule, pebble, cobble, and boulder size classes.

Udden-Wentworth Scale (Modified by Arcadis, 2008)				
Size Category	**Size Class**	**Millimeters**	**Inches**	**Standard Sieve #**
Gravel (Cobble)	Boulder	256 – 4096	10.08+	
	Large cobble	128 - 256	5.04 -10.08	
	Small cobble	64 - 128	2.52 – 5.04	
Gravel (Pebble)	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

Sand	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
Fines	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	0.00002 – 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.

Sieve and hydrometer grain-size analysis can be used to vet the visual description, as well as used to estimate hydraulic conductivity. Lab or field sieve analysis is advisable to characterize the variability and facies trends within each hydrostratigraphic unit. It is recommended that sieve-hydrometer analysis be performed on representative samples from each soil type to estimate the fraction of each grain size category using ASTM D422 Standard Test Method for Particle-Size Analysis of Soils. If desired sieve sizes can be specified to follow the Udden-Wentworth classification (U.S. Standard sieve 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.

Several empirical formulas provide a reliable means of estimating hydraulic conductivity (K) from grain-size distribution data, provided that the formation does not contain abundant fines that result in cohesive or plastic behavior or include cobble-sized grains (Payne et al. 2008). Grain-size analysis can help bracket the permeability of hydrostratigraphic units (HSUs) and identify order-of-magnitude spatial variations in K. Arcadis has completed modifications to the Excel-based program HydroGeoSieveXL (Devlin 2015) to process sieve data quickly and estimate K. The tool calculates estimated K values from grain-size data using 15 different empirical formulas. A decision matrix then selects which of the formulas is relevant for the soil type and calculates an average K.

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% small to medium pebbles would be “PEBBLES, small to medium”; 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”.

The boring log form (**Appendix D**) includes a graphic log to visually illustrate a relative estimate of soil permeability. To use the graphic log, place an ‘X’ or shade the appropriate column for the primary soil texture. If the soils have a high percentage of a secondary soil texture (i.e., when the ‘and’ modifier’ is used), it’s acceptable to mark off the appropriate column for the secondary soil texture in this instance. However, care should be used to avoid marking off the columns for other minor soil textures because doing so will make it difficult to determine the relative soil permeability of the poorly sorted soils.

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.

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, 20% silt and 20% clay – there are two identified minor components: silt and clay.

Include a standard modifier to indicate percentage of minor components (see particle size table) and the same descriptors that would be used for a principal component. An example of minor constituents with modifiers include: some silt and clay, low plasticity; little medium to large pebbles, sub-round.

8.2.1 Secondary Descriptors

The following are the descriptors used outside of the principal and minor components. Note that 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.

Angularity. Describe the angularity for coarse sand and larger particles in accordance with the table below (ASTM D-2488-17). Figures showing examples of angularity are available in ASTM D2488-17 and the Arcadis Soil Description Field Guide (**Appendix A**).

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Sub-Angular	Particles are like 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-2488-17).

- As in the dilatancy test (described 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-2488-17).

- 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.

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:

Description	Criteria
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).

Consistency or Density. This can be determined by standard penetration test (SPT) blow counts (ASTM D-1586) obtained when using hollow-stem auger drilling methods and a split spoon sampling device. Otherwise, some field tests are available as outlined 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. For example, for a 24-inch split spoon soil core, the recorded blows per 6-inch interval are: 4/6/9/22. Since the second interval is 6" to 12", 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	Blow Counts (6-12 to 12-18-inch split spoon interval)
Very soft	Easily penetrated several inches by thumb	N-value < 2
Soft	Easily penetrated one inch by thumb	N-value 2-4
Medium Stiff	Indented about ½ inch with much effort	N-value 5-8
Stiff	Indented with ¼ inch with great effort	N-value 9-15
Very Stiff	Readily indented by thumbnail	N-value 16-30
Hard	Indented by thumbnail with difficulty	N-value > than 30

Coarse-grained soil – Density

Description	Criteria	Blow Counts (6-12 to 12-18-inch split spoon interval)
Very loose	Density classification of coarse-grained soils is only required when blow counts from standard penetration tests are performed during hollow-stem auger drilling	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

Moisture Content. Moisture content should be described for each soil sample in accordance with the table below (percentages should not be used unless determined in the laboratory). *Note that some drilling methods (e.g., sonic) can compress and dry out the sample during drilling. Therefore, it can be difficult to determine if a sample is saturated, or merely moist. In this case, care should be taken to try and determine a static water level within the borehole by measuring depth to water through the drill casing, if possible.*

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty
Moist	Damp but no visible water
Wet	Visibly free water

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.

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.).

8.3 Example of Soil Descriptions

The standard generic description order is presented below.

- Depth
- PRIMARY TEXTURE
- Principal and Minor Components with Descriptors
    - % Modifiers and grain size fraction
    - Angularity for coarse sand and larger particles
    - Consistency or Density
    - Plasticity for silt and clay
    - Dilatancy for silt and silt-sand mixtures
- Sorting
- Moisture Content
- Color
- Notes

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

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).

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.

9 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.

10 Data Recording and Management

10.1 Digital Data Collection Process Overview

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

10.2 Digital Data Collection Tools for Soil Descriptions

Arcadis is transitioning from the use of paper forms to a digital soil description logging process using web-based FieldNow applications accessible on field tablets and smart phones. Company-wide roll out of a FieldNow application for soil descriptions is targeted by the end of 2022.

Paper forms are included in Revision 3 (April 2022) of this Soil Description TGI. Specifically, a blank boring log and completed boring log are provided in **Attachment D** and **Attachment E**. Additional guidance and examples of the digital data collection tools for soil descriptions will be provided in the next revision to this TGI.

10.3 Additional Guidance

The general logging scheme for soil descriptions is described in this document. Depending on project data quality objectives, specific soil description parameters that are not applicable to project goals may be omitted at the project manager's discretion. In any case, use of consistent procedures 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. Photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or logbook and a label showing this information in the photo is useful.

For projects involving soil logging and soil sampling, the soil sample should be recorded on the Arcadis boring log form and the field logbook based on Data Quality Objectives for the task/project.

11 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.

12 References

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

ASTM D-2488-17, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

ASTM D422, 63rd Edition, 1972 - Standard Test Method for Particle-Size Analysis of Soils.

Devlin, J.F. 2015. HydroGeoSieve XL: an Excel-based tool to estimate hydraulic conductivity from grain-size analysis. Hydrogeology Journal, DOI 10.1007/s10040-015-1255-0.

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

Payne, F. C., Quinnan, J. A., & Potter, S. T. 2008. Remediation Hydraulics. Boca Raton: FL: CRC Press.

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.

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.”

NIOSH Pocket Guide to Chemical Hazards.

Attachment A

Soil Field Reference Guide

The purpose of this attachment is to present a field reference guide for use during soil logging. Field staff are encouraged to bring a laminated copy of this reference guide into the job site.

SOIL DESCRIPTION FIELD GUIDE (APRIL, 2022; REV. 3.0)

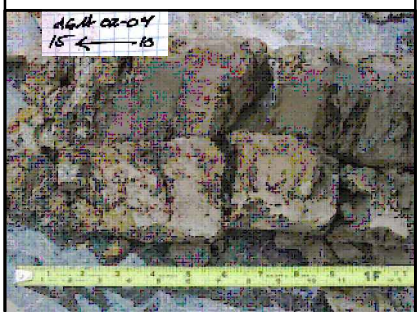
ARCADIS Design & Consultancy for natural and built assets

FINE-GRAINED SOILS

Description	Criteria
	Descriptor - Plasticity
Nonplastic	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.
	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, trace silt, trace small to very large pebbles, subround to subangular up to 2" diameter; medium to high plasticity, stiff, moist, 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
PRIMARY TEXTURE (e.g., SAND)
Principal and Minor Components with Descriptors:
- % Modifiers and grain size fraction
- Angularity coarse sand and larger
- Consistency or Density
- Plasticity for silt and clay
- Dilatancy for silt and silt-sand

Sorting for granular sediments
Moisture Content
Color
Other NOTES

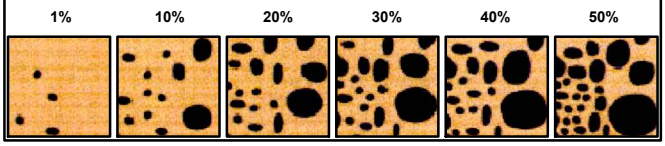
MINOR COMPONENTS % MODIFIERS

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

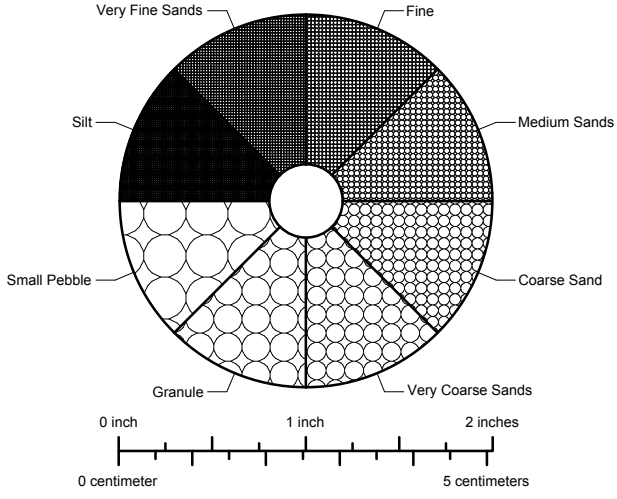
UDDEN-WENTWORTH SCALE

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



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 (10YR 5/2).

SOIL DESCRIPTION FIELD GUIDE (APRIL, 2022; REV. 3.0)

ARCADIS Design & Consultancy for natural and built assets

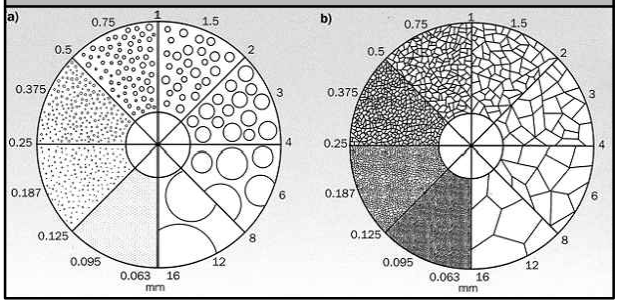
VARIATIONS IN SOIL STRATIGRAPHY

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.

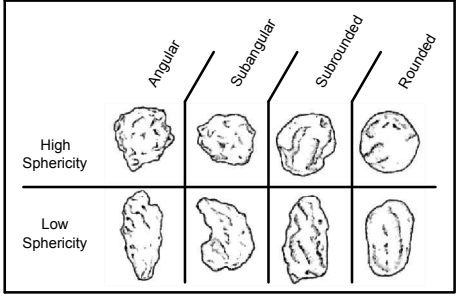
SOIL STRUCTURE DESCRIPTIONS

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.

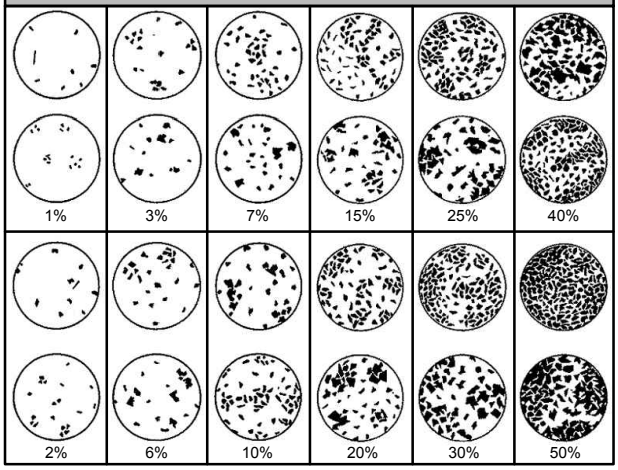
GRAPH FOR DETERMINING SIZE OF PARTICLES



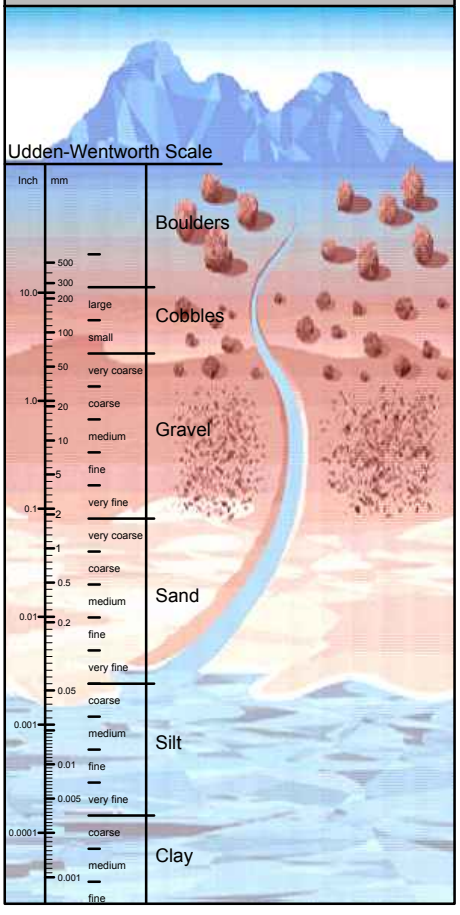
ANGULARITY CHART



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	

Attachment B

Particle Size System Comparison

The purpose of this attachment is to illustrate how the Udden-Wentworth particle sizes and descriptive terms compares to other particle size systems.

When in the field, it is a customary practice to compare current soil descriptions to historical soil boring logs for reference purposes. When reviewing boring logs prepared by others, field staff should first note the particle size system used and recognize these particle size systems may differ. This will avoid confusion when cross referencing between historical and new boring logs and when reviewing existing geologic cross-sections.

For example, a well-sorted sand with grain sizes ranging from 1 to 2 mm should be classified as a very coarse sand by the Udden-Wentworth system. As shown in this attachment, the same particle size would be classified as a medium sand by the United Soil Classification System. The later system has fewer particle size grades and in general, is less descriptive than the Udden-Wentworth system.

PARTICLE SIZE SYSTEM COMPARISON

Grain size distribution in millimeters (mm)

Udden-Wentworth — Remediation Geologists and Engineers

		V. Fine	Fine	Medium	Coarse	V. Coarse	Granule	Pebbles				Cobbles		
								Small	Medium	Large	V. Large	Small	Large	
CLAY	SILT	SAND					GRAVEL							
0.039	0.065	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	
	1/16	1/8	1/4	1/2										

United Soil Classification System — Geotechnical Engineers

		Fine	Medium	Coarse	Fine	Coarse	
CLAY	SILT	SAND			GRAVEL		COBBLE
	0.074	0.42		2	4.75	19	75	300

U.S. Dept. of Agriculture — Soil Scientists

		V. Fine	Fine	Medium	Coarse	V. Coarse	
CLAY	SILT	SAND					GRAVEL
0.002	0.05	0.10	0.25	0.5	1	2	75

Remediation Hydraulics 2008, page 195): The Udden-Wentworth scale is preferred "...because the geometric progression of grain-size diameter also reflects relationships that are important when considering the erosion and deposition of sediments during the depositional process. The correlation between increasing grain size and degree of sorting and permeability is the most important, as permeability structure is responsible for the mobile and immobile porosity within aquifer systems. "

Attachment C

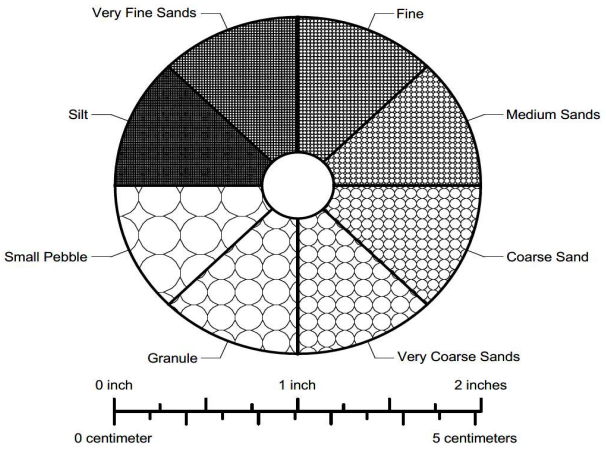
Description of Soil Logging Terms

The purpose of this attachment is to concisely define the soil logging terms used when filling out boring logs. During report preparation, project staff could use this sheet as an index placed in front of the completed boring logs. Also, it can serve as a supplemental reference sheet during field activities.

Description of Logging Terms

Note: Soil descriptions based on Arcadis Technical Guidance and Instructions (TGI) procedures. Key terms defined below.

GRAPH FOR DETERMINING SIZE OF PARTICLES



Udden Wentworth Soil Sizes

Boulder	> 256 mm
Large Cobble	128 to 256 mm
Small Cobble	64 to 128 mm
Very Large Pebble	32 to 64 mm
Large Pebble	16 to 32 mm
Medium Pebble	8 to 16 mm
Small Pebble	4 to 8 mm
Granule	2 to 4 mm
Very Coarse Sand	1 to 2 mm
Coarse Sand	0.5 to 1 mm
Medium Sand	0.25 to 0.5 mm
Fine Sand	0.125 to 0.25 mm
Very Fine Sand	0.062 to 0.12 mm
Silt/Clay	<0.065 mm

Primary Texture *(e.g. CLAY, SILT, SAND, GRANULE, PEAT, MUCK, FILL, etc.)*
List particle size with the highest percentage per sample interval (e.g. SAND)
Always CAPITALIZE the primary texture
Follow primary texture with a comma followed by grain-size descriptors, etc.

Minor Texture

And	(36 to 50%)
Some	(21 to 35%)
Little	(10 to 20%)
Trace	(>10%)

Angularity

Angular	Sharp edges
Sub-Angular	Rounded edges
Sub-Rounded	Well-rounded
Rounded	Smooth curved edges

Sand Density (Blow Counts/ft)

Very Loose	0-4
Loose	5-10
Medium Dense	11-30
Dense	31-50
Very Dense	<50

Silt/Clay Consistency (Blow Counts/ft)

Very Soft	0-2,	thumb easily penetrates several inches
Soft	3-4,	thumb easily penetrates one inch
Medium Stiff	5-8,	thumb indents 0.5 in. with much effort
Stiff	9-15,	thumb indents 0.25 in. with great effort
Very Stiff	16-30,	thumbnail is readily intended

Sorting

Well Sorted	1 to 3 Particle Sizes
Poorly Sorted	4+ Particle Sizes

Moisture Content

Dry	Dry to touch
Moist	No visible water
Wet	Visible free water

Plasticity (for silts and clays)

Non-Plastic	3 mm thread can not be rolled
Low Plasticity	3 mm thread can barely be rolled
Medium Plasticity	3 mm thread can easily and quickly rolled, but not rerolled
High Plasticity	3 mm thread can be rolled slowly, but can be rerolled

Dilatancy (for silts and silt-sand mixtures)

None	No visible change in the specimen
Slow	Water appears slowly during shaking / disappears slowly or not at all upon squeezing
Rapid	Water appears quickly during shaking / disappears quickly upon squeezing

Example Description

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).

Attachment D

Blank Boring Log

The purpose of this attachment is to present a blank field form for use during soil logging. A digital version (Microsoft Excel) of this field form is available from the authors (upon request). If project specific modifications to this boring log template are warranted, please contact the Site Investigation Community of Practice leader for further assistance.

BORING LOG

ARCADIS

Boring ID:		**Project Name:**		**Page:**	/
Permit ID:		**Date Started:**		**Ground Elevation:**	
Site Address:		**Date Completed:**		**Vertical Datum:**	
City, State:		**Total Depth:**		**Northing:**	
Drilling Co:		**Depth to Water:**		**Easting:**	
Driller:		**Hole Diameter:**		**Horizontal Datum:**	
Drilling Method:		**Core Device:**		**Prepared by:**	
Boring Status:		**Drilling Fluid:**		**Reviewed by:**	

Drilling Information				Graphical Log for Primary Texture									Soil Description (Udden-Wentworth System)	Field Notes
				Fines		Sand					Gravel			
Drilling Depth (ft bgs)	Core Interval (ft)	Core Recovery (inches)	Vapor Reading (ppm)	clay	silt	very fine	fine	medium	coarse	very coarse	granule	pebble	cobble	boulder	Depth Interval (ft), PRIMARY TEXTURE, Principal and Minor Components with Descriptors (% modifiers and grain size fraction, angularity for coarse sand and larger, consistency/density, plasticity for silt and clay, dilatancy for silt/silt-sand); Sorting, Moisture Content, Color. NOTES: *Texture Modifiers: Trace (<10%), Little (10 to 20%), Some (21 to 35%), And (36 to 50%)*	Driller's Observations, Geologic Formation, Field Screening Results, Sample Interval etc.

BORING LOG

Boring ID: _____ **Project Name:** _____ **Page:** _____ / _____

Drilling Information				Graphical Log for Primary Texture										Soil Description (Udden-Wentworth System)	Field Notes
				Fines		Sand					Gravel				
Drilling Depth (ft bgs)	Core Interval (ft)	Core Recovery (inches)	Vapor Reading (ppm)	clay	silt	very fine	fine	medium	coarse	very coarse	granule	pebble	cobble	boulder	Depth Interval (ft), PRIMARY TEXTURE, Principal and Minor Components with Descriptors (% modifiers and grain size fraction, angularity for coarse sand and larger, consistency/density, plasticity for silt and clay, dilatancy for silt/silt-sand); Sorting, Moisture Content, Color. NOTES: *Texture Modifiers: Trace (<10%), Little (10 to 20%), Some (21 to 35%), And (36 to 50%)*	Driller's Observations, Geologic Formation, Field Screening Results, Sample Interval etc.

Attachment E

Completed Boring Log

The purpose of this attachment is to provide an example of a completed boring log for reference purposes to field staff. The example provided is for a soil boring completed outside the waste mass of a closed municipal landfill near Baltimore, Maryland. The objective of the drilling program was to determine the depth to groundwater to determine the appropriate depth interval to install a soil gas monitoring well and groundwater monitoring well across the first water-bearing zone. The site geology consists of unconsolidated sediments of the Mid-Atlantic Coastal Plain, specifically the Upper Patapsco formation. These sediments were deposited in a moderate gradient fluvial environment during the Cretaceous period. The landfill was constructed into a regional clay confining unit.

BORING LOG

ARCADIS

Boring ID:	MW-08	**Project Name:**	Acme Landfill	**Page:**	1 / 1
Permit ID:	MD-PG-100	**Date Started:**	7/18/2018	**Ground Elevation:**	50.5 ft
Site Address:	100 Landfill Road	**Date Completed:**	7/18/2018	**Vertical Datum:**	NAVD 88, feet
City, State:	Baltimore, Maryland	**Total Depth:**	35 ft below ground	**Northing:**	123456.79
Drilling Co:	Earth Matters	**Depth to Water:**	19 ft below ground	**Easting:**	123456.79
Driller:	Rod E. Piper	**Hole Diameter:**	2-inch	**Horizontal Datum:**	NAD 83 feet, MD State
Drilling Method:	Direct-push/hollow-stem	**Core Device:**	5-foot macrocore sampler	**Prepared by:**	Sandy Pebbles
Boring Status:	completed as well	**Drilling Fluid:**	none	**Reviewed by:**	Clay Brown

Drilling Information				Graphical Log for Primary Texture										Soil Description (Udden-Wentworth System)	Field Notes
				Fines		Sand					Gravel				
Drilling Depth (ft bgs)	Core Interval (ft)	Core Recovery (inches)	VOC Vapor Reading (ppm)	clay	silt	very fine	fine	medium	coarse	very coarse	granule	pebble	cobble	boulder	Depth Interval (ft), PRIMARY TEXTURE, Principal and Minor Components with Descriptors (% modifiers and grain size fraction, angularity for coarse sand and larger, consistency/density, plasticity for silt and clay, dilatancy for silt/silt-sand); Sorting, Moisture Content, Color. NOTES: *Texture Modifiers: Trace (<10%), Little (10 to 20%), Some (21 to 35%), And (36 to 50%)*	Driller's Observations, Geologic Formation, Field Screening Results, Sample Interval etc.
0 to 1			< 1												0-0.5 ft, topsoil with organics	Grass covered area
1 to 2			< 1				X								0.5-5 ft, SAND, fine, trace silt, trace pebble, round; poorly sorted, moist, yellowish brown (7.5 YR 5/8). NOTE: some cementation, does not react with HCl	continuous macro-core logging
2 to 3	0-5	43.2/60	< 1				X									
3 to 4			< 1				X									cemented sand @3.6-4 ft
4 to 5			< 1				X									
5 to 6			< 1				X	X	X						5-10 ft, SAND, fine to coarse, round to subround; well sorted, moist, light to strong brown (7.5 YR 6/4 to 7.5 YR 5/6).	
6 to 7			< 1				X	X	X							
7 to 8	5-10	40.8/60	< 1				X	X	X							
8 to 9			< 1				X	X	X							
9 to 10			< 1				X	X	X							
10 to 11			< 1				X	X	X						10-12.5 ft, same as above with trace silt	
11 to 12			< 1				X	X	X							
12 to 13	10-15	36/60	< 1				X	X	X							
13 to 14			< 1				X	X	X						12.5 to 15 ft, same as above, color change to pink (7.5 YR 7/3) and reddish yellow (7.5YR 6/8)	
14 to 15			< 1				X	X	X							
15 to 16			< 1						X	X					15-18.9 ft, SAND, coarse to very coarse, round to subround; well sorted, moist, strong brown (7.5YR 5/6) to reddish yellow (7.5YR 6/6)	
16 to 17			< 1						X	X						
17 to 18	15-20	55.2/60	< 1						X	X						
18 to 19			< 1		X	X	X								18.9-22.7 ft, SAND, very fine to fine, and SILT, coarse to very coarse, poorly sorted, wet, light gray (7.5YR 7/1)	water table encountered @ 18.9 ft
19 to 20			< 1		X	X	X									
20 to 21			< 1		X	X	X									
21 to 22			< 1		X	X	X									
21 to 23	20-25	36/60	< 1		X	X	X									
23 to 24			< 1	X	X										22.7-25 ft, CLAY and SILT, high plasticity, soft to stiff at 25 ft, dry to moist, light gray (2/5YR 7/1) w/ red mottling (2.5YR 4/6)	Middle Patapsco Confining Unit
24 to 25			< 1	X	X											
25 to 26			< 1	X	X										25-31.1 ft, CLAY and SILT, high plasticity, stiff; dry to moist, light gray (2/5YR 7/1) with red mottling (2.5YR 4/6)	
26 to 27			< 1	X	X											
27 to 28	25-30	30/60	< 1	X	X											
28 to 29			< 1	X	X											
29 to 30			< 1	X	X											
30 to 31			< 1	X	X											
31 to 32			< 1		X											
32 to 33	30-35 ft	60/60	< 1		X											
33 to 34			< 1		X										31.1-35 ft, SILT, low plasticity, high dilatancy; wet, gray (7.5YR 7/1)	End of direct-push boring @ 35 ft
34 to 35			< 1		X											

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Appendix B

Health and Safety Plan

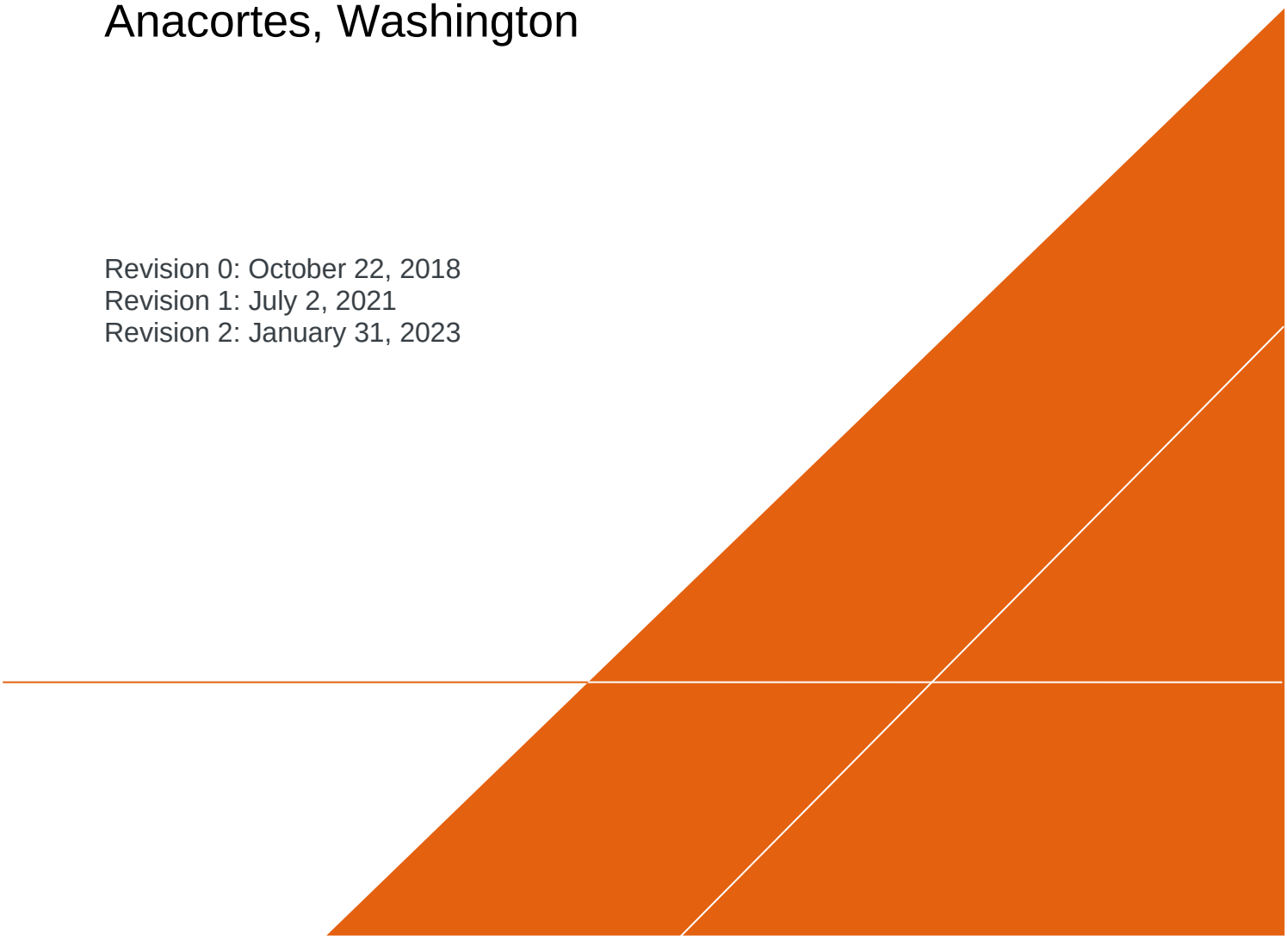
ARCADIS Design & Consultancy for natural and built assets

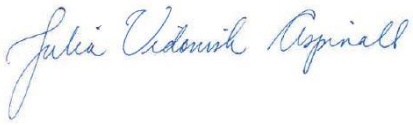
USCG

Site Specific Health and Safety Plan

Burrows Island Light Station
Anacortes, Washington

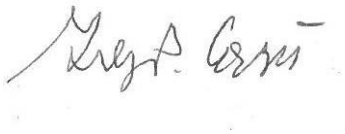
Revision 0: October 22, 2018
Revision 1: July 2, 2021
Revision 2: January 31, 2023





Julia Vidonish Aspinall

HASP Preparer



Grey Coppi

HASP Reviewer

Paul McCullough

Project Manager

SITE SPECIFIC HEALTH AND SAFETY PLAN

Burrows Island Light Station

Anacortes, Washington

Prepared by:

Arcadis U.S., Inc.

1100 Olive Way

Suite 800

Seattle

Washington 98101

Tel 206 325 5254

Fax 206 325 8218

Our Ref.:

30092874

Date:

October 22, 2018

Revised January 31, 2023

VERSION CONTROL

This Health and Safety Plan (HASP) must be reviewed annually and revised when conditions on the project site change and the change is not addressed by this HASP or if a new task is conducted that is not addressed by this HASP.

Issue	Revision No	Date Issued	Page No	Description	Reviewed by
	0	10/22/2018		Original HASP	Grey Coppi
	1	6/29/2021		Updated for Phase III Field Events	Grey Coppi
	2	1/31/2023		Updated signatories, project roles, and phone numbers	Mark Ullery

Contents

Appendices

ACRONYMS AND ABBREVIATIONS

AST	aboveground storage tanks
CIH	Certified Industrial Hygienist
CoCs	constituents of concern
CMV	commercial motor vehicles
CSP	Certified Safety Professional
EAP	Emergency Action Plan
FHSHB	Field H&S Handbook
GVWR	gross vehicle weight rating
H&S	health and safety
HARC	Hazard Assessment and Risk Control
HASP	Health and Safety Plan
HAZCOM/GHS	Hazard Communication/ Globally Harmonized System
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDW	Investigation Derived Waste
JSA	job safety analysis
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
ppm	parts per million
ROW TSP	Right-of-Way Traffic Safety Plan
SDS	safety data sheet
SSE	short-service employees
SSO	Site Safety Officer
THA	Task Hazard Analysis
TIP	Task Improvement Process

CULTURE OF CARING CERTIFICATION

Arcadis is committed to a Culture of Caring that ensures each Arcadis employee and contractor goes home at the end of the day free from injury or illness. I certify that the following has been performed with all Arcadis field staff on this project either in person or by Skype:

☐ Reviewed the HASP, including a discussion of hazard identification and controls.

- ☐ If conducting activities deemed by Arcadis to be "High Risk," frontline management has reviewed applicable H&S standards (job safety analyses [JSA] when authorized by H&S) for these activities with field staff.
- ☐ If permit to work is required, frontline management has reviewed the permit(s) with field staff.

☐ Reviewed proactive H&S engagement expectations/injury prevention actions.

☐ Reviewed Stop Work Authority.

☐ Reviewed the incident reporting process and expectations including when WorkCare should be contacted by staff (WorkCare incident intervention for all minor, non-emergency injuries) and that the WorkCare phone number is programmed into field team cell phone.

For short-service employees (SSE) (0-1 years with Arcadis):

☐ Provided coaching and mentoring on Arcadis H&S expectations during project work. Reviewed - in detail - specific hazards and controls and provided a resource who can be contacted if SSE has questions regarding planned or unplanned work tasks.

Resource Name:
Phone Number:

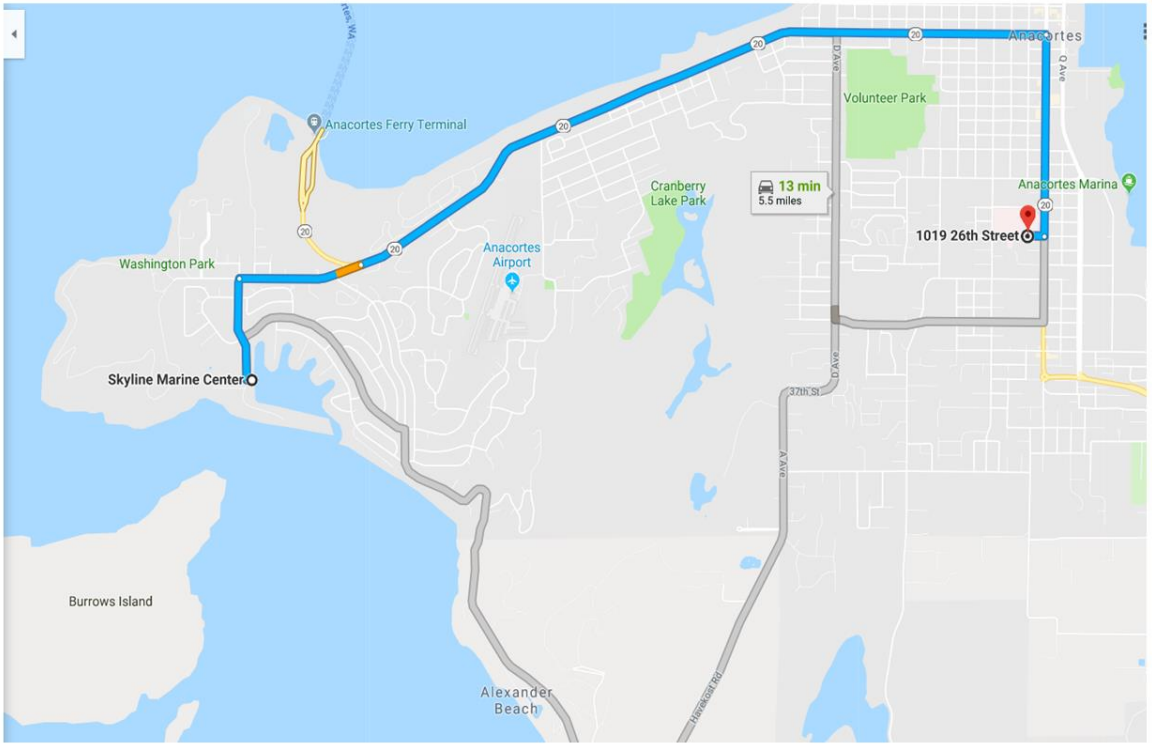
_____

Signed

1 EMERGENCY ACTION PLAN

1.1 Route to the Hospital

Directions from Skyline Marine Center to Island Hospital (ER entrance is on 26th St.)



Skyline Marine Center
(2011 Skyline Way, Anacortes, WA 98221)

1. Head north on Skyline Way towards Kingsway (0.4 mi)/.
2. Turn right onto Sunset Ave (0.5 mi).
3. Slight right onto WA-20 Spur E (3.1 mi)
4. Turn right onto Commercial Ave (0.8 mi).
5. Turn right onto 26th St. (367 ft).

The ER entrance to Island Hospital is located at 1019 26th St.

1.2 Helicopter Pad Location

The Burrows Island Light Station (Site) has a helicopter pad. Urgent emergencies should call 911 to procure helicopter transport to the hospital, while minor emergencies can use boat transport to reach the Skyline Marine Center before continuing to the hospital by road.

Helicopter pad coordinates: 48.478149, -122.713351

1.3 Hospital Information

The designated hospital for this project is provided below.

Hospital name: Island Hospital

Hospital address: 1211 24th Street, Anacortes, WA 98221

Hospital phone: 360.299.1300

The Emergency Department of Island Hospital can be reached directly at 360.299.1311 and has a separate entrance at 1020 26th St., Anacortes, WA 98221.

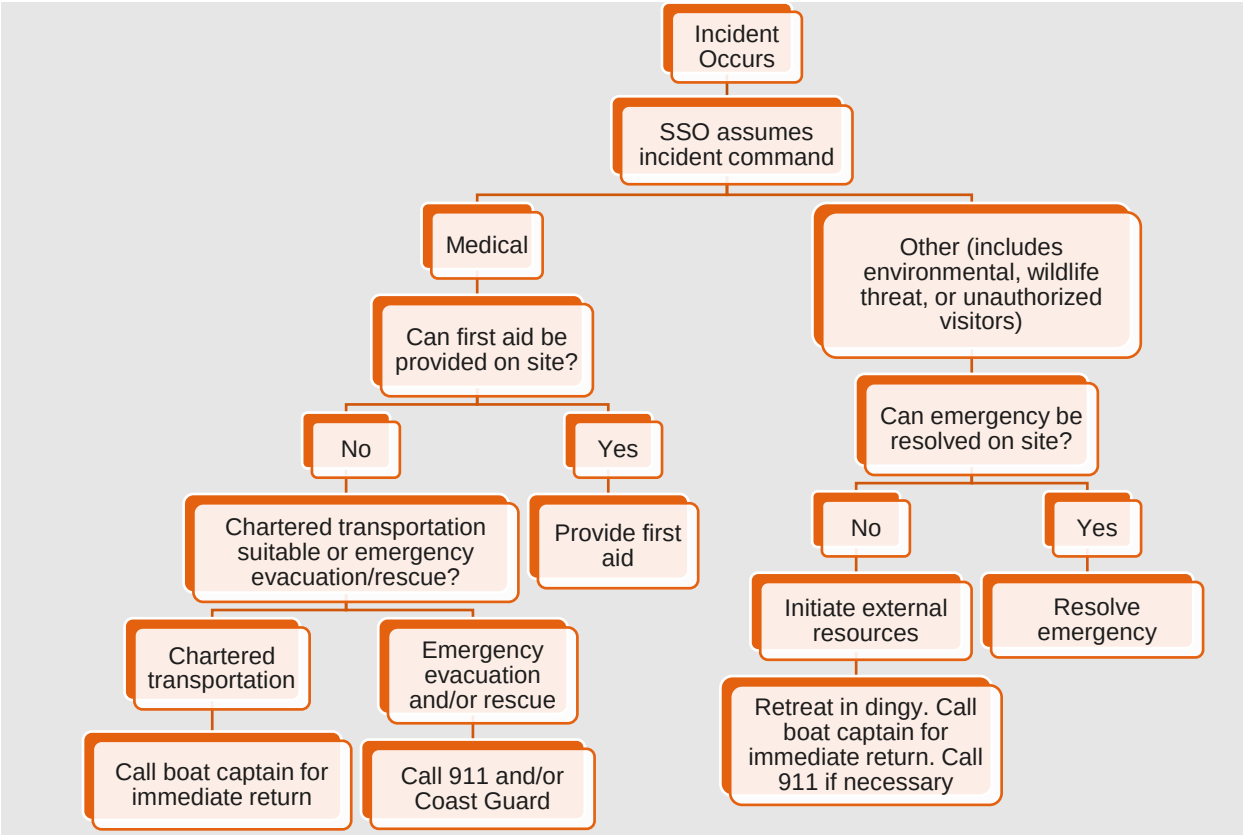
1.3 Emergency Contact Information and Procedures

Local Police	911
Local Ambulance	911
Local Fire Department	911
Local Hospital	360.299.1300 (General) 360.299.1311 (Emergency Dept. Direct)
Local Weather Data	Weather.com
Poison Control	800.222.1222
National Response Center (all spills in reportable quantities)	800.424.8802
Washington State Division of Emergency Management (24-hour response for spills of any quantity)	800.258.5990
U.S. Coast Guard (spills to water or other water emergency)	800.424.8802
Arcadis Project Manager – Paul McCullough	206.214.7161 (Cell)
Arcadis Corporate H&S Director – Andrew McDonald	410.923.7820

Arcadis Federal H&S Lead – Grey Coppi (SHM)	908.917.6948
Arcadis Site Safety Officer (SSO) – Mark Ullery or alternate	360.292.8990 (cell)
Client Primary Contact – Erin Hale	510.637.5567
Client Backup Contact – Karen Ladd	510.637.5522
Island Express Charters (primary contact: Scott Carden)	360.299.2875 (call or text)
WorkCare	888.449.7787

Use the following notification procedure in the event of an emergency:

- Step 1: Contact the Site Safety Officer (SSO).
- Step 2: SSO will determine the nature of the incident (medical or other).
- Step 3: SSO will ensure that the incident site is safe to enter and secure.
- Step 4: SSO will evaluate the severity of the incident.
- Step 5: If the incident is deemed minor, first aid will be applied as suitable, and WorkCare will be contacted. If the incident is deemed serious, the SSO will contact the chartered boat captain for immediate return to Washington Island or will call 911 and/or the Coast Guard for emergency services.
- Step 6: SSO will contact the Arcadis Project Manager (PM; Paull McCullough).
- Step 7: Arcadis PM with contact corporate H&S Director (Andrew McDonald).
- Step 8: Arcadis PM will contact client.
- Step 9: SSO will photograph incident site, complete witness statements, and initiate preliminary investigation.


Incident Occurs
SSO assumes incident command
Medical
Other (includes environmental, wildlife threat, or unauthorized visitors)
Can first aid be provided on site?
Can emergency be resolved on site?
No
Yes
No
Yes
Chartered transportation suitable or emergency evacuation/rescue?
Provide first aid
Initiate external resources
Resolve emergency
Chartered transportation
Emergency evacuation and/or rescue
Retreat in dingy. Call boat captain for immediate return. Call 911 if necessary
Call boat captain for immediate return
Call 911 and/or Coast Guard

1.4 Emergency Supplies and Equipment List

Emergency supplies and equipment for specific tasks are presented on job safety analyses (JSAs) for the task. The following supplies and equipment are applicable to all tasks performed on the project.

Emergency Supplies and Equipment		Location on Project Site
X	First-Aid Kit (type)	Field Supply Staging Area
X	Fire Extinguisher ABC 10 lb (no less than two units)	Field Supply Staging Area
X	Mobile Phone	Each field staff will have mobile phone
X	Water or Other Fluid Replenishment	Field Supply Staging Area
X	Eye Wash Bottle	Field Supply Staging Area
X	Wash and Dry Towelettes	Field Supply Staging Area
X	Sunscreen (SPF 15 or higher)	Field Supply Staging Area
X	Permethrin for tick repellent	Field Supply Staging Area
X	*Other (specify):* Personal Floatation Device	Field Supply Staging Area

2 INTRODUCTION

2.1 General

All work on this project will be carried out in compliance with Arcadis' H&S standards, and the Occupational Safety and Health Administration's (OSHA's) Hazardous Waste Operations and Emergency Response (HAZWOPER) regulation. The design of this Health and Safety Plan (HASP) conforms to the requirements of the ARC HSFS010-H&S Plan Standard. Specific H&S information for the project is contained in this HASP. All personnel working on hazardous operations or in the area of hazardous operations shall read and be familiar with this HASP before doing any work. All project personnel shall sign the Certification page acknowledging that they have read and understand this HASP.

Changes in the scope of the project or introduction of new hazards to the project shall require revision of the HASP by the HASP writer and reviewer, and approval by the Project Manager.

2.2 HASP Structure

This HASP contains important information related to this project in appendices. Review of relevant appendix information is important to ensure work is conducted safely on the project site. The following appendices are included in this HASP with a summary of their contents:

- Appendix A – Task Hazard Analysis (THA): This appendix contains an analysis of the hazards and controls to be used for tasks performed on this project.
- Appendix B – Job Safety Analyses and Permits: This appendix contains all the project JSAs. If a H&S Standard is required to be attached to this HASP, the standard will also be located in this appendix. Some JSAs include mark-ups during previous Burrows Island field events.
- Appendix C – Hazard Communication/Globally Harmonized System (HAZCOM/GHS): This appendix contains a list of chemicals used on the project and safety data sheets (SDSs) applicable to the chemicals used on site.
- Appendix D – Field Forms: This appendix contains all the field forms and checklists staff are expected to use on the project.
- Appendix E – Supplemental Plans: This appendix contains all applicable supplemental plans (e.g., Lone or Remote Worker Plan, Journey Management Plan, COVID-19 Guidance, Tick Safety Share, Washington Heat Plan). Shipping Determinations are also included in this appendix.
- Appendix F – Near Miss Reports from Similar USCG/Arcadis Poverty Island Project: This appendix contains three near miss reports for a similar project performed by Arcadis for the USCG at Poverty Island, Fairbanks Township, Michigan.
- Appendix G – Near Miss Reports and TIPS from 2018 – 2020 USCG Burrows Island Field Mobilizations

2.3 Hierarchy of Administrative Controls

This HASP references several documents that might be used in the field which contain requirements specific to project. Arcadis staff utilizing these documents must implement the requirements (PPE, safety equipment, monitoring equipment) based on the hierarchy specified below (in order of decreasing priority):

1. Permits or supplemental plan templates (if applicable to the task or project)
2. JSAs
3. HASP
4. H&S Standards
5. Field H&S Handbook (FHSHB)

During the tailgate safety briefing, the applicable administrative controls to be utilized for the task/project will be identified, communicated to the field staff, and documented. Requirement changes to a lesser control in a lower hierarchy document requires approval of the HASP reviewer or member of the Corporate H&S Department.

3 PROJECT SITE HISTORY AND REQUIREMENTS

3.1 Site Background

The Site is located on Burrows Island, which is approximately 1.5 miles southwest of Anacortes along the Rosario Strait. Burrows Island covers less than one square mile and is densely forested with approximately 4 miles of jagged and rocky coastline. There is no public ferry service or bridge access to the island, making it only accessible by private boat charter or helicopter. The Site contains a light station, consisting of a lighthouse, a boat house (including a staircase descending to a narrow dock), and a duplex residence on the westernmost point of Burrows Island. Two additional residence buildings are included in previous site plans provided by the Northwest Schooner Society but are no longer present based off review of recent aerial images. The light station was established in 1906 and the light house was automated in 1972, after which no USCG personnel occupied the light station. There are also two former pump houses; a former freshwater pump house with associated groundwater seep northwest of the site along the northern coastal edge and a former salt water pump house along the western edge of the Site.

Currently, there are no permanent or part-time residents at the light station, and the remainder of the island is uninhabited. In 2010, custodianship of the Burrows Island Light Station was conferred to the Northwest Schooner Society, with the intention of restoring and ultimately maintaining the buildings on-site for community access and historical preservation.

Previous environmental investigations indicate the presence of elevated levels of lead in shallow soils from lead-based paint. In 2005, various structures were encapsulated to mitigate further environmental impact from lead-based paint on these existing structures. However, the current effectiveness of the encapsulation is uncertain due to the passage of time and, although some investigations and limited soil removal actions for lead were completed, the extent of lead impacts in shallow soil has not been fully defined.

Additionally, there has been a documented historic release of polychlorinated biphenyl (PCB)-containing oil in the vicinity of a former transformer near the lighthouse. Targeted soil removal actions were undertaken to remove the PCB-affected soil; however, additional PCB-impacted soil may remain at the site. The extent of such impacts, if any, are unknown.

Additionally, the site has historically contained diesel and gasoline products in painted aboveground storage tanks (ASTs) and underground storage tanks (USTs) or partially buried tanks and associated piping. No petroleum impacts have been identified at the site other than the PCB-containing oil at the one location discussed above; however, site-wide assessment is not complete to fully rule out there are no petroleum impacts from the former use of petroleum products at the site.

From 2018 until 2020, Arcadis completed a series of field events as part of a Remedial Investigation, Focused Feasibility Study and remedial design in accordance with CERCLA requirements. Several mobilizations were completed for soil sampling, including XRF screening and incremental composite sampling (ICS) of soils for lead, as well as PCBs and TPH sampling. This HASP was developed for the remedial investigation activities at the site and has been revised for the confirmation sampling and removal action oversight activities in 2021 and 2022. Arcadis will not be conducting the removal action, which will include the use of a crane, barge, and heavy machinery to excavate impacted soils from the

island. Arcadis will perform confirmation soil sampling (discrete and XRF sampling as done in 2018) as well as site-wide dust monitoring during the removal event. As described in Section 14, Simultaneous Operations between Arcadis and soil removal contractors will occur during the project.

3.2 Site Description

	Active		Inactive Industrial	X	Remote Area		Parking Lot/Private Roadway
	Bridge		Active Industrial		Residential		Public Roadway or Right of Way
X	Buildings		Landfill		Retail		Security Risk Site/Location
	Commercial	X	Marine		Service Station		Non-Military Government Installation
	Construction		Mining	X	Utility		
X	Military Installation		Railroad	X	Other: Island		
	Other Specify:						

The contaminants of potential concern are listed below:

Compounds of Concern	Source (soil/water/drum)	Known Concentration Range (ppm, mg/kg, mg/L)	
		Lowest	Highest
Lead	Soil	64 mg/kg	3,470 mg/kg
PCBs	Transformer	1 mg/kg	45 mg/kg
TPH	ASTs	DRO: 30 mg/kg HO: 66 mg/kg	DRO: 2,700 mg/kg HO: 2,900 mg/kg

3.3 List of Project Tasks and Scope of Work

This HASP addresses the following project work tasks:

- Task 1 – Driving
- Task 2 – Mobilization to the island by boat (Island Express Charters)
- Task 3 – Building Inspections and Audits
- Task 4 – Inspection of Non-building areas (Includes site walk of main area [cleared vegetation] and AST/UST area [forested], and stairs [no significant vegetation])
- Task 5 – Soil Sampling with manual tools (discrete soil sampling and XRF analysis)
- Task 6 – Demobilization from the island (including removal of investigation derived waste [IDW])
- Task 7 – Monitoring – Air monitoring using hand-held or stationary equipment – non-radiation
- Task 8 – Contractor oversight of excavation and stair inspection/replacement

3.4 Required Health and Safety Training

Arcadis personnel working under this HASP are required to have the following training:

Staff Required to Have Training	Training
All staff	H&S Program Orientation
All Field staff	HAZCOM/GHS/EAP
All Field staff	Arcadis Defensive Driving (Smith On-Line)
At least one field staff	Fire Extinguisher
All field staff	First Aid/CPR
All field staff	Hazwoper 40 Hour
All field staff	Hazwoper 8-Hour Annual Refresher
At least the SSO	Hazwoper Supervisor
All field staff	Lead General Awareness
Field staff that operate XRF	Ionizing Radiation - General Awareness
Field staff that operate XRF	Thermo Scientific XRF training
At least one field staff	DOT HazMat #1

Subcontractors, particularly the historic architects and archaeological monitors, may not have all hazardous materials and ionizing radiation trainings. Site control measures such as exclusion zones will be enforced as discussed in Section 14 to protect subcontractors from site hazards.

4 ARCADIS ORGANIZATION AND RESPONSIBILITIES

4.1 All Personnel

Every person is responsible for completing tasks safely and reporting any unsafe acts or conditions to their supervisor. No person may work in a manner that conflicts with these procedures. Prior to initiating site activities, all Arcadis and subcontractor personnel will receive training in accordance with applicable regulations and be familiar with the requirements and standards referenced in this HASP. In addition, all personnel will attend daily safety meetings (tailgate meetings) to discuss site specific hazards prior to beginning each day's work. Every Arcadis employee, subcontractor, and client representative at the site has the responsibility to stop the work of a coworker or subcontractor if the working conditions or behaviors are considered unsafe.

4.2 Project Manager/Task Manager

The Project Manager is responsible for verifying that project activities are completed in accordance with the requirements of this HASP. The Project Manager is responsible for confirming that the project has the equipment, materials, and qualified personnel to fully implement the safety requirements of this HASP, and/or that subcontractors assigned to this project, meet the requirements established by Arcadis. It is also the responsibility of the Project Manager to:

- Review with project staff the information required in the Culture of Caring Certification included in this HASP or designate an Associate Project Manager or Task Manager to perform this function.
- Review all applicable H&S standards and confirm that project activities conform to all requirements.
- Obtain client-specific H&S information and communicate with the client on H&S issues.
- Communicate with the Site Safety Officer (SSO) on H&S issues.
- Allocate resources for correction of identified unsafe work conditions.
- Confirm that Arcadis site workers have all training necessary for the project.
- Report all injuries, illnesses, and near-misses to the client representative, lead incident investigations, and confirm that any recommendations made are implemented.

4.3 Site Safety Officer

The SSO has overall responsibility for the technical H&S aspects of the project. Inquiries regarding Arcadis H&S standards, project procedures, and other technical or regulatory issues should be addressed to this individual. It is also the responsibility of the SSO to:

- Review and work in accordance with the components of this HASP.
- Make sure that this HASP is available to and reviewed by all site personnel including subcontractors.
- Validate that necessary site-specific training is performed (both initial and "tailgate" safety briefings).
- Confirm site visitors have been informed of the hazards related to Arcadis work.

- Confirm that work is performed in a safe manner and has authority to stop work when necessary to protect workers and/or the public.
- Coordinate activities during emergency situations.
- Disseminate to other site personnel all necessary permits and safety information provided by the client and confirm that the material is maintained in an organized manner.
- Communicate with the Project Manager, Associate Project Manager, and/or Task Manager on H&S issues.
- Report all injuries, illnesses, and near-misses to the Project Manager, Associate Project Manager, and/or Task Manager.
- Make sure that necessary safety equipment is maintained and used at the site.

5 PROJECT HAZARDS AND CONTROL MEASURES

5.1 Task Hazard Analysis

The scope of work for this project has been subdivided into tasks and each task has been evaluated for hazards using the Hazard Ranking Chart illustrated in Table 1 in accordance with the Arcadis Hazard Assessment and Risk Control (HARC) Health and Safety Standard (AUS HSMS002). Refer to Appendix A for a detailed THA for this project.

Table 1. Hazard Ranking Chart

Risk Assessment Matrix		Likelihood Ratings			
Consequences Ratings		A	B	C	D
People	Property	0 Almost Impossible	1 Possible but Unlikely	2 Likely to Happen	4 Almost Certain to Happen
1-Slight or No Health Effect	Slight or No Damage	0-Low	1-Low	2-Low	3-Low
2-Minor Health Effect	Minor Damage	0-Low	2-Low	4-Medium	6-Medium
3-Major Health Effect	Local Damage	0-Low	3-Low	6-Medium	9-High
4-Fatalities	Major Damage	0-Low	4-Medium	8-High	12-High

5.2 Job Safety Analyses, Permits, and Health and Safety Standards

5.2.1 Job Safety Analyses

A JSA has been completed for each safety-critical task and is included in Appendix B. Some JSAs include mark-ups with lessons learned during the previous field events at Burrows Island in red. Hazards identified in the task hazard analysis (Appendix A) are addressed specifically in the JSAs, as well as control methods to protect employees and property from hazards. The JSA also lists the type of PPE required for the completion of the task or activity. PPE listed in the task-specific JSA will take precedence over PPE requirements listed in Section 5.3.1 of this HASP.

5.2.2 Permits

None of the tasks anticipated for this project will require use of a permit.

5.2.3 H&S StandardsA

Arcadis H&S Standards addressing safety-critical work activities are listed below. These standards should be reviewed by the Project Manager, Associate Project Manager and/or Task Manager, and site personnel prior to start of the project or applicable task to confirm that all requirements are met.

- ARC HSFS019 – Utility Location
- ARC HSGE004 – First Aid/CPR
- ARC HSIH010 – Lead

- ARC HSIH011 – Radiation (Sealed Source Instruments)
- ARC HSFS002 – Water Operations

5.3 Personal Protective Equipment

A5.3.1 General Requirements

PPE requirements are specified in task-specific JSAs and/or permits listed in Appendix B. If the work activity is not performed under a permit or JSA, then all project workers working on site outside of an office must wear, at a minimum:

- Hard hat;
- Safety glasses;
- Safety-toed boot;
- Class II traffic vest;
- Light-colored clothing or duct tape barrier on clothing (to help identify presence of ticks on staff);
- Permethrin-treated clothing (shirt and pant legs tucked to help prevent tick bites);
- Insect spray (at least 20 - 40% DEET) on exposed skin; and
- Type I or II personal flotation device (PFD) when working on or within 6 feet of water.

Regardless of the requirements above, the following PPE marked “R” is required to be available on site for this project:

- Rain gear
- Hard hat
- Traffic Safety Vest (Class II minimum)
- Safety glasses
- Safety boots (steel toe and shank)
- Work gloves (leather)
- Chemical resistant gloves (nitrile and latex)

Subcontractors are required to have the same PPE available on site as the PPE listed above.

5.3.2 Levels of PPE Protection

The following is the level D PPE ensemble which is referenced in this HASP, project-related JSAs/permits, or in H&S Standards:

Level D – Standard work clothing consisting of long pants, shirt with at least a quarter sleeve, hard hat, safety glasses, safety-toed boots, protective gloves, and Class II retroreflective vest (traffic vest).

5.4 Field Health & Safety Handbook

The FHSHB is an Arcadis document containing information about topic-specific H&S requirements for the field. This handbook contains relevant general topics and is used as part of the overall HASP process.

To aid in the consistency of the HASP process, the handbook will be used as an informational source in conjunction with this HASP. Relevant sections of the FHSHB include:

II. Health and Safety Administration

A. ARCADIS Responsibilities

B. Employee Responsibilities

C. Visitors

E. Hazard Identification, Risk Assessment, and Risk Control Process

F. Near Miss, Incident Reporting and Investigation

G. Stop Work Authority

K. Emergency Action Planning

L. WorkCare

III. General Field Health and Safety Requirements

A. Daily Safety Meetings/Tailgates

C. First Aid/Cardiopulmonary Resuscitation

D. Blood-borne Pathogens

E. General H&S Rules and Safe Work Permits

F. General Housekeeping, Personal Hygiene and Field Sanitation

G. Site Security, Work Zones and Decontamination for HAZWOPER Sites

I. Severe Weather

M. Heat and Cold Stress

N. Biological Hazards

R. Fatigue Assessment

S. Personal Protective Equipment

V. Driving

Y. Boating Operations Safety

V. Specific Project Sites, Hazards, and Activities

C. Wilderness

G. Water Operations Work

6 HAZARD COMMUNICATION / GLOBAL HARMONIZATION SYSTEM

All project-required chemicals must be handled in accordance with the Arcadis-HAZCOM/GHS Standard (ARC HSGE007), and the requirements outlined in the FHSHB. The table in Appendix C lists all chemicals/SDS that will be brought, used, and/or stored on the site by Arcadis or its subcontractors.

All Arcadis staff must be made aware of the location of and have ready access to the SDS information on site. For this project, SDSs will be located:

- HASP located in the Field Staging Area

7 TAILGATE MEETINGS

Tailgate safety briefings must be conducted at least once daily. The tailgate safety briefing must be documented on the form included in Appendix D or documented on an equivalent form and maintained with the project files. Alternatively, the tailgate safety briefing may be documented and stored/archived digitally using Arcadis-approved software. The tailgate safety briefing will serve as a final review for hazard identification and controls to be utilized. JSA and the Arcadis FHSHB controls (including any applicable permit or supplemental plans) should be reviewed as part of the briefing to ensure hazard controls are adequate for planned work. A tailgate safety briefing should be conducted again and documented during the same work shift if site conditions change from anticipated conditions. During the 2021-2022 field events, both Arcadis and other contractors and subcontractors will participate in tailgate meetings together to discuss SimOps hazards.

8 PERSONAL EXPOSURE MONITORING AND RESPIRATORY PROTECTION

TPH: A review of project tasks indicates that PID monitoring should be implemented at the site. Due to unknown concentrations of TPH, a Stop Work threshold is set at the Arcadis administrative exposure limit of 15 ppm for diesel. While gasoline was chosen as a representative standard for TPH at the Site, the PID will monitor for all volatile hydrocarbons that could pose a risk to human health. The field forms for PID monitoring (Air Monitoring Log and PID Calibration Log) are located in Appendix D. Arcadis staff will utilize stop work if conditions on site change indicating the need to utilize area or personal exposure monitoring. Work will not resume until proper monitoring, engineering controls, and/or PPE upgrades are in place to safely perform work.

Dosimetry Monitoring Program (during sampling utilizing XRF):

1. Designate “operators” who will be utilizing XRF equipment.
    a. Dosimeter badges will be ordered from Sierra Dosimetry.
2. A “visitor” dosimeter badge will be utilized for anyone else standing within the exclusion zone during XRF operation or in the event an alternate operator will be needed.
3. A “Control” dosimeter badge will be transported with and carried around with the other dosimeter badges but will isolated from and NOT be exposed to the XRF survey activities.
4. Each XRF team member will wear the dosimeter badge on their vest during field operations with the XRF. Do not wear the dosimeter badges at other times than listed below (including while driving).
    a. Start of the field day – put on dosimeter badge
    b. End of the field day – take off dosimeter badge
    c. Store all personnel dosimeter badges with control.
5. At the end of field work, dosimeters will be sent to Sierra Dosimetry for analysis. Sierra will generate a report for each dosimeter badge and the field team will compare field exposure to the exposure limit (100 mem/yr). Radiation exposure at the Site is anticipated to be extremely low, but Arcadis Health and Safety will be consulted if the analysis results indicate a potential increase in exposure over the action limit. The dosimetry reports will be stored with project files for future reference.

Lead:

Arcadis will provide and manage area-wide dust monitoring equipment during implementation of the soil removal action. The Removal Contractor will be responsible for personal monitoring if deemed appropriate by the Removal Contractor.$Site\ Action\ Level\ for\ Particulate\ Dust = \frac{OSHA\ PEL \times 10^6\ mg/kg}{Lead\ Soil\ Concentration\ \left(\frac{mg}{kg}\right) \times Safety\ Factor}$

Using the OSHA Permissible Exposure Level (PEL) for lead of 0.05 mg/m^3 (based on a time weighted average [TWA]) a maximum observed soil lead concentration of 6,600 mg/kg and a safety factor of 4, the site specific action level is as follows: 0.05 X 1,000,000 / 6600 / 4 approx 2 mg/m3

$$Site\ Action\ Level\ for\ Particulate\ Dust = \frac{0.05\ mg/m^3\ \times 10^6\ mg/kg}{6{,}600\ \left(\frac{mg}{kg}\right) \times 4} = 1.9\ mg/m^3$$

If sustained concentrations of particulates above the action level are observed, STOP WORK and discuss additional controls or monitoring with the project team. Site controls will be implemented by the Removal Contractor to mitigate the generation of dust. If visual observations or monitoring data indicate that dust control measures are insufficient, STOP WORK and consult with the Removal Contractor and USCG to determine if additional control measures or best practices are needed.

9 MEDICAL SURVEILLANCE

Medical surveillance requirements prescribed by OSHA's HAZWOPER regulations apply to all tasks on this project. Arcadis' medical surveillance requirements for HAZWOPER work are outlined in the Arcadis Medical Monitoring Program Standard ARCHSGE010. All medical surveillance requirements as indicated must be completed and site personnel medically cleared before being permitted on the project site.

10 SANITATION

10.1 Potable Water

There is no potable water supply or other utilities (e.g., gas, electric, internet) at the site. Potable water will be purchased and brought to the site in a cooler or other suitable container. The cooler will be located in the field staging area.

10.2 Toilet Facilities

Toilet facilities will be limited at the Site; however, two primitive facilities are present if needed. A “privy” is located on the eastern end of the northern duplex fence and includes a hand washing station. Additionally, a “humanure composting toilet” and sink are available in the boathouse. The field team will communicate with the NW Schooner Society (who manages the Site) prior to arrival to ensure these facilities are prepared.

11 DECONTAMINATION AND SITE CONTROL PROCEDURES

11.1 Decontamination

Site workers should exercise good hygiene practices by washing hands and face with soap and water prior to consumption of food, drink. No smoking will be permitted on the island. Ready access to an adequate supply of potable water, soap, and disposable towels is expected to be maintained on site. Exposed skin in contact with potentially impacted environmental media, site chemicals, decontamination materials or calibration solutions should be promptly washed with soap and water to reduce potential for contamination or skin irritation.

11.2 Site Control

Site control is required for all field work. The primary purpose of site control is to minimize worker exposure to known or potentially harmful contaminants in environmental media, remediation, or process chemicals or waste materials. Site control also serves to protect site workers not involved with the environmental investigation or remediation and members of the public from potential contamination. Finally, site control can be used to prevent theft and vandalism of equipment.

All visitors to the project work area/site are required to sign in and out on the Arcadis Visitor's Log (located in Appendix D) for the project and must receive a safety briefing described in Section 7 of this HASP.

For Level D projects, formal establishment of site control zones is not ordinarily required unless specified by the THA or task-specific JSA. The site is unoccupied and on a remote island. Therefore, traffic control or barricading of the work area to prevent unauthorized access to the work area will not be required.

12 SUPPLEMENTAL PLANS AND REQUIREMENTS

12.1 Supplemental Plans

The following supplemental plans are applicable to this project and are presented in Appendix E:

- Lone or Remote Worker Plan
- Journey Management Plan
- Washington State Heat Prevention Plan
- COVID-19 Plan
- Tick Safety Share (following 2020 tick bite at site)

12.2 Hazardous Materials Shipping Determinations

A shipping determination is required for all equipment, chemical, battery, and sample shipments. The completed shipping determinations for this project are included in Appendix E.

12.3 Commercial Motor Vehicles

Vehicles with a gross vehicle weight rating (GVWR) ≥10,001 pounds (alone or when attached to a trailer) are commercial motor vehicles (CMVs) and require driver's to be enrolled in the Arcadis CMV Program. CMV operation is not applicable for this project.

12.4 Tick Hazard Control

Tick exposure is a potential hazard associated with tasks completed on this project.

Arcadis has established a supplemental hazard ranking system for the evaluation of tick hazards. The chart below defines tick hazards as "high," "medium," or "low" based on anticipated site conditions.

Tick Hazard Ranking Guide:

Low	Paved areas; parking lots; well-manicured lawns and fields; no work taking place within 15 feet of vegetated areas; work in regions with no tick populations; sub-freezing temperatures, snow, or ice cover on ground. *
Medium	Brush-hogged fields, wetlands, grasslands; forested areas with little undergrowth; weeds less than knee height; moderately dense foliage; sporadic or moderately vegetated shaded areas; average leaf accumulation and decaying material on the ground; work taking place in fields after application of insecticide; work in regions with a recognized moderate tick population; outdoor work during spring, summer, and fall months. *
High	Uncut fields, wetlands, forested areas, grasslands; weeds taller than knee height; heavy dense foliage; heavily vegetated shaded areas;

excessive accumulations of leaves and decaying material on the ground; work in regions with recognized heavy tick populations; areas with posted tick hazard warnings; outdoor work during spring, summer, and fall months. *

* Cold weather does not eliminate risk of exposure to ticks as they may be active all year in areas that experience subfreezing temperatures.

Work on this project has a **high** tick exposure hazard. In March 2020, a tick bite occurred at the site. A safety share was assembled to share with field staff and USCG following the event and is presented in Appendix E. The following measures will be implemented to reduce the risk and impact of ticks:

- Use insect repellent (permethrin on clothing in combination with 20%-40% DEET on skin)
- Wear light-colored clothing or apply a duct tape "barrier" to clothing to help identify presence of ticks on staff.
- Complete clothing and exposed skin "buddy checks" periodically throughout the day.
- Keep shirt tails inside pants and pant legs taped to ankle.
- Perform personal self-tick check each day after work.
- Tick safety will be discussed in daily tailgate meetings.
- Avoid walking through tall vegetation unless necessary to complete project task. When possible, use worn paths. Complete "buddy checks" immediately following work in heavily vegetated areas.
- Provide HASP to subcontractors in advance and discuss tick hazards and safety expectations prior to work. Bring extra PPE (duct tape, permethrin, etc.) in case subcontractors need it.

The following measures will be implemented if a tick bite occurs:

- If a tick bite is discovered during working hours **STOP WORK** and notify the SSO immediately. If the tick bite is discovered after working hours, notify the SSO immediately. The SSO will notify the PM while the affected staff member contacts WorkCare to determine next steps, including safe removal of the tick. The PM, SSO, and affected staff member will communicate with Arcadis H&S and/or USCG H&S as directed.
- Discuss additional safety measures to be taken to avoid additional tick exposure (increased frequency of tick checks, additional clothing layers or tucking, etc.). The PM will determine when it is safe to resume work with updated procedures.
- Document the incident as appropriate following discussions with Arcadis and USCG H&S.

12.5 Poisonous Plant Hazard Control

Poisonous plant exposure is a potential hazard associated with this project.

Arcadis has established a supplemental hazard ranking system for the evaluation of poisonous plant hazards. The supplemental ranking of "high," "medium," or "low" based on anticipated site conditions. As part of the ranking process, staff should consider poisonous plants hazardous throughout the year, including winter months.

Work on this project has a medium poisonous plant exposure hazard. Plan work to avoid areas of identified poisonous plants. Evaluate and implement poisonous plant elimination (mowing, clear cutting) and control, as practicable. Workers known to have a sensitivity to poisonous plants should be assigned

tasks that will not have poisonous plant exposure. If unavoidable, workers known to have a sensitivity should use a pre-exposure lotion on exposed skin.

First aid kits must be equipped with post-exposure soap. Inspect work area for presence of hazard prior to initiating work at the location. Wear disposable gloves during work and while removing outer footwear. Use of clothing with long sleeves to protect forearms is an Arcadis expectation. Disposable coveralls are recommended. Potential exposure to plant oils should be managed in a manner consistent with chemical exposure.

13 ARCADIS BEHAVIOR BASED SAFETY PROGRAM

As part of any project, no matter how simple or complex, Task Improvement Processes (TIPs) should be conducted when practical and when able to integrate into normal business activities. TIPs should be scheduled based on the risk of the tasks being performed and should be conducted for different tasks and at different times.

The following tasks are (at a minimum) suitable for TIP activity for the project:

- Driving
- Mobilization
- Soil Sampling
- Dust Monitoring
- Construction Oversight

All Arcadis field staff are encouraged to identify and report near misses that could affect H&S of Arcadis employees, our subcontractors, or the public. Near miss reports for a similar project performed by Arcadis for USCG at Poverty Island, Fairbanks Township, Michigan, is included in Appendix F. Near miss reports and TIPs from 2018 – 2020 Burrows Island field events are included in Appendix G.

14 SUBCONTRACTORS

Subcontractors are responsible for the H&S of their employees at all times and have the authority to stop work if unsafe conditions arise.

A copy of this HASP is to be provided to all subcontractors prior to the start of work so that the subcontractor is informed of the hazards at the site. While the Arcadis HASP will be the minimum H&S requirements for the work completed by Arcadis and its subcontractors, each subcontractor, in coordination with Arcadis H&S personnel, is expected to perform its operations in accordance with its own HASP, policies, and procedures unique to the subcontractor's work to ensure that hazards associated with the performance of the work activities are properly controlled. Copies of any required safety documentation for a subcontractor's work activities will be provided to Arcadis for review prior to the start of on-site activities. Because subcontractors (particularly the historic architect and archaeological monitor) may not have training associated with ionizing radiation or hazardous materials handling, an exclusion zone will be defined for XRF analysis, sample handling, and IDW management. The exclusion zone boundaries will provide at least 5 ft of distance from hazardous activities and will be communicated in the tailgate meeting.

In the event that the subcontractor's procedures/requirements conflict with requirements specified in this HASP, the more stringent guidance will be adopted after discussion and agreement between the subcontractor and Arcadis project H&S personnel. Hazards not listed in this HASP but known to the subcontractor or known to be associated with the subcontractor's services, must be identified and addressed to the Arcadis Project Manager, Associate Project Manager and/or Task Manager, and SSO prior to beginning work operations.

When the subcontractor is under contract to Arcadis or if directed by the client to act on the client's behalf, the Project Manager, Associate Project Manager, and/or Task Manager, along with the SSO (or authorized representative) has the authority to halt the subcontractor's operations and to remove the subcontractor or subcontractor's employee(s) from the site for failure to comply with established H&S procedures or for operating in an unsafe manner.

Removal action activities at the site will be conducted by a separate contractor (Removal Contractor) operating under their own HASP. Simultaneous operations include Arcadis performing dust monitoring, oversight, and soil confirmation sampling while the other contractors perform soil removal with heavy machinery and a barge. Arcadis will conduct tailgate meetings with all other contractors and subcontractors present onsite and will review and comply with the HASP for removal activities as appropriate. **Project Personnel HASP Certification**

All site project personnel will sign the certification signature page provided in this HASP.

APPENDIX A

Task Hazard Analysis

APPENDIX B

Job Safety Analyses and Permits

APPENDIX C

Hazard Communication/Globally Harmonized System

APPENDIX D

Field Forms

APPENDIX E

Supplemental Plans

APPENDIX F

Near Miss Reports from Similar USCG/Arcadis Poverty Island Project

APPENDIX G

Near Miss Reports and TIPs from 2018 – 2020 Burrows Island Field Events

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