Pennsylvania Department of Environmental Protection

Attachment B - Sampling and Analysis Plan / Quality Assurance Project Plan

GTAC 8 – Bishop Tube HSCA Site

S Malin Road

East Whiteland Township

Chester County, PA

December 17, 2025

Version 1.0

Sampling and Analysis Plan / Quality Assurance Project Plan

GTAC 8 – Bishop Tube HSCA Site
S Malin Road, East Whiteland Township
Chester County, Pennsylvania

Prepared for:
Mr. Dustin Armstrong
Pennsylvania Department of Environmental Protection
Southeast Regional Office
2 East Main Street
Norristown, PA 19401

Prepared by:
Groundwater & Environmental Services, Inc.
410 Eagleview Boulevard, Suite 110
Exton, Pennsylvania 19341

TEL: 800-220-3068
www.gesonline.com

GES Project:
0070462

Date:
December 17, 2025

Alison M. Gibbons
Staff Environmental Scientist

Timothy Uhler
Principal Project Manager

Bonnie Janowiak, Ph.D.
Principal Chemist

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Acronyms

Act 2	Pennsylvania Land Recycling Act
AOC	Areas of Concern
ASTM	American Society for Testing and Materials
CLP	Contract Laboratory Program
CM	Case Manager
COC	Constituents-of-Concern
CVOC	Chlorinated Volatile Organic Compound
DEP	Pennsylvania Department of Environmental Protection
DNAPL	Dense Non-Aqueous Phase Liquid
DOD	Department of Defense
DOE	Department of Energy
DQL	Data Quality Level
DQI	Data Quality Indicator
DQO	Data Quality Objective
EPA	United States Environmental Protection Agency
GES	Groundwater & Environmental Services, Inc.
GTAC	General Technical Assistance Contracts
HAL	Health Advisory Levels
HASP	Health and Safety Plan
HSCA	Hazardous Sites Cleanup Act
ISCO/ ISCR	In Situ Chemical Oxidation and/or In Situ Chemical Reduction
IDW	Investigation Derived Waste
LAN	Local Area Network
LAP	Laboratory Accreditation Program
LCS	Laboratory Control Samples
LCSD	Laboratory Control Sample Duplicates
LNAPL	Light Non-Aqueous Phase Liquid
MDL	Method Detection Limit
mg/kg	Milligrams per kilogram
mL	Milliliter
MS	Matrix Spikes
MSD	Matrix Spike Duplicates
NELAP	National Environmental Laboratory Accreditation Program
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PARCCS	Precision, accuracy, representativeness, comparability, completeness, sensitivity
PCE	Tetrachloroethene
PDA	Personal Digital Assistant
PFAS	Per-and Polyfluoroalkyl Substances
PID	Photoionization Detector
PM	Project Manager
PMA	Project Manager Assistant
PPE	Personal Protective Equipment
ppm	Parts per Million

QAM	Quality Assurance Manual
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QO	Quality Observation
RCRA	Resource Conservation and Recovery
RI/FS	Remedial Investigation Report and Feasibility Study
RIR	Remedial Investigation Report
RL	Reporting Limit
Roux	Roux Associates, Inc
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SD	Standard Deviation
SOP	Standard Operating Procedure
TAL	Target Analyte List
TAM	Technology Assessment Memorandum
TCE	Trichloroethene
TCL	Target Compound List
USCG	U.S. Coast Guard
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound
WAN	Wide Area Network
XRF	X-Ray Fluorescence
µg/kg	Micrograms per Kilogram
µg/L	Micrograms per Liter
%	Percent

Document Revision Details

Revision	Date	Prepared By	Reviewed/Approved By	Comments
1.0	12/16/2025	Maggie Gibbons – Staff Environmental Scientist	Tim Uhler – Project Manager	

1 Introduction

The following Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) discusses the methods and procedures that will be used for the screening and collection of representative samples of environmental media for analysis at the Bishop Tube Hazardous Sites Cleanup Act (HSCA) Site (Site) located at South Malin Road, East Whiteland Township, Chester County, Pennsylvania. Quality control and quality assurance procedures are also specified. The SAP/QAPP was developed in accordance with the requirements specified in Pennsylvania's Hazardous Sites Cleanup Program; PA Code Chapter 250, *Administration of the Land Recycling Program*; and Pennsylvania's Land Recycling Program *Technical Guidance Manual* (253-0300-100/January 19, 2019) and the Quality Assurance Program Plan for the Bureau of Environmental Cleanup and Brownfields Hazardous Sites Cleanup Act Section, Pennsylvania Department of Environmental Protection, March 2025.

The purpose of establishing a written protocol for sampling and analysis is to ensure that the data that are generated are valid and representative of site conditions. During the investigation, soil, groundwater, and surface water samples will be collected. The SAP/QAPP discussed in the following sections defines the Data Quality Objectives (DQOs) for the investigation, specifies acceptable procedures for sample collection, sample preservation, and handling, identifies analytical procedures and Quality Assurance/Quality Control (QA/QC) requirements, and identifies the procedures that will be used to evaluate the data and determine if the DQOs have been met.

The following documents were referenced during the development of this SAP/QAPP:

- Environmental Investigation Guidelines, American Society for Testing and Materials, 1997
- Guidance for the Data Quality Objectives Process, EPA QA/G-4, EPA/240/B-06/001, February 2006
- Guidance for the Data Quality Assurance Project Plans, EPA QA/G-5, EPA/240/R-02/009, December 2002
- IT/IM Directive Guidance Quality Assurance Project Plan Guidance. EPA, 20 Feb. 2025.
- Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, QA00 Update, EPA/600-R-96/084, July 2000.
- Test Methods for Evaluating Solid Waste (SW846), 3rd Edition, Revised 1986.
- Sampling and Analysis Plan Guidance and Template, Version 4, General Projects, EPA R9QA/009, May 2014
- Data Quality Assessment and Data Usability Evaluation Technical Guidance, Version 1.0, New Jersey Department of Environmental Protection, Site Remediation Program, April 2014.
- Quality Assurance Program Plan for the Bureau of Environmental Cleanup and Brownfields Hazardous Sites Cleanup Act Section, Pennsylvania Department of Environmental Protection, March 2025 (HSCA QAPP).

1.1 Health and Safety / Hazard Communication

All field activities will be conducted in accordance with the approved Site-Specific Health and Safety Plan (HASP). Groundwater & Environmental Services, Inc. (GES) personnel engaged in on-site activities will have the training necessary to perform each of the prescribed tasks. Familiarity with the following guidance documents and standards is required prior to engaging in on-site activities:

- Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response Standard (OSHA 29CFR1910.120)
- Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities (1985) (NIOSH/OSHA/USCG/EPA)
- Health and Safety Requirements for Employees Engaged in Field Activities (EPA Order 1440.2)

Documentation supporting the required training will be maintained by GES in the project file.

1.2 Lines of Authority and Responsibilities

Lines of authority and responsibilities are discussed in **Table 1** (Lines of Authority and Responsibilities). The GES Project Manager (PM) is responsible for directing all site activities. The GES Case Manager (CM) will coordinate all field activities, including scheduling field personnel, subcontractors, and the laboratory, managing daily activities, reviewing all field documentation and chains of custody, and receiving and verifying the data. The GES Project Manager and Case Manager for the site are identified as follows:

- GES PM – Timothy Uhler
- GES CM – Alison M. Gibbons

The GES Field Supervisor is the on-site lead and will be identified prior to each site activity in the event's scope-of-work/field work order that details the additional information specific to each field event. The GES Field Supervisor will provide on-site supervision of contractors, assign tasks to field personnel, conduct subsurface investigations, and provide summary reports of field work completed. GES field personnel who will be thoroughly familiar with this plan and the sampling requirements will collect all soil, surface water, and groundwater samples. Field personnel will be required to collect the samples in accordance with the procedures specified in the SAP, properly package the samples for transfer to the laboratory, complete the chain-of-custody, and ensure that all documentation regarding the sampling event is properly recorded.

General instructions to be followed by field personnel before, during, and after mobilizing to the site are provided in the following standard operating procedures (SOPs) provided in **Appendix A**:

- SOP FM-1.2 Subsurface Clearance Protocol
- SOP FM-1.3 Controlling the Work Area

- SOP FM-1.5 General Instructions for Field Personnel
- SOP FM-1.6 Field Note Documentation
- SOP FM-1.7 Field Instrument Calibration and Documentation
- SOP FM-2.1 Field Logging of Subsurface Investigations
- SOP FM-2.2 Classification of Soils via Unified Soil Classification System (USCS)
- SOP FM 4.0 Drilling Protocol
- SOP FM-4.1 Soil Boring Advancement
- SOP FM-4.4 Boring / Well Construction Field Log Completion
- SOP FM-4.6 Per-and Polyfluoroalkyl Substances (PFAS) Investigation – Drilling
- SOP FM-5.4 Monitor Well Design and Construction
- SOP FM-5.6 Monitor Well Development
- SOP FM-7.3 Packer Testing
- SOP FM-8.1 Liquid Level Gauging
- SOP FM-8.13 Passive Groundwater Sample Acquisition
- SOP FM-9.1 Soil Sampling for Analysis
- SOP FM-9.4 Surficial Soil Sampling
- SOP FM-10.1 Surface Water and Sediment Sampling
- SOP FM-13.2 Sample Preservation and Handling
- SOP FM-13.3 Sample Identification and Labeling
- SOP FM-13.4 Chain-of-Custody Procedures
- SOP FM-13.5 Sample Management, Packing, and Shipping
- SOP FM-14.1 Decontamination of Non-Dedicated Sampling Equipment
- SOP FM-14.2 Decontamination of Heavy Equipment
- SOP FM-14.3 Field Personnel Decontamination
- SOP FM-15.1 Containerization and Removal of Remedial Investigation Derived Waste
- SOP FM-20.1 Waste Sampling
- SOP FM-22.0 PFAS Sampling
- SOP FM-22.2 PFAS Sampling - Groundwater
- SOP FM-22.4 PFAS Sampling - Surface Water and Surface Water Foam
- SOP FM-22.7 PFAS Sampling – Soil
- SOP QA-1.1 Collection of Field QA/QC Samples (Trip Blanks, Equipment Blanks,

Duplicate Samples, Matrix Spike Samples)

These SOPs provide general instructions for scheduling, assembling required materials, calibrating equipment, and documentation.

1.3 Background

The Site, located at 1 South Malin Road in Malvern, East Whiteland Township, Chester County, Pennsylvania, is an approximate 13.7-acre former manufacturing facility located in Malvern, East Whiteland Township, Chester County, Pennsylvania. The approximate geographical coordinates of the center of the property site are 40 degrees, 02 minutes, 23 seconds north (latitude) by 75 degrees, 32 minutes, 12 seconds west (longitude). The area defined as the Site includes the area within the Property and the extent of groundwater contamination (See Figure 2 of the Data Gap Pre-Design Investigation Work Plan [GES, 2025]).

In 1951, J. Bishop & Co. Platinum Works was the first entity known to begin manufacturing operations at the Site. The plant was used primarily for the manufacturing of tubing from stainless steel and also, among other things, for specialty metal fabrication. The facility that was built in 1951 (referred to as "Plant 5") is the more southerly of the two current buildings. In 1958, a second building was constructed, referred to as "Plant 8." The facility continued to operate under various owners and operators as a metal alloy tube manufacturing facility until 1999. Metal alloy tube production concentrated on seamless stainless-steel products for much of the period of operation. During certain periods of time, chlorinated solvents were used for degreasing at the Site. The Site is currently owned by Constitution Drive Partners, L.P., who purchased it from the Central and Western Chester County Industrial Development Authority in 2005. The Site has been vacant from 1999 to present.

Current features include two large vacant structures identified as Building 5 and Building 8 that cover approximately 3.7 acres of the Property (See Figure 2 of the Data Gap Pre-Design Investigation Work Plan [GES, 2025]). The area immediately surrounding the two buildings predominantly consists of concrete covered surfaces formerly used for facility driveways, parking and loading areas. The remainder of the Property, primarily in the southern and eastern portions, is overgrown with vegetation and trees. Little Valley Creek runs south to north just within the eastern property boundary. The Property was historically zoned industrial; however, the Property was rezoned by East Whiteland Township for residential use in 2014.

The Site and surrounding area are located within the Piedmont Physiographic Province and are underlain by rocks that are folded, faulted and metamorphosed. The Site is located primarily within the northeast trending Chester Valley. Chester Valley is predominantly underlain by less resistant carbonate rocks and is bounded by more resistant upland areas to the north and south. The carbonate rocks in the vicinity of the Site are the Ordovician Conestoga Formation. The upper portion of the Conestoga Formation in the Chester Valley area consists of blue-gray to light gray, thin-bedded, argillaceous limestone with intervals of purer, granular limestone. In addition, the carbonate rock of the upper portion of the Conestoga Formation has a finely laminated appearance with shaley partings along bedding planes. The South Valley Hills are underlain by non-carbonate metamorphic phyllite and schist rocks that, in the vicinity of the Site, make up the

Octoraro Formation. According to Sloto (1997), the Octoraro Formation in the vicinity of the Site consists of green to silver-gray, fine to medium grained phyllite.

Roux Associates, Inc. (Roux) submitted a Remedial Investigation Report and Feasibility Study (RI/FS) to DEP in 2021, which was accepted by DEP in February 2021. The RI/FS identified the Site constituents of concern (COCs) to include compounds related to historical manufacturing operations at the Site. Specifically, the RI/FS COCs for the Site included chlorinated volatile organic compounds (CVOCs) and inorganics (metals and fluoride). The primary source areas for CVOCs were identified in the RI/FS as the former Building 8 vapor degreaser area (VDA), former drum storage area 3 outside Building 8, and the former Building 5 VDA. The source areas for inorganics (metals and fluoride) were identified in the RI/FS to include, among other areas, the area east of Building 8, area south of the eastern portion of Building 8, and area south of the central portion of Building 5. Additionally, arsenic, nickel, and vanadium were detected at concentrations above the DEP Direct Contact Numeric Values for a Residential Area (0-15 feet) in soils samples collected across the Site as part of the RI/FS.

In 2021 and 2022, Roux conducted additional investigation activities to continue soil delineation, refine the COC list for the Site, and evaluate per-and polyfluoroalkyl substances (PFAS) in groundwater and surface water. These activities involved collection of soil samples from select treatment areas previously identified by GES in the 2020 Remedial Alternatives Analysis (RAA) and 2020 Technology Assessment Memorandum (TAM). Roux identified the treatment areas as Areas of Concern (AOCs) in their documentation. The locations of the GES treatment areas are identified on **Figure 3** of the Data Gap Pre-Design Work Plan (GES, 2025). The soil samples were analyzed for total chromium, hexavalent chromium, nickel, and fluoride. The results of this sampling concluded that the hexavalent chromium was not detected at concentrations above DEP medium specific concentrations (MSCs). However, fluoride was detected at concentrations above the DEP MSCs in multiple locations. These locations are identified on **Figure 4** of the Data Gap Pre-Design Work Plan (GES, 2025). Also, a partial round of groundwater samples were collected from the monitoring well network and analyzed for PFAS. It was determined that select PFAS compounds were detected at concentrations above the DEP MSCs. As a result of the additional investigation activities, the COC list for the Site was updated to include PFAS in addition to the originally-defined list presented in the RI/FS. It was determined that additional delineation of fluoride in soils and of PFAS in soils and groundwater would be necessary to adequately address these areas during remediation. Areas that need further delineation of fluoride in soils include near the former cesspool area, the acid rinsewater handling/spill area at the eastern end of Building 8, and in AOC 1, 4, 5, 6, and 9. Areas that need further delineation of PFAS in soils include in the former pipe drawing and vapor degreasing areas in Building 8, and in AOC 2 thorough 10. The proposed soil boring locations for the data gap investigation activities are shown on **Figure 6** of the Data Gap Pre-Design Work Plan [GES, 2025]. In addition, further delineation of PFAS in groundwater is required across the full monitoring network, both on- and off-site, to adequately define the boundaries and extent of the PFAS contamination plume in groundwater.

Please note that complete references for any citations in this section are presented in the Remedial Investigation Report (RIR) and not in this document.

2 Sampling Plan Objectives

2.1 Pre-Design Investigation Objectives

- Conduct a background soil investigation for select inorganics, including total metals and fluoride, and PFAS.
- Conduct a Site soil investigation to address data gaps, including an evaluation of PFAS and fluoride concentrations.
- Install one (1) nested bedrock monitoring well set (shallow, intermediate, and deep) via a stepwise approach:
    - Complete installation of the borehole via sonic drilling methods to an assumed maximum depth of 400 feet below ground surface (bgs)
    - Conduct downhole geophysical analyses (3-arm caliper, optical televiewer, acoustic televiewer, and heat pulse flow meter) to identify fracture zone and groundwater flow conditions and to establish the primary intervals to be monitored in each zone
    - Conduct packer testing on each selected zone to collect hydrological data and initial groundwater samples for analysis
    - Ream the borehole to final diameter needed for the nested well construction
    - Construct the nested poly-vinyl chloride (PVC) monitoring wells within the borehole at the selected intervals
- Conduct a round of groundwater monitoring of the full monitoring well network to evaluate the Site COCs and obtain a baseline round of data for PFAS in groundwater.
- Perform a round of surface water sampling to evaluate the COCs and obtain a baseline round of data for PFAS in surface water.

2.2 Sampling and Analysis Components

- Background soil investigation
- Site soil investigation to address data gaps
- Groundwater monitoring of the full monitoring network
- Surface water monitoring

3 Data Quality Objectives (DQO)

DQOs are both qualitative and quantitative statements established to help ensure that field activities, data collection, and the resulting data support the project objectives. The primary objective of this Data Gap Pre-Design Site Investigation is to collect additional analytical data (from soil, groundwater, and surface water) as part of remedial pre-design activities following the initial Remedial Investigation completed by Roux in 2021. This supplemental data is being collected to address areas requiring further characterization and to support the development and implementation of the selected remedial response action.

While fluoride and PFAS are known COCs in soil, groundwater, and surface water on Site, further horizontal and vertical delineation is required to fully understand the extent of fluoride and PFAS contamination and to further identify the specific areas where remediation will be required. In September 2022, DEP issued a Statement of Decision selecting a remedial response action to address soil, groundwater, surface water, and one (1) residential drinking water supply which includes the following:

- In Situ Chemical Oxidation and/or In Situ Chemical Reduction (ISCO/ISCR), coupled with soil mixing to address unsaturated and saturated soils impacted by Site COCs;
- In situ injection of ISCO, ISCR or bioremediation amendments in the two primary CVOCs source areas to address contaminated groundwater with engineering, and/or institutional controls, and long-term monitoring; and
- Connection of the residence with an impacted domestic well to the existing public water line.

Analytical data collected during this Data Gap Pre-Design Site Investigation will be evaluated in comparison to the DEP Statewide Health Standard MSCs for soil and groundwater and Water Quality Criteria for Toxic Substances for surface water to determine the extent of contamination. Based on the results of this investigation, the DEP will determine if additional sampling is required to support the development of the remedial design and implementation of the remedial response action.

The DQO process for the data gap sampling was developed using the objectives in Scope of Work dated July 31, 2025. The resulting DQO statements are summarized in the following:

Problem	Unknown background concentrations of Site COCs in soils
Goal of the Study	To provide data to determine the background concentrations of metals, fluoride, and PFAS for comparison to contaminated soils on Site
Information Inputs	Soils sample analytical data for total metals, fluoride, and PFAS concentrations
Boundaries	Four (4) soil borings installed on the southern boundary of the Site where no known activities related to the Site operations occurred. See Figure 5 of the Data Gap Pre-Design Site Investigation Work Plan (GES, 2025).
Analytical Approach	EPA published analytical methods
Performance/Acceptance Criteria	Laboratory provided criteria for QC recoveries and precision
Design Plan	Best professional judgment based off historical data and DEP guidance.

Problem	Data gaps for fluoride and PFAS in soils due to fluoride not being fully delineated and PFAS not being evaluated during the remedial investigation phase of the project
Goal of the Study	To provide data to further delineate the concentrations of VOCs, fluoride and PFAS in soils on Site
Information Inputs	Soil sample analytical data for TCL VOCs, fluoride, and PFAS concentrations
Boundaries	Soil borings installed in areas of known contamination and in all areas of concern identified in the GES Technology Evaluation Memo. See Figure 6 of the Data Gap Pre-Design Site Investigation Work Plan (GES, 2025).
Analytical Approach	EPA published analytical methods
Performance/Acceptance Criteria	Laboratory provided criteria for QC recoveries and precision
Design Plan	Best professional judgment based off historical data and DEP guidance.

Problem	Additional analytical data needed to characterize contamination in groundwater and surface water on and near the Site
Goal of the Study	To provide data to evaluate the Site COCs and obtain a baseline round of analytical data for PFAS in groundwater and surface water
Information Inputs	Groundwater and surface water analytical data for TCL VOCs, fluoride, dissolved metals, total chromium and manganese, hexavalent chromium, and PFAS concentrations
Boundaries	The full monitoring well network and previously established Roux surface water sample locations, SW-1 through SW-10
Analytical Approach	EPA published analytical methods
Performance/Acceptance Criteria	Laboratory provided criteria for QC recoveries and precision
Design Plan	Best professional judgment based off historical data and DEP guidance.

3.1 Data Collection Requirements

Table 2-1 (Sampling and Investigative Methodologies) summarizes data that will be collected during the pre-design investigation of the site. **Table 2-2** (Soil Sampling Requirements) summarizes the data that will be collected for each soil sample. **Table 2-3** (Groundwater Sampling Requirements) summarizes the data that will be collected for each groundwater sample. **Table 2-4** (Surface Water Sampling Requirements) summarizes the data that will be collected for each surface water sample.

The specific compounds required for soil, groundwater, and surface water samples along with the respective analytical methods to be utilized are summarized in **Table 3** (Analytical Program). Analytical data obtained will be evaluated in comparison to the regulatory criteria specified in **Table 4** (Regulatory Criteria).

3.2 Data Quality Indicators (DQI)

All samples will be collected using standard operating procedures outlined in the attached SOPs provided in **Appendix A**.

The GES CM will review all field documentation and chain-of-custodies to ensure that all protocols and requirements have been met for quality field data collection and sample integrity.

The quality of sampling is evaluated in terms of precision, accuracy, representativeness, comparability, and completeness (PARCCs) in relation to the intended use of the data. Precision and accuracy are derived from correctly calibrated field instruments and sampling consistency as a direct effect of validated sampling procedures and protocols. Representativeness, completeness, and comparability are typically defined in the sampling plan for the project as a whole. Definitions of the terms as described by the United States Environmental Protection Agency (EPA) (2014) are provided below:

- *Precision* is the degree of mutual agreement between or among independent measurements of a similar property (usually reported as a standard deviation [SD] or relative percent difference [RPD]). This indicator relates to the analysis of duplicate field samples. Typically, field precision is assessed by co-located samples, field duplicates, or field splits and a calculation of the variance of the results of the samples.
- *Accuracy* in sampling is the degree of agreement of a measurement with true value and includes a combination of any random error (precision) in sampling protocols. Accuracy in sampling is assessed through compliance to all sample handling, preservation, and holding time requirements. Accuracy is also assessed by field blanks. All field blanks should be non-detect. Any contaminant detected in an associated field blank will be evaluated against laboratory blanks and field samples collected on the same day to determine potential for bias. Accuracy in field sampling is dependent upon well calibrated equipment and consistent sampling techniques.
- *Representativeness* is the expression of the degree to which data accurately and precisely represent a characteristic of an environmental condition or a population. It relates both to the area of interest and to the method of taking the individual sample. Representativeness is best assured by a comprehensive statistical sampling design. One-time events should focus on issues related to judgmental sampling and why certain areas are included or not included and the steps being taken to avoid either false positives or false negatives.
- *Comparability* expresses the confidence with which one data set can be compared to another. The use of validated and published methods from a recognized source, such as the latest validated EPA analytical methods found on the EPA website, or Standard Methods for the Examination of Water and Wastewater allows the data to be compared to similar data sets, facilitating evaluation of trends or changes in a site, a river, groundwater, etc. Validated methods to be utilized in the data collection are listed in **Table 3** (Analytical Program).

- *Completeness* is expressed as percent of samples taken compared to samples planned. For the sampling to be considered complete, there must be at least 95% of the planned samples collected.

The associated evaluation criteria (types and frequencies of QC checks, acceptance limits, and corrective actions) for field DQIs are summarized in **Table 5** (Field Quality Control Summary).

3.3 Analytical DQIs and Measurement Performance Criteria

The GES laboratory data management team will review the analytical data for reliability and usability.

The quality of analytical data will be evaluated in terms of PARCCS in relation to the intended use of the data. Precision, accuracy, and sensitivity are usually covered in method specific criteria, whereas representativeness, completeness, and comparability are typically defined in the plan for the project as a whole. The PARCCS terms in relation to the analytical DQIs) are provided below:

- *Precision* and reproducibility are measured by the analysis of sample duplicates, matrix spike duplicates (MSD), or laboratory control sample duplicates (LCSD).
- *Accuracy* is determined comparing a laboratory value to a known or true concentration. Accuracy is determined by such QC indicators as: laboratory blank samples, matrix spikes (MS), surrogate spikes, laboratory control samples (LCS, also blank spikes) and performance samples and is accessed through the calculation of percent recovery in spiked samples and the presence of uncontaminated blanks.
- *Representativeness* relates both to the area of interest and to the method of taking the individual sample. Utilizing EPA validated analytical methods and procedures with verifiable QC associated with the data results in representative data. It is also measured utilizing both field- and laboratory-generated blanks, insuring that there are no concentrations of COCs that are not sourced in the sampled location.
- *Comparability* is achieved by validated and published methods from recognized sources, such as the latest validated EPA analytical methods found on the EPA website, or Standard Methods for the Examination of Water and Wastewater, allowing the data to be compared to similar data sets, facilitating evaluation of trends or changes in a site, a river, groundwater, etc. Validated methods to be utilized in the data collection are listed in **Table 3** (Analytical Program). Comparability also refers to the reporting of data in comparable units.
- *Completeness* is expressed as percent of valid usable data actually obtained compared to the amount that was expected. It may happen that, due to a variety of circumstances, either not all samples scheduled to be collected were collected or else the data from samples cannot be used due to, for example, loss or spillage of samples, instrument failures, technical mistakes, etc. The minimum percent of completed analyses defined in this section depends on how much information is needed for decision making. Generally, the fewer the number of samples taken per event or the more critical the data are for decision making, the higher the

completeness goals. 90% of analytical data must be usable for the dataset to be considered complete.

- *Sensitivity*, usually expressed as method detection limits (MDLs) or quantitation limit for all analytes or compounds of interest for all analyses requested must be included in this section. The MDLs for all analytes are to be below applicable DEP regulatory standards (DEP Sitewide Health Standards for soil and groundwater and Chapter 93 Water Quality Criteria for Toxic Substances for surface water), and the subcontracted laboratory will be selected based on their ability to meet this requirement. A list of the subcontracted laboratory reporting limits (RL) and MDLs will be provided, and this document updated, upon final approval of the recommended laboratory.

The subcontracted laboratory will meet analytical DQI requirements (types and frequencies of QC samples and QC acceptance limits) as specified in their internal SOPs and laboratory QA manuals in accordance with the DEP National Environmental Laboratory Accreditation Program (NELAP) accreditation. The subcontracted laboratory certification and Scope of Accreditation will be provided, and this document updated, upon final approval of the recommended laboratory. The criteria that the analytical quality control elements will be compared to are summarized in **Table 6** (Types of Information Used to Evaluate Precision, Accuracy, Representativeness, Comparability, Completeness, and Sensitivity).

The specific criteria for analytes and methods will be those outlined in *Quality Assurance Program Plan for the Bureau of Environmental Cleanup and Brownfields Hazardous Sites Cleanup Act Section, Pennsylvania Department of Environmental Protection, March 2025* or laboratory-provided criteria.

Quality control samples that are field generated are detailed in **Section 7.0** (Quality Assurance/Quality Control).

4 Sample Collection

4.1 General Instructions

General instructions to be followed by field personnel before, during, and after mobilizing to the site are provided in the following SOPs:

- SOP FM-1.3 Controlling the Work Area
- SOP FM-1.5 General Instructions for Field Personnel
- SOP FM-1.7 Field Instrument Calibration and Documentation

Before mobilizing to the site, all field equipment must be checked to verify functionality. Prior to initiating site activities, all measuring devices (with the exclusion of oil/water interface probes or water-level indicators) must be calibrated in accordance with equipment vendor recommendations, and the calibration must be recorded in the Site-dedicated field notebook. In addition, a calibration check should be performed and recorded at the end of each day to verify that instruments remained in calibration throughout the day. This check is performed while the instruments are in measurement mode, not calibration mode.

4.2 Soil Sampling

A Geoprobe® Model 7822 or similar will be mobilized to the Site to complete the advancement of soil borings via direct push methodologies. All underground utilities will be identified prior to installation of the soil borings via PA One Call notification. Prior to soil boring advancement, each location will be hand cleared to five (5) feet bgs with a hand auger and/or vacuum excavation methodologies.

The soil borings will be advanced to approximately 20 feet below ground surface (bgs) or to bedrock refusal. During the soil boring installation, soil cores will be collected continuously within each soil sample location for lithologic evaluation and sampling. The borings will be logged for lithology and photoionization detector (PID) readings. The composition, color, texture, and moisture content of the soil will be monitored as it is recovered and recorded on a subsurface log. Additionally, during the background soil and data-gap soil sampling for fluoride, each one-foot interval of soil will be field screening utilizing X-Ray Fluorescence (XRF) technology to evaluate the presence/absence of metals. The fluoride delineation borings will be sampled from the 0'-2' interval (surface soil collected via hand auger during pre-clearance) and the interval with the highest field screening results via XRF or the soil/bedrock interface (if no impacts are identified via XRF screening). The PFAS investigation soil boring locations will be sampled from the depth of the historically identified impacts, the soil/water interface and/or soil/bedrock interface.

A total of 20% of the soil boring locations will include collection of a saturated soil sample for analysis. These locations will be selected based on field observation. Analytical data from these soil samples will be used to characterize saturated soil quality as saturated soils are expected to be mixed and treated as part of the planned remediation activities.

Soil samples will be collected directly from the acetate sleeves and placed directly into laboratory supplied bottleware. At each sampling location, all bottles designated for a particular analysis (e.g., PFAS) will be filled sequentially before bottles designated for the next analysis are filled (e.g., VOCs). If a duplicate sample is to be collected at this location, all bottles designated for a particular analysis for both sample designations will be filled sequentially before bottles for another analysis are filled. In the filling sequence for duplicate samples, bottles with the two different sample designations will alternate (e.g., PFAS designation MW, PFAS designation MW Duplicate, VOC designation MW, and VOC designation MW Duplicate). The sampling sequence should be: VOCs first, PFAS second, metals third, and fluoride last.

The soil background sample locations will be submitted for laboratory analysis of metals via EPA Method 6010D, fluoride via EPA Method 9056A, and PFAS via EPA Method 1633. Soil samples from the fluoride data-gap analysis investigation areas will be submitted for fluoride analysis via EPA Method 9056. Soil samples from the PFAS investigation areas will be analyzed for PFAS via EPA Method 1633. Additionally, an estimated 20 samples from the data-gap analysis soil samples will be submitted for laboratory analysis of target compound list (TCL) volatile organic compounds (VOCs) [including trichloroethene (TCE) and tetrachloroethene (PCE) and all daughter products].

These locations will be based on field observations ((i.e. if staining is observed or a high PID reading is measured). QA/QC samples will be collected in accordance with **Table 7 (**Summary of Quality Control Checks and Sample).

All soil samples will be transferred directly into the appropriate sample containers with preservative, if required, chilled, and processed for shipment to the laboratory as detailed in **Section 5.0** (Sample Preservation and Handling). Applicable procedures for soil sampling are provided in:

- SOP FM-1.2 Subsurface Clearance Protocol
- SOP FM-2.1 Field Logging of Subsurface Investigations
- SOP FM-2.2 Classification of Soils via Unified Soil Classification System (USCS)
- SOP FM 4.0 Drilling Protocol
- SOP FM-4.1 Soil Boring Advancement
- SOP FM-4.4 Boring / Well Construction Field Log Completion
- SOP FM-4.6 Per-and Polyfluoroalkyl Substances (PFAS) Investigation – Drilling
- SOP FM-9.1 Soil Sampling for Analysis
- SOP FM-9.4 Surficial Soil Sampling
- SOP FM-13.2 Sample Preservation and Handling
- SOP FM-13.3 Sample Identification and Labeling
- SOP FM-13.4 Chain-of-Custody Procedures
- SOP FM-13.5 Sample Management, Packing, and Shipping
- SOP FM 22.0 PFAS Sampling
- SOP FM-22.7 PFAS Sampling – Soil
- SOP QA-1.1 Collection of Field QA/QC Sampling (Trip Blank, Equipment Blanks, Duplicate Samples, Matrix Spike Samples)

4.3 Packer Testing

After the installation of the new nested monitoring well, and water bearing zones and/or fracture zones have been identified through the downhole geophysical investigation, packer testing will be conducted at discrete intervals to obtain information regarding the groundwater quality in each targeted fracture location. The packer testing will consist of collecting static head pressure data, purging groundwater in an appropriate amount, collecting discrete groundwater samples, and collecting recovery head pressure data for each targeted fracture location. Data obtained from the packer testing will be used to determine final monitoring well construction.

In conjunction with the packer testing, a submersible pump will be utilized to purge at least three (3) packer interval volumes and collect initial groundwater samples from each targeted fracture location. The groundwater samples will be submitted to the subcontracted laboratory for analysis of TCL VOCs (including TCE and PCE and all daughter products) via EPA method 8260D, with a five-day rush turnaround time.

4.4 Groundwater Sampling

The full monitoring network, including the proposed new nested well set, will be investigated and sampled. The full monitoring well network is depicted on **Figure 1** (Groundwater Monitoring Well Location Map from the Remedial Investigation Report (Roux, 2021) included in **Appendix C.** The following procedures will be used to collect representative groundwater samples from the monitoring well network.

4.4.1 Well Inspection and Preparation

Upon arrival at the site, GES personnel will inspect each well and protective manhole or stickup casing (if applicable) prior to opening to determine if the well has been tampered with or damaged. The well cap and lock will also be inspected. Cracks in the casing and/or surface cement will be noted, as well as soil washouts and depressions around the casing. Before taking measurements, GES sampling personnel will remove weeds and debris from around the well, as necessary. Observations regarding the condition of the well will be recorded in a Site-dedicated field notebook. If the inspection reveals that well maintenance is required, the information will be forwarded to the GES CM for action.

4.4.2 Well-Head Monitoring

Before sampling, GES personnel will unlock and open each well. The air in the well head will then be sampled for organic vapors using a PID, dependent on event-specific requirements. PID readings will be recorded in the Site-dedicated field notebook and checked against the HASP limits prior to proceeding with field activities.

4.4.3 Initial Well Gauging and Detection of Immiscible Liquids

Prior to collecting groundwater samples, GES personnel will measure the static water level in the specified wells. Static water level measurements will be recorded to the nearest hundredth of a foot (± 0.01 foot), referenced to the marked surveyed elevation on the top of the inner casing, using an electronic oil-water interface probe. Additionally, GES personnel will measure the depth to the bottom of each well. The interface probe will be decontaminated between wells in accordance with procedures specified in **Section 9.0** (Instrument/Equipment Testing, Inspection and Maintenance).

The presence of immiscible layers [light non-aqueous phase liquid (LNAPL) and/or dense nonaqueous phase liquid (DNAPL)] in the water column in each well will be determined utilizing an interface probe or a transparent bailer. Applicable procedures for well gauging and detection of immiscible liquids are provided in:

- SOP FM-8.1 Liquid Level Gauging

If LNAPL and/or DNAPL is encountered, GES personnel are instructed to contact the GES CM for additional instructions before purging and/or sampling the well.

4.4.4 Sampling

Following the installation and development of the proposed nested monitoring wells detailed, GES will conduct groundwater monitoring and sampling of the full monitoring well network. The full monitoring well network, including the addition of the nested well set, will consist of 57 overburden, 42 shallow bedrock, 16 intermediate bedrock, and 23 deep bedrock monitoring wells on- and off-property. The monitoring wells will be sampled utilizing hydrasleeves. Hydrasleeve teethers will be prepared and provided by the supplier based off well construction information (including well depth, diameter, top of screen, depth to water, and sampler location depth) provided to the supplier by GES. The target sample depth in each monitoring well will be at the bottom of the screen interval due to increased volume requirements for sampling.

At each sampling location, all bottles designated for a particular analysis (e.g., PFAS) will be filled sequentially before bottles designated for the next analysis are filled (e.g., VOCs). If a duplicate sample is to be collected at this location, all bottles designated for a particular analysis for both sample designations will be filled sequentially before bottles for another analysis are filled. In the filling sequence for duplicate samples, bottles with the two different sample designations will alternate (e.g., PFAS designation MW, PFAS designation MW Duplicate, VOC designation MW, and VOC designation MW Duplicate). The sampling sequence should be: VOC first, PFAS second, metals third, and fluoride last. The sampling sequence for the site is reflected in the sampling requirements specified in **Table 2-3** (Groundwater Sampling Requirements).

VOC samples should be collected first, with as little agitation or disturbance as possible. The vials should be filled so that there is a meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. Air bubbles can be checked for by inverting the vial and tapping. If any bubbles are present, the sample should be discarded and retaken. Do not “top-off” the container to fill the additional head space.

Samples designated for dissolved metals analysis will be filtered. A 0.45-micron filter will be used to remove particles that have been entrained in the water sample. A clean, unused filter will be used for each filtered sample collected. Filtration should be completed prior to preservation and in as short a time as possible while minimizing sample aeration, agitation, pressure changes, temperature changes, and prolonged contact with ambient air. Groundwater samples will be transferred from the filter directly into the appropriate sample containers to which preservative has been added and processed for shipment to the laboratory. When transferring samples, care should be taken not to touch the filter to the sample container.

The groundwater samples will be submitted for laboratory analysis of TCL VOCs via EPA method 8260D, dissolved metals via EPA Method 6010D, total chromium (Cr^{+6} plus Cr^{+3}) via EPA 6010D, dissolved hexavalent chromium via EPA Method 218.6, dissolved fluoride via EPA Method 9056A, and PFAS via EPA Method 1633. Groundwater samples from all monitoring wells south of Lancaster Avenue will be analyzed for inorganics (dissolved metals, hexavalent chromium, and fluoride).

Groundwater samples will be transferred directly into the appropriate sample containers with preservative, if required, chilled, and processed for shipment/courier to the laboratory as detailed in **Section 5.0** (Sample Preservation and Handling).

Well sampling procedures are specified in the following SOP:

- SOP FM-8.13 Passive Groundwater Sample Acquisition
- SOP FM-8.3 Groundwater Sample Acquisition
- SOP FM-22.0 PFAS Sampling
- SOP FM-22.2 PFAS Sampling – Groundwater

4.4.5 PFAS Sample Collection

Special care must be considered when sampling for PFAS to avoid sample contamination. Sampling will be conducted in accordance with GES PFAS sampling procedures, and the GES Daily PFAS Sampling Checklist (GES Media Sampling for PFAS SOP). Some of the special considerations are:

- Sample PFAS first after collecting VOC samples and replacing gloves
- Store PFAS bottles in separately-sealed plastic bags, away from other sample parameter bottles (e.g., a designated PFAS sample bottle cooler)
- Use high density polyethylene (HDPE) or silicon tubing rather than low density polyethylene (LDPE) or Teflon™ tubing
- Avoid waterproof paper, adhesive paper products (bottle labels), sunscreen, and cosmetics.

4.5 Surface Water Sampling

The surface water investigation will include surface water sampling of the previously established Roux surface water sample locations, SW-1 through SW-10. The surface water sample locations are depicted on Figure 2 included in **Appendix C.**

- SOP FM-8.1 Fluid Level Gauging

Surface water samples will be collected using a disposable bailer and samples will be collected from the surface of each location. At each sampling location, all bottles designated for a particular analysis (e.g., PFAS) will be filled sequentially before bottles designated for the next analysis are filled (e.g., VOCs). If a duplicate sample is to be collected at this location, all bottles designated for a particular analysis for both sample designations will be filled sequentially before bottles for another analysis are filled. In the filling sequence for duplicate samples, bottles with the two different sample designations will alternate (e.g., PFAS designation MW, PFAS designation MW Duplicate, VOC designation MW, and VOC designation MW Duplicate). The sampling sequence should be: VOCs first, PFAS second, metals third, and fluoride last. The sampling sequence for the site is reflected in the sampling requirements specified in **Table 2-4** (Surface Water Sampling Requirements).

VOC samples should be collected with as little agitation or disturbance as possible. The vials should be filled so that there is a meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. Air bubbles can be checked for by inverting the vial and tapping. If any bubbles are present, the sample should be discarded and retaken. Do not "top-off" the container to fill the additional head space.

Samples designated for dissolved metals analysis will be filtered. A 0.45-micron filter will be used to remove particles that have been entrained in the water sample. A clean, unused filter will be used for each filtered sample collected. Filtration should be completed in as short a time as possible while minimizing sample aeration, agitation, pressure changes, temperature changes, and prolonged contact with ambient air. Surface water samples will be transferred from the filter directly into the appropriate sample containers to which preservative has been added and processed for shipment to the laboratory. When transferring samples, care should be taken not to touch the filter to the sample container.

The surface water samples will be submitted for laboratory analysis of TCL VOCs via EPA method 8260D, dissolved metals (including magnesium and calcium for hardness calculation) via EPA Method 6010D, total chromium and manganese via EPA Method 6010D, dissolved hexavalent chromium via EPA Method 218.6, dissolved fluoride via EPA Method 9056A, and PFAS via EPA Method 1633

Surface water samples will be transferred directly into the appropriate sample containers with preservative, if required, chilled, and processed for shipment to the laboratory as detailed in **Section 5.0** (Sample Preservation and Handling).

Surface water sampling procedures are specified in the following SOPs:

- SOP FM-10.1 Surface Water and Sediment Sampling
- SOP FM 22.0 PFAS Sampling
- SOP FM 22.4 PFAS Sampling - Surface Water and Surface Water Foam

5 Sample Preservation and Handling

The objective of the sampling program is to obtain samples that are representative of actual site conditions. Since the chemical constituents of a sample may be altered by variations in temperature, the length of time the sample is stored prior to analysis, the use of improper preservatives or sample containers, etc., the following methods have been selected to ensure that the samples are properly collected, preserved, and handled from the time of sample collection to analysis. The selected methods are taken from recommended procedures found in *Test Methods for Evaluating Solid Waste (SW846),* 3rd Edition, Revised 1986. EPA Method 1633, a collaboration between the EPA, Department of Defense (DOD), and Department of Energy (DOE), is not included in SW-846; however, it compliments Method 8327 found in SW846.

Laboratory specific procedures for each method will be followed. No modifications of analytical methods will be requested from the lab for this project. Specific procedures for sample preservation, identification, chain-of-custody, packaging and shipping, and proper documentation of sample handling procedures are provided in the following SOPs:

- SOP FM-13.2 Sample Preservation and Handling
- SOP FM-13.3 Sample Identification and Labeling
- SOP FM-13.4 Chain-of-Custody Procedures
- SOP FM-13.5 Sample Management, Packing, and Shipping
- HSCA QAPrP Sections A.6.2, A.6.3, and B.3 Sample Containers, Preservatives, & Holding Times

Soil, surface water, and groundwater samples will be transferred directly to the sample containers that have been prepared with appropriate preservatives by the laboratory or approved bottleware supplier. Sample bottles will be pre-labeled with site specific information and will be packed in insulated shipping containers prior to transport to the site. Filled sample containers will be returned to the cooler, placed on ice to maintain a temperature of 4°C ± 2°C, and returned to the laboratory for analysis via overnight shipping or courier pick-up. **Table 8** (Sample Containers, Sample Volumes, Preservation, and Holding Times) summarizes preservative, container, and sample holding times for the analytical program.

Sample bottles will either be supplied and pre-preserved by the analytical laboratory or obtained from an approved bottleware supplier. Certification documentation received by the field sampling team will be removed from the bottle shipment packaging and maintained by the Field Supervisor.

The Field Supervisor is responsible for inspecting each shipment of bottles for breakage. Sample bottles are to be compared to the analytical program requirements to ensure a sufficient supply of bottles has been provided. Sample bottles containing preservatives will be checked against the required preservative for particular analytes. Sample bottles will be stored in coolers/shipping containers in a cool, dark place until transport to the Site for sampling. The Field Supervisor will report any missing, broken, or inappropriate sample container to the CM. The CM will notify the laboratory or bottleware supplier and request replacement bottles.

5.1 Sample Identification and Labeling

Samples will be appropriately marked for identification at the time of sample collection. The label attached to the sample container will include, as appropriate, the following items:

- Project name
- Sample identification
- Sample collector's name
- Date and time of collection
- Parameters requested for analysis
- Chemical preservatives (if used)

Specific information for each sample will be documented in the Site-dedicated field notebook and on a chain-of-custody form. The sample identification will be correlated in the Site-dedicated field notebook and on the chain-of-custody by sample designation, sampling date, time, and location.

Procedures for maintaining the Site-dedicated field notebook and completing the chain-of-custody form are discussed in **Section 8.0** (Documentation).

5.2 Sample Shipping

A custody seal will be attached to each cooler to ensure that each cooler cannot be opened without evidence of the seal being broken. GES will package the samples for shipment and delivery to the laboratory. Samples will be placed in a cooler with ice to maintain a temperature at or less than 4^{o} C ± 2°C. Sample preparation, shipping/handling, custody seal identification number, and laboratory submittal details will be recorded in the Site-dedicated field notebook.

6 Decontamination Procedures and Waste Disposal

6.1 Decontamination

6.1.1 Electronic Water Level Probe

The electronic oil-water interface probe will be decontaminated by thoroughly rinsing that portion of the probe that is exposed to the media with the appropriate decontamination liquid and rinsed with deionized PFAS-free water. Rinse water will be treated through the portable GAC units.

6.1.2 Non-Dedicated Sampling Equipment: Samplers, Pumps, etc.

Non-dedicated sampling equipment will be cleaned prior to initial use and before each re-use. When non-dedicated sampling equipment is used, a daily field blank will be prepared at the end of each day to determine if cleaning procedures are effective and adequate. Equipment field blanks will be prepared by collecting deionized PFAS-free water that has been run through or poured over the cleaned sample collection equipment. Field decontamination procedures are specified in the following SOP:

- SOP FM-14.1 Decontamination of Non-Dedicated Sampling Equipment

6.1.3 Geoprobe® and Sonic Drill

Direct-push rods and equipment associated with soil boring and monitoring well installation activities will be cleaned prior to initial use and before each re-use. Field decontamination procedures are specified in the following SOP:

- SOP FM-14.2 Decontamination of Heavy Equipment

6.1.4 Personal Protective Equipment

GES will provide a decontamination staging area for personnel. Refer to the HASP and the following SOP for appropriate decontamination procedures:

- SOP FM-14.3 Field Personnel Decontamination

6.1.5 PFAS Decontamination

Prior to the collection of PFAS samples, sampling personnel must use PFAS-free water to decontaminate and change gloves. Decontamination procedures are fully described in the PFAS SOP (**Appendix A**).

6.2 Investigation Derived Waste

Personal Protective Equipment (PPE), disposable sampling equipment, and groundwater generated during field activities will be disposed of in accordance with the Investigation Derived Waste (IDW) SOP. Refer to the following SOPs for appropriate waste handling and removal procedures:

- SOP FM-15.1 Containerization and Removal of Remedial Investigation Derived Waste
- SOP FM-20.1 Waste Sampling

6.2.1 PPE and Used Sampling Materials

Used PPE (e.g., disposable gloves), disposable equipment (e.g., plastic baggies, acetate liners), and disposable sampling materials (e.g., peristaltic tubing) will be drummed pending disposal requirements.

At each sample location, a sufficient quantity of 55-gallon drums will be available to containerize waste materials. Each drum will be properly labeled with the type of waste and date of accumulation. The drums will be sealed after use. At each location, the drums will be stored in the controlled work zone to minimize contact by the general public.

When characterization activities are completed at each location or at the end of the day if activities occurred at only one location, the drums will be moved to a temporary staging area prior to final disposition.

6.2.2 Soil

All solid waste will be containerized and shipped off-site for proper disposal pending analytical testing. Solid waste will be stored in 55-gallon drums until the waste is removed from site. If drums are used, each drum will be properly sealed and labeled with the type of waste and date of accumulation.

6.2.3 Liquid Waste – Well Development, Well Purge, Excess Groundwater from Sampling, Decontamination Rinse Water

All liquid waste will be containerized and shipped off-site for proper disposal pending analytical testing. Liquid waste will be stored in 55-gallon drums until the waste is removed from site. If drums are used, each drum will be properly sealed and labeled with the type of waste and date of accumulation.

6.2.4 Waste Temporary Staging Area

The staging area will be located away from traffic or pedestrian areas and will be clearly identifiable and secured. IDW drums will be clearly labeled and dated (accumulation start date). The drums will be stored with enough aisle space between the drums to identify each drum and to check for leaks. The integrity of each drum will be inspected prior to mobilization and use at the site. In the event that other site activities warrant the unexpected long-term duration of on-site storage, tarping or covering of the IDW drums will be discussed with the Department.

6.2.5 Waste Characterization

Upon completion of site characterization activities, solid and liquid samples will be collected and submitted for the appropriate analyses in accordance with the disposal facility's requirements and any applicable municipal or regulatory agency requirements to determine waste disposition.

Samples will be analyzed for hazardous waste characteristics to determine if the waste needs to be managed as hazardous waste. If the analysis indicates the waste is hazardous, then the waste will be transported off-site to an approved disposal facility. If the analysis indicates that the waste is not hazardous by characteristic, then additional testing would be completed to determine residual waste classification and disposal requirements.

All sampling personnel will be familiar with sample collection and waste storage protocols and will have completed Hazard Communication Training in accordance with 29 CFR 1910.120 as well as being trained appropriately per the HASP.

The waste classification samples will be sent to a licensed, qualified laboratory for waste classification analysis (i.e., toxicity characteristic leaching procedure [TCLP] and Resource Conservation and Recovery Act [RCRA] characteristics) to determine appropriate waste classification and handling requirements. All waste classification and handling activities will be conducted in accordance with DEP Title 25 hazardous and residual waste regulations, including the requirements of 25 Pa. Code, Articles VII, Chapters 260a through 270a (DEP, 2025) and 25 Pa. Code, Article IX, Chapter 287 (DEP, 2025). There are no regulatory-required certification requirements for waste characterization analysis; however, the laboratory subcontracted to perform the analysis will be certified through the NELAP for the analytical parameters being analyzed, so there is assurance that the laboratory has passed a nationally recognized quality assurance program that includes audits and analysis of blind performance samples to check data quality, and that meets certain minimum technical standards for the qualifications of testing personnel. The subcontracted laboratory will also be accredited by the Pennsylvania Bureau of Laboratories Laboratory Accreditation Program (LAP) for all analytical parameters, methods, and technologies used per 25 Pa. Code, Chapter 252.1-252.6 (DEP, 2025).

Following receipt of analytical results, the appropriate waste classification will be determined and arrangements made for disposal with the approved subcontractor.

7 Quality Assurance/Quality Control

7.1 Field Quality Assurance/Quality Control

Field sampling operations are described in the SOPs (**Appendix A**) attached to this document. Sampling procedures include specific steps to ensure proper documentation of all pre-field activities such as equipment preparation and cleaning, calibrations, container storage, and preparation. Several different types of quality control samples will be used to assess the types and amounts of contamination introduced to samples during collection, handling and transportation prior to analysis at the laboratory. They will also be used to evaluate precision and variability in the sampling process. The type of information used to evaluate the PARCCS parameters are summarized in **Table 6** (Types of Information Used to Evaluate Precision, Accuracy, Representativeness, Comparability, Completeness, and Sensitivity). The quality control sampling frequency is summarized in **Table 7** (Summary of Quality Control Checks and Samples). The field quality control sample collection plan is summarized in **Table 5** (Field Quality Control Summary).

Standard operating procedures for collecting QA/QC samples are contained in the following SOP:

- SOP QA-1.1 Collection of Field QA/QC Samples (Trip Blanks, Equipment Blanks, Duplicate Samples, Matrix Spike Samples)

7.1.1 Trip Blanks

Soil, groundwater, and surface water trip blanks will be collected each day that samples are collected for VOC analysis. At least one trip blank shall be included in each shipping container that contains VOC samples. The containers will be filled prior to sampling, carried to the field, and submitted to the analytical laboratory for analysis.

7.1.2 Field Blanks

Soil, groundwater, and surface water field blanks will be collected each day that samples are collected for VOCs, metals, fluoride, and PFAS analysis. PFAS field blanks require PFAS-free water and will be stored and transported in their own coolers. Field blanks will be collected at a frequency of one field blank in twenty samples, one per sampling event, or once per analysis or media type, whichever is greater.

7.1.3 Equipment Blanks

To verify that no constituents are introduced from sampling equipment, equipment blanks are collected by filling, pumping, or pouring distilled water through the representative sampling device and analyzing for all constituents of interest. One equipment blank is to be collected at the end of each day and submitted with the samples submitted for delivery to the subcontracted laboratory. The collection of equipment blanks is contingent upon the equipment utilized for a sampling event and are collected as requested by DEP per sampling event.

7.1.4 Duplicate Samples

Field duplicate samples are grab samples collected sequentially from a specific location as close as possible in space and time to the original sample, followed by identical analyses of the two samples. Duplicate samples will be determined at the time of sample collection and will be collected at a frequency of one field duplicate in twenty samples, one per sampling event, or once per analysis or media type, whichever is greater. The locations of the duplicate samples will be recorded in the field notebook, but will not be known to the subcontracted laboratory on the chain-of-custody or bottleware labels. Duplicate samples will be identified in the Data Gap Pre-Design Investigation Report.

7.1.5 Split Samples

Split samples will not be collected during this mobilization.

7.2 Laboratory Quality Assurance/Quality Control

QC checks will be performed in order to confirm that the QA objectives for measurement data in terms of precision, accuracy, and completeness are being met for field sampling and analytical laboratory analyses. The analytical laboratory's Quality Assurance Program Plan discusses the laboratory's internal quality control program, including the frequencies and types of QC checks performed to confirm that the laboratory analyses QA objectives are being met. The specific quality control procedures are detailed in the laboratory's Analytical Methods Standard Operating Procedures and are based upon EPA methods guidance. Quality controls follow EPA methods and accreditation requirements per their DEP NELAP standards.

The analytical laboratory shall analyze MS and MSD samples on aliquots of actual samples of matrix material. This is to determine if the sample exhibits “matrix effects” that can invalidate MS/MSD analysis. MS/MSD samples will be analyzed with each analytical batch with a minimum of one per twenty samples or fraction thereof. Separate samples or additional sample volume will be collected and submitted for the MS/MSD samples as requested by the laboratory.

The analytical laboratory shall analyze LCS and LCSD samples to evaluate the laboratory performance of the entire analytical process. LCS samples are sometimes referred to as blank spikes and are used to monitor the accuracy of the analyst(s) performing the laboratory method. LCS/LCSD samples are typically evaluated in terms of percent recovery of the target analytes. LCS/LCSD samples are prepared by the laboratory and included with each analytical batch with a minimum of one per twenty samples or fraction thereof.

The type of information used to evaluate the PARCCS parameters are summarized in **Table 6** (Types of Information Used to Evaluate Precision, Accuracy, Representativeness, Comparability, Completeness, and Sensitivity). The quality control sampling frequency is summarized in **Table 7** (Summary of Quality Control Checks and Samples).

8 Documentation

The management of samples from the point of collection to the point of analysis will be carefully controlled. Samples will be collected by GES personnel using the sampling protocol discussed in the previous sections. Sampling procedures will be documented on Field Data Sheets or in field notebooks. Chain-of-custody sheets will be completed by field personnel at the time of sample collection and maintained through transport to the laboratory.

8.1 Field Sampling Log Sheets/Field notebooks

Field personnel are required to maintain Site-dedicated field notebooks to document procedures for all sampling events. All site activities are to be recorded in the Site-dedicated field notebook. Upon completion of the task, the sampler is required to sign and date all Field Data Sheets and the field notes for the event. Signed and dated data sheets and/or the field notes are to be returned to the GES Project Management Assistant (PMA). The PMA is required to maintain a log of all Field Data Sheets and field notes used for a project and to maintain the data sheets and/or field notes in the project file.

8.2 Chain-of-Custody Record

Chain-of-custody documentation will be maintained for each sample in order to document sample possession from the time of collection to final laboratory testing. Sampling personnel will record the following information on the chain-of-custody form:

- Project name and purchase/project number
- Client/Company name (PaDEP)
- Date and time of collection
- Sample identification/location
- Sample Matrix, target parameters and analytical methods
- Number of containers/sample and preservatives
- Requested turnaround time and data deliverable
- Samples flagged or denoted that require special handling by the laboratory (e.g. high PID readings)
- Facility name and ID number
- Project Managers and other Contact names and numbers
- Signature of sample collector(s) (GES)
- Shipping method
- Signature of person(s) involved in the chain of possession
- Inclusive dates for time of possession

Procedures for completing the chain-of-custody are contained in the following SOP:

- SOP-FM-13.4 Chain-of-Custody Procedures

A completed chain-of-custody record will accompany each sample shipment prior to transport. Upon receipt of samples in the laboratory, the contents of each shipment will be checked against the chain-of-custody record. The laboratory Sample Custodian will sign the chain-of-custody form to acknowledge transfer of custody of the samples. Any discrepancies between the custody record and the shipment contents (e.g., broken container, improper temperature, broken seal) will be reported immediately to GES.

All original Field Data Sheets and chain-of-custody forms will be maintained in the project file by the GES PMA.

9 Instrument/Equipment Testing, Inspection and Maintenance

Periodic preventive maintenance is required for equipment whose performance can affect results. Instrument manuals are kept on file for reference if equipment needs repair. Troubleshooting sections of manuals are often useful in assisting personnel in performing maintenance tasks.

9.1 Field Equipment

Field sampling personnel will be responsible for preventive maintenance of all field instruments. The field sampling personnel will protect the instruments by placing them in portable boxes and/or protective cases.

All field equipment will be subject to a routine maintenance program, prior to and after each use. The routine maintenance program for each piece of equipment will be in accordance with the manufacturer's operations and maintenance manual. All equipment will be cleaned and checked for integrity before and after each use. Necessary repairs will be performed immediately after any defects are observed, and before the item of equipment is used again.

Equipment parts with a limited life (such as batteries, membranes, and some electronic components) will be periodically checked and replaced or recharged as necessary according to the manufacturer's specifications.

Preventive maintenance is important since it provides for a longer useful life of the equipment and helps to ensure a successful field sampling and testing program. Each piece of field equipment will have its own log sheet that contains the equipment identification and the type of maintenance performed. Since most equipment is used on an irregular basis, all equipment will be properly stored when not in use.

9.2 Instrument/Equipment Calibration and Frequency

Field and laboratory equipment are calibrated before use to ensure proper operating conditions. At a minimum, the following field calibration procedures and frequencies will be followed:

- PIDs will be calibrated daily according to manufacturer specifications using a known concentration of 100 parts per million (ppm) of isobutylene standard calibration gas.

9.3 Laboratory Equipment

A significant portion of major laboratory instruments are under service contract so that trained professionals are available on call to minimize instrument downtime; however, this does not apply to other laboratory instruments. Preventative maintenance schedules and/or procedures for laboratory equipment are, therefore, presented in the laboratory Quality Assurance Manual (QAM) and follow accreditation protocols.

10 Data Management

The primary objective is to maintain the security and integrity of project specific data from initial acquisition through final archiving, while providing team members with access to information. Project-specific information, such as background and historical data, field data, analytical data, accounting information and reports, are maintained on a local area network (LAN). Each team member involved in acquiring data is responsible for recording the original computer records and making these records available to the project team in the required format.

10.1 Documentation and Records Administration

Information associated with the project will be retained in the project file. These files will include the following:

- Field records (field notebooks, field data sheets, copies of filed field note pages)
- Chains-of-custody
- Laboratory analytical reports
- Test data
- Numerical calculations
- Reports and other transmittals
- Copies of work requisitions, notices to proceed, and contracts
- Correspondence including incoming and outgoing letters, memoranda, and records of conversation
- Photographs
- Reference material
- Figures

Field data, such as survey information, geologic logs, well construction diagrams, and field notes, are recorded directly in the field or recorded via Personal Digital Assistant (PDA)/computer (e.g. pump test data, feasibility test data, and geophysical test data). To achieve these objectives for accurate, secure, and complete data, field data are downloaded into the project file on the LAN as soon as practical. The data file is stored in “read only” format, and all further processing is done on working copies made from the master file.

Professional field personnel transcribe their own data into appropriate computer files, which are then checked by the originator and verified for accuracy and completeness. Data acquired by technicians are transcribed by administrative personnel and checked by the professional staff for accuracy and completeness. These files are named and stored in accordance with a hierarchal structure. Paper copies of field notes are dated, stamped, and maintained in a secure project file by the PMA. If corrections are made to an original file, the team member initiating the change is responsible for informing the project data manager who documents the correction in the original master file, initials the original paperwork, and retains a copy. All versions of master files are labeled and saved. Members of the project team that generate these records are required to provide the records to the designated project PMA. The PMA will check that incoming records have proper identification for filing, are legible, and are in suitable condition for filing.

For the project file, individual file folders will be divided into appropriate categories based on content.

10.2 Data Processing

GES processes data using duplicate copies of master files to ensure that processing is conducted with secure methods that do not compromise the integrity of the data throughout the processing sequence. Field data are initially processed into a common format for import into processing, display and database programs. Data are then imported to analysis and display programs to produce graphical displays. The project team is responsible for verifying results. The LAN is backed up onto the wide area network (WAN) daily.

Field data are processed as soon as practical to allow for ongoing data evaluation that may result in corrections and/or additions to the work plan. Maps, figures, and tables are provided to the project team for verification. The project team is responsible for notifying the data manager regarding erroneous or inconsistent results, and corrections are appropriately handled as described above. Final data processing results, such as graphical displays, database files, spreadsheets, and AutoCAD files, are saved to the project file as final files.

10.3 Data Archival

All master files, files of final results, files of significant intermediate or auxiliary results, and copies of databases are archived in permanent storage together with supporting paperwork and documents. Archival is on a removable system in addition to data saved on standard backup systems. Archived files will be stored throughout the contract period and as directed by the Commonwealth. All project data files will be provided to DEP as electronic files. Hard copies can be provided upon request.

11 Assessment and Oversight

11.1 Assessment and Response Actions

Assessments are designed to determine whether the QAPP is being implemented as approved, to increase confidence on the information obtained, and to determine whether the information may be used for their intended purpose. The following sections describe what assessments will occur and how the assessment reports will be provided to management.

The Field Supervisor, Case Manager, and Project Manager are responsible for ensuring that all field investigations are performed in accordance with the requirements and specifications outlined in this QAPP. As part of the field QA/QC program, GES will conduct at least one Quality Observation (QO) during the course of the project. The QO will involve reviewing field procedures, such as gauging, purging, and sampling, for conformance with standard operating procedures.

The Field Supervisor, Case Manager, and Project Manager are responsible for reviewing all data obtained in the field as they are generated by the Field Team for accuracy and clarity to ensure their reproducibility after completion of field activities.

The analytical results of the field blanks and replicate samples are indirect audits of the level of performance of field activities. If significant inconsistencies occur in the evaluation of these field QC samples, corrective actions may be required. It is the responsibility of the Quality Assurance Manager to determine whether any corrective actions are required. If necessary, corrective actions may include re-analysis by the laboratory or re-sampling to address flagged issues. The evaluation criteria is summarized in **Table 5** (Field Quality Control Summary).

11.2 Reports to Management

Results of the QO will be documented on the Quality Observation form, which is included as **Appendix D**. Areas of conformance and nonconformance will be identified, and mechanisms for resolving non-conforming issues will be developed and implemented. The QO results will be reviewed with the Field Team members.

12 Data Validation and Usability

Data evaluation, transfer, and support are essential functions in summarizing information to support conclusions. It is essential that these processes are performed accurately and, in the case of data reduction, accepted statistical techniques are used.

12.1 Data Reduction

Data reduction is the process of converting raw data to final results. The subcontracted laboratory will complete analytical data reduction and QA/QC review following the laboratory SOPs and laboratory accreditation procedures. The Laboratory Quality Assurance Officer (QAO) is responsible for assessing data quality and communicating if any data is considered unacceptable or qualified that would cause possible unreliability of the data.

For soil, groundwater, and surface water analytical data, data reduction and interpretation will include preparation of result summary tables, preparation of groundwater elevation contour maps and groundwater and soil analytical maps, QA/QC of all data, and comparison of data to applicable DEP standards. Data that are reduced into result summary tables will be verified by manually checking the sample data against the laboratory analytical reports.

Project-specific data reduction methods may be designed to ensure that data are accurately and systematically reduced into a usable form. Data reduction methods that may be utilized include the computation of summary statistics (e.g. means, geometric means, and medians) and their standard errors (standard deviations), calculation of confidence intervals, testing of hypotheses relative to the parameters, and model validation.

12.2 Verification and Validation Methods

Data are typically validated by the laboratory and field personnel. First, during the field operations, field measures will be validated at the time of collection by the Field Team Leader by verifying the use of standard operating procedures for the sampling effort and using field QC checks. Second, laboratory analytical results will be validated by the Laboratory Department Manager or the analyst who is the specific analytical task leader.

12.2.1 Field Data Validation

Validation of field-obtained data, as well as ongoing QA/QC checks of environmental samples being taken, is performed on field data. All field data are reviewed during the time of collection and second, all data are reviewed by secondary field personnel if multiple personnel are present. If the Case Manager or (if delegated) Field Supervisor is performing the initial review, a designee will do the secondary review. Otherwise, the Case Manager or Field Supervisor will perform the secondary review. In review of the field data, care will be taken to ensure that correct codes, units, and sample locations, as well as other pertinent information are included in the field notebooks, records, and chains-of-custody. Any inconsistencies discovered will be resolved immediately, if possible. Corrections to field data sheets or field notebooks will be removed by placing a single line through the entry and initialing and dating the correction. If information is added without a correction being necessary, that entry will be initialed and dated to indicate that it was not entered at the original time of data entry. Entries should never be “whited out” or made in pencil.

Additionally, the Case Manager or Field Supervisor will be responsible for ensuring that accurate and correct data and representative samples are obtained by following field investigation procedures as they are described in the Work Plan to achieve work objectives. It is important that the Case Manager or Field Supervisor makes sure the field team adheres to the approved Work Plan and follows QA/QC measures as outlined in this document including the proper calibration of instruments, sampling according to standard operating procedures, and taking of sufficient sample volumes and field QC samples.

12.2.2 Laboratory Data Validation

The individual Laboratory Department Managers shall validate all laboratory data, prior to reporting, originating from his or her section. Some of the following QA/QC measures are reviewed or procedures are typically used:

- A standard calibration curve is prepared prior to sample analysis
- The standard regression coefficient is within the acceptable range
- Standard reference materials are analyzed at the proper frequencies and acceptable results are obtained
- The reagent blanks are analyzed at the proper frequency
- Precision requirements of this plan are met
- Accuracy requirements of this plan are met
- Completeness requirements of this plan are met
- Samples are analyzed within the proper sample holding times
- All calculations are verified as correct
- Proper units are reported
- The proper methodologies were used

Besides this review of analytical results and project specific precision, accuracy, and completeness requirements, the Laboratory Department Manager should perform unannounced audits of report forms and other data sheets as well as regular reviews of instrument logs, performance test results, and analysts’ performance. Any review of analytical results or internal QA/QC checks that indicate problems, immediate corrective actions should be taken and all data collected since the previous approved QC audits should be reviewed for validity. Specific laboratory procedures for validation of the analytical data generated are described in the laboratory QAM.

Once the data have been validated internally by the laboratory, all of the results are electronically or automatically entered into the laboratory's data management system where they are stored prior to reporting. When all analyses are completed for data storage, the Laboratory Director (or his/her designee) will issue a final data report including a descriptive case narrative. He or she will then issue the report to the data user. All applicable QC data should be included with the final report.

12.3 Reconciliation with User Requirements

The data reports generated for this project should contain all pertinent information for the data user to determine the applicability and usability of the data for its intended purposes. For this reason, a specified and uniform data reporting format should be implemented. The following criteria and information should be supplied, at a minimum, for all data reports generated for this project:

- A descriptive case narrative identifying any problems encountered during internal data validation (as described above).
- Completed and legible chains-of-custody for all analyses contained within each submitted data package.
- A lab sample chronicle indicating which analyses were requested and performed for the samples contained in the data package.
- A summary of the laboratory sample identifications and the correlating field sample identifications.
- A summary of all applicable analytical results reported in the correct number of significant figures, reporting units.
- Included in the analytical results summary will be the evaluation of the reported data in comparison to the regulatory criteria specified in **Table 4** (Regulatory Criteria).
- Included in the individual sample reporting results should be the complete sample identifications, the sample dilutions (if necessary), and the individual sample analysis dates.

The reporting level required for this project will be Level II Reporting per the HSCA QAPP Section B.10.6. In addition, the subcontracted laboratory will provide electronic data deliverable (EDD) files for data review. The reporting levels and data packages are detailed in the following subsections.

12.3.1 Level I Reporting

Summary reporting only will be provided. Bulleted items above are required under this data quality level (DQL).

12.3.2 Level II Reporting

Summary reporting only will be provided. The data package reporting requirements are the same as Level I except legible and calculated QA/QC summaries for laboratory quality control blanks, surrogate recoveries (if applicable), laboratory control sample results and recoveries, and matrix spike/matrix spike duplicate recoveries (or matrix spike recovery and laboratory duplicate results) must also be supplied under this DQL. This will also include sample documentation (location, date, and time of collection and analysis, etc.), case narratives, lab chronicle, certification summary, project notes, a copy of a completed and signed chain-of-custody. Sample reports should include levels of quantitation or RLs, detection limits, analytes identification and quantitation, and duplicate results.

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Tables

Table 1 – Lines of Authority and Responsibilities

Personnel	Responsibilities
GES Project Manager (PM)	• Manages the project • Reviews and approves the work plan, schedule, and other documents and reports • Identifies data quality objectives and data needs • Assigns tasks to project staff • Serves as “collection point” for project staff reporting of non-conformances and changes in project documents and activities • Determines the effects on the project from the reported changes and non-conformances and determines the appropriateness for reporting such issues to DEP • Directly responsible to DEP for all activities performed by GES and subcontractors • Prime point of contact with DEP Case Manager
GES Case Manager (CM)	• Reports to the PM • Executes the work plan and schedule • Coordinates with the LHSO and Quality Assurance Officer (QAO) • Schedules analytical services with the laboratory and secures bottleware • Ensures field activities implemented in accordance with HASP, SAP, and QAPP • Reviews and evaluates field investigation data • Reviews all field documentation and chains of custody • Recommends modifications to work plan • Prepares reports
GES Field Supervisor	• Reports to the CM • Ensures site work complies with the HASP and QAPP • Coordinates sampling activities with the Case Manager • Supervises sample collection and provides for proper documentation, handling, and shipment • Maintains field data sheets and the field notebook • Ensures compliance with SOPs contained in SAP
Project Management Assistant (PMA, GES)	• Reports to the PM • Maintains the project file • Finalizes work products for distribution • Distributes work products • Assist PM and CM with administrative duties
Local Health and Safety Officer (LHSO)	• Reports to the PM • Develops and implements the HASP • Manages health and safety functions • Point of contact for health and safety matters • Verifies compliance with the HASP • Maintains health and safety records
Quality Assurance/Quality Control Officer (QAO)	• Responsible for all QA/QC functions • Independent of PM/CM • Ensures compliance with all QA/QC protocols • Prepares and implements the QAPP • Monitors QC compliance • Documents nonconforming activities • Administers corrective action • Controls QC documentation • Oversees preparation of QC reports

Personnel	Responsibilities
DEP Regional Project Officer (RPO)	• DEP point of contact with GES Contractor • Maintains DEP's project file • Reviews and approves the WP, SAP/QAPP, and other documents and reports
Laboratory Director	• Develop policies and general QA strategies • Allocate personnel and resources throughout the laboratory section • Implements long-term planning, goal setting and quality objectives • Reviews quality assurance reports
Laboratory Project Manager	• Lab point of contact with GES Contractor • Serves as liaison between the laboratory and project personnel • Reports non-conformances and changes on laboratory activities to GES Project Manager
Laboratory Manager	• Reports to the Project Manager • Coordinates with the Lab Project Manager to establish analytical programs • Serves as the collection point for laboratory non-conformances • Reports non-conformances and changes on laboratory activities to Lab Project Manager
Laboratory Quality Assurance Officer	• Reports to the project QA/QC officer • Independent of the laboratory analyst • Conducts laboratory performance and system audits on a regular basis • Monitors adherence to laboratory QA objectives as stated in the laboratory's Quality Assurance Manual • Writing, maintaining, implementing and reviewing laboratory SOPs • Investigates non-conformances and initiates corrective actions • Follows up on corrective actions to ensure problem resolved

Note: The responsibilities detailed above are typical job tasks for the identified personnel and will be performed according to the DEP approved Pre-Design Data Gap Work Plan (GES, 2025). Laboratory specific responsibilities will comply with 25 Pa. Code, Chapter 252.1-252.6 (DEP, 2025) and TNI standard and are covered under laboratory accreditation.

Table 2-1 – Sampling and Investigative Methodologies

Media of Concern	Sampling and Investigative Methodologies	Data Obtained	Data Use
Soil	Soil sampling for background investigation; laboratory analysis by EPA Method 6010	Metals	Assess background soil quality
Soil	Soil sampling for background investigation; laboratory analysis by EPA Method9056A	Fluoride	Assess background soil quality
Soil	Soil sampling for background investigation; laboratory analysis by EPA Method 1633	PFAS	Assess background soil quality
Soil	Soil sampling for data gap investigation; laboratory analysis by EPA Method 8260D	TCL VOCs	Assess soil quality
Soil	Soil sampling for data gap investigation; laboratory analysis by EPA Method 9056A	Fluoride	Assess soil quality
Soil	Soil sampling for data gap investigation; laboratory analysis by EPA Method 1633	PFAS	Assess soil quality
Groundwater	Groundwater sampling of full monitoring well network; laboratory analysis by EPA Method 8260D	TCL VOCs	Assess groundwater quality
Groundwater	Groundwater sampling of full monitoring network; laboratory analysis by EPA Method 1633	PFAS	Assess groundwater quality
Groundwater	Groundwater sampling of monitoring network south of Lancaster Avenue; laboratory analysis by EPA Method 6010D	Dissolved (filtered) Metals: Ni, Mn, Cr (Total Cr = Cr^{+6} plus Cr^{+3})	Assess groundwater quality
Groundwater	Groundwater sampling of monitoring network south of Lancaster Avenue; laboratory analysis by EPA Method 218.6	Dissolved (filtered) Hexavalent Chromium	Assess groundwater quality
Groundwater	Groundwater sampling of monitoring network south of Lancaster Avenue; laboratory analysis by EPA Method 9056A	Dissolved Fluoride (filtered)	Assess groundwater quality
Surface Water	Surface water sampling; laboratory analysis by EPA Method 8260D	TCL VOCs	Assess surface water quality
Surface Water	Surface water sampling; laboratory analysis by EPA Method 6010D (same bottle)	Dissolved (filtered) Metals: Ni, Cr (Total Cr = Cr^{+6} plus Cr^{+3})	Assess surface water quality

Media of Concern	Sampling and Investigative Methodologies	Data Obtained	Data Use
Surface Water	Surface water sampling; laboratory analysis by EPA Method 6010D (separate bottle)	Total (unfiltered) Manganese	Assess surface water quality
Surface Water	Surface water sampling; laboratory analysis by EPA Method 6010D	Dissolved Magnesium and Calcium	Assess surface water hardness
Surface Water	Surface water sampling; laboratory analysis by EPA Method 218.6	Hexavalent Chromium (filtered/dissolved)	Assess surface water quality
Surface Water	Surface water sampling; laboratory analysis by EPA Method 9056A	Fluoride	Assess surface water quality
Surface Water	Surface water sampling; laboratory analysis by EPA Method 1633	PFAS	Assess surface water quality
QA/QC	Sample collection and laboratory analysis	All parameters	QA/QC laboratory measurements

Note: Groundwater samples from all monitoring wells north of Lancaster Avenue will not be analyzed for inorganics (dissolved metals, hexavalent chromium, and fluoride).

Table 2-2 – Soil Sampling Requirements

Sample ID	Target Sample Depth	Sampling Requirements	Comments
SB-# (TBD)	0'-2' interval (surface soil) and interval with the highest field screening results via XRF or the soil/bedrock interface (if no impacts are identified via XRF screening)	6010D, 9056A,1633	Background soil investigation samples; Total number of samples to be determined based on field data
SB-# (TBD)	Fluoride delineation: 0'-2' interval (surface soil) and interval with the highest field screening results via XRF or the soil/bedrock interface (if no impacts are identified via XRF screening) PFAS investigation: Depth of the historically identified impacts and the soil/water interface or soil/bedrock interface.	8260D, 9056A,1633	Data gap soil investigation samples; Total number of samples to be determined based on field data
Duplicate		8260D, 9056A,1633, 6010D	One per 20 samples collected or fraction thereof
Trip Blank		8260D	One trip blank per day, per cooler with VOC samples or submission to laboratory
Field Blank		8260D, 6010D, 9056A,1633	One per 20 samples collected or fraction thereof
Equipment Blank		8260D, 6010D, 9056A,1633	One per 20 samples collected or fraction thereof

Table 2-3 – Groundwater Sampling Requirements

Sample ID	Geological Material	Total Depth (ft bgs)	Screen/Open Hole Interval (ft bgs)	Well Diameter (inches)	Construction Material	Sampling Requirements
MW-01	Bedrock	48	28-48	4	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-02	Bedrock	24	15-24	4	PVC	
MW-03	Overburden	13.5	8-13.5	4	PVC	
MW-04	Bedrock	20	7-20	4	PVC	
MW-05	Overburden	20	10-20	4	PVC	
MW-06	Overburden	20.7	10.7-20.7	4	PVC	
MW-07	Overburden	19.8	9.8-19.8	4	PVC	
MW-07 (MOBIL)	Bedrock	Unknown	14-110			8260D, 1633
MW-08	Overburden	18	8-18	4	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-09	Bedrock	63	46-63		Open Borehole	
MW-11	Overburden	16	6-16	4	PVC	
MW-12	Overburden	21	8-21	4	PVC	
MW-13	Bedrock	31	27-31	4	PVC	
MW-14	Overburden	15	5-15	4	PVC	
MW-14D (MOBIL)	Bedrock	Unknown	30-50			8260D, 1633
MW-15	Bedrock	78	68-78	4	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-16	Overburden	21	7-21	4	PVC	
MW-17	Bedrock	301	200-301		Open Borehole	
MW-18	Bedrock	47	22-47	4	PVC	
MW-19	Bedrock	500	300-500		Open Borehole	
MW-20R	Overburden	16.5	6.5-16.5	4	PVC	
MW-21	Bedrock	53	27-53		Open Borehole	
MW-22	Bedrock	91	45-91		Open Borehole	
MW-23	Bedrock	45	33-45		Open Borehole	
MW-24	Overburden	30	3-27	4	PVC	
MW-25A	Bedrock	282	106-116	2	Stainless Steel	
MW-25B	Bedrock	282	212-222	2	Stainless Steel	
MW-25C	Bedrock	282	272-282	2	Stainless Steel	
MW-26A	Bedrock	250	90-100	2	Stainless Steel	
MW-26B	Bedrock	250	176-186	2	Stainless Steel	
MW-26C	Bedrock	250	222-232	2	Stainless Steel	
MW-27A	Bedrock	250	87-97	2	Stainless Steel	
MW-27B	Bedrock	250	177-187	2	Stainless Steel	
MW-27C	Bedrock	250	230-240	2	Stainless Steel	
MW-28A	Bedrock	250	100-110	2	Stainless Steel	
MW-28B	Bedrock	250	173-183	2	Stainless Steel	
MW-28C	Bedrock	250	222-232	2	Stainless Steel	
MW-29	Overburden	8	3-8	2	PVC	
MW-30	Overburden	20	5-20	2	PVC	
MW-31	Overburden	15.5	5.5-15	2	PVC	
MW-32	Overburden	16.5	6.5-16.5	2	PVC	8260D, 1633
MW-33	Overburden	13	5-13	2	PVC	8260D, 1633
MW-34	Overburden	15	5-15	2	PVC	8260D, 1633
MW-35	Overburden	15	5-15	2	PVC	8260D, 1633

Sample ID	Geological Material	Total Depth (ft bgs)	Screen/Open Hole Interval (ft bgs)	Well Diameter (inches)	Construction Material	Sampling Requirements
MW-36	Overburden	11	4-11	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-37	Overburden	24	14-24	2	PVC	8260D, 1633
MW-38	Overburden	35	25-35	2	PVC	8260D, 1633
MW-40	Overburden	41	31-41	2	PVC	8260D, 1633
MW-41	Overburden	28	18-28	2	PVC	8260D, 1633
MW-42	Overburden	31	31-41	2	PVC	8260D, 1633
MW-43A	Bedrock	306	95-120	2	PVC	8260D, 1633
MW-43B	Bedrock	3-06	175-200	2	PVC	8260D, 1633
MW-43C	Bedrock	3-6	255-295	2	PVC	8260D, 1633
MW-44A	Bedrock	306	90-120	2	PVC	8260D, 1633
MW-44B	Bedrock	306	172-202	2	PVC	8260D, 1633
MW-44C	Bedrock	306	265-295	2	PVC	8260D, 1633
MW-45A	Bedrock	306	70-80	2	PVC	8260D, 1633
MW-45B	Bedrock	306	182-232	2	PVC	8260D, 1633
MW-45C	Bedrock	306	273-293	2	PVC	8260D, 1633
MW-46	Overburden	26	19-26	2	PVC	8260D, 1633
MW-47	Overburden	74	64-74	2	PVC	8260D, 1633
MW-49A	Bedrock	106	15-35	2	PVC	8260D, 1633
MW-49B	Bedrock	106	60-85	2	PVC	8260D, 1633
MW-50A	Bedrock	106	57-73	2	PVC	8260D, 1633
MW-50B	Bedrock	106	80-100	2	PVC	8260D, 1633
MW-51A	Bedrock	106	25-40	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-51B	Bedrock	106	56-66	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-52	Bedrock	106	29-44	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-53A	Bedrock	106	40-80	2	PVC	8260D, 1633
MW-53B	Bedrock	106	95-105	2	PVC	8260D, 1633
MW-54	Bedrock	76	30-40	2	PVC	8260D, 1633
MW-55	Bedrock	106	75-100	2	PVC	8260D, 1633
MW-56	Bedrock	306	55-65	2	PVC	8260D, 1633
MW-57A	Bedrock	306	25-35	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-57B	Bedrock	306	85-130	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-57C	Bedrock	306	285-305	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-58A	Bedrock	306	34-49	2	PVC	8260D, 1633
MW-58B	Bedrock	306	155-165	2	PVC	8260D, 1633
MW-58C	Bedrock	306	285-300	2	PVC	8260D, 1633
MW-59A	Bedrock	306	36-46	2	PVC	8260D, 1633
MW-59B	Bedrock	306	126-136	2	PVC	8260D, 1633
MW-59C	Bedrock	306	275-300	2	PVC	8260D, 1633
MW-60	Overburden	43	33-43	2	PVC	8260D, 1633
MW-61	Overburden	76	66-76	2	PVC	8260D, 1633
MW-62	Overburden	17.5	12.5-17.5	2	PVC	8260D, 1633
MW-63	Overburden	21.5	11.5-21.5	2	PVC	8260D, 1633
MW-64	Overburden	14	7-14	2	PVC	8260D, 6010D, 218.6, 9056A, 1633

Sample ID	Geological Material	Total Depth (ft bgs)	Screen/Open Hole Interval (ft bgs)	Well Diameter (inches)	Construction Material	Sampling Requirements
MW-65	Overburden	24	14-24	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-66	Overburden	24	14-24	2	PVC	
MW-67	Overburden	12.5	3.5-12.5	2	PVC	
MW-68	Overburden	16	4-16	2	PVC	
MW-69	Overburden	25	4-25	2	PVC	
MW-70	Overburden	11.5	4.5-11.5	2	PVC	
MW-71	Overburden	16.5	4.5-16.5	2	PVC	
MW-72	Overburden	10	3-10	2	PVC	
MW-73	Overburden	9.5	3.5-9.5	2	PVC	
MW-74	Overburden	17	7-17	2	PVC	
MW-75A	Bedrock	436	345-360	2	PVC	
MW-75B	Bedrock	436	374-419	2	PVC	
MW-76	Bedrock	41	31-41	2	PVC	
MW-77	Bedrock	50	40-50	2	PVC	
MW-78A	Bedrock	400	85-110	2	PVC	
MW-78B	Bedrock	400	262-287	2	PVC	
MW-78C	Bedrock	400	340-400	2	PVC	
MW-79A	Bedrock	356	140-170	2	PVC	
MW-79B	Bedrock	356	320-350	2	PVC	
MW-80A	Bedrock	405	145-170	2	PVC	8260D, 1633
MW-80B	Bedrock	405	320-360	2	PVC	8260D, 1633
MW-80C	Bedrock	405	375-405	2	PVC	8260D, 1633
MW-81	Bedrock	26	11-26	2	PVC	8260D, 1633
MW-82A (53)	Bedrock	386	50-85	2	PVC	8260D, 1633
MW-82B	Bedrock	386	235-265	2	PVC	8260D, 1633
MW-83	Bedrock	42	32-42	2	PVC	8260D, 1633
MW-84A	Bedrock	416	135-165	2	PVC	8260D, 1633
MW-84B	Bedrock	416	270-300	2	PVC	8260D, 1633
MW-85A	Bedrock	TBD	TBD	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
MW-85B	Bedrock	TBD	TBD	2	PVC	
MW-85C	Bedrock	TBD	TBD	2	PVC	
PZ-1	Overburden	5	1-5	2	PVC	8260D, 1633
PZ-2	Overburden	5	1-5	2	PVC	8260D, 1633
PZ-3	Overburden	7	2-7	2	PVC	8260D, 1633
PZ-4	Overburden	9	2-9	2	PVC	8260D, 1633
PZ-5	Overburden	5	1-5	2	PVC	8260D, 1633
PZ-6	Overburden	7	2-7	2	PVC	8260D, 1633
PZ-7	Overburden	10	3-10	2	PVC	8260D, 1633
PZ-8	Overburden	13.5	3.5-13	2	PVC	8260D, 1633
PZ-9	Overburden	13	3-10	2	PVC	8260D, 1633
SMP-1	Overburden	10	5-10	2	PVC	8260D, 6010D, 218.6, 9056A, 1633
SMP-2R	Overburden	10	5-10	2	PVC	
SMP-3	Overburden	10	6-11	2	PVC	
SMP-4	Overburden	11	6-11	2	PVC	
SMP-5	Overburden	10	5-10	2	PVC	
30CR	Bedrock	165	160-165		Open Borehole	8260D, 1633

Sample ID	Geological Material	Total Depth (ft bgs)	Screen/Open Hole Interval (ft bgs)	Well Diameter (inches)	Construction Material	Sampling Requirements
CH2432	Bedrock	292	41-292		Open Borehole	8260D, 6010D, 218.6, 9056A, 1633
CH2749	Bedrock	200	Unknown		Open Borehole	8260D, 6010D, 218.6, 9056A, 1633
Duplicate						8260D, 6010D, 218.6, 9056A, 1633
Trip Blank						8260D
Field Blank						8260D, 6010D, 218.6, 9056A, 1633
Equipment Blank						8260D, 6010D, 218.6, 9056A, 1633

Note: Groundwater samples from all monitoring wells south of Lancaster Avenue will be analyzed for inorganics (dissolved metals, hexavalent chromium, and fluoride).
ft bgs: feet below ground surface
PVC: Polyvinyl chloride

Table 2-4 – Surface Water Sampling Requirements

Sample ID	Approximate location	Sampling Requirements	Comments
SW-1	South of the Site, Little Valley Creek (LVC) near the Amtrak culvert	8260D, 6010D, 218.6, 9056A, 1633	
SW-2	In tributary to LVC, North of the Site between Building 8 and the railroad tracks	8260D, 6010D, 218.6, 9056A, 1633	
SW-3	In tributary to LVC, North of the Site, Northeast of Building 8, South of the railroad tracks	8260D, 6010D, 218.6, 9056A, 1633	
SW-4	In LVC, North of the Site, Northeast of Building 8, just North of the railroad tracks, South of Lancaster Avenue	8260D, 6010D, 218.6, 9056A, 1633	
SW-5	In LVC, just North of Lancaster Avenue	8260D, 6010D, 218.6, 9056A, 1633	
SW-6	In LVC, North of Lancaster Avenue between SW-5 and SW-7, near PZ-1	8260D, 6010D, 218.6, 9056A, 1633	
SW-7	In LCV, North of Lancaster Avenue between SW-6 and SW-8, near PZ-2	8260D, 6010D, 218.6, 9056A, 1633	
SW-8	In LCV, North of Lancaster Avenue between SW-7 and SW-9, near PZ-3	8260D, 6010D, 218.6, 9056A, 1633	
SW-9	In LCV, North of Lancaster Avenue between SW-8 and SW-10, near PZ-4	8260D, 6010D, 218.6, 9056A, 1633	
SW-10	In LCV, Southwest of Conestoga Road, near PZ-5	8260D, 6010D, 218.6, 9056A, 1633	
Duplicate		8260D, 6010D, 218.6, 9056A, 1633	One per 20 samples collected or fraction thereof
Trip Blank		8260D	One trip blank per day, per cooler with VOC samples or submission to laboratory
Field Blank		8260D, 6010D, 218.6 9056A, 1633	One per 20 samples collected or fraction thereof

Table 3 – Analytical Program

Sample ID	Analysis	Analytical Method
Soil	TCL VOCs	EPA 8260D
Soil	Total Metals	EPA 6010D
Soil	Fluoride	EPA 9056A
Soil	PFAS	EPA 1633
Groundwater	TCL VOCs	EPA 8260D
Groundwater	Dissolved Metals	EPA 6010D
Groundwater	Total Chromium	EPA 6010D
Groundwater	Hexavalent Chromium	EPA 218.6
Groundwater	Fluoride	EPA 9056A
Groundwater	PFAS	EPA 1633
Surface Water	TCL VOCs	EPA 8260D
Surface Water	Dissolved Metals	EPA 6010D
Surface Water	Dissolved Magnesium and Calcium	EPA 6010D
Surface Water	Total Chromium and Manganese	EPA 6010D
Surface Water	Hexavalent Chromium	EPA 218.6
Surface Water	Fluoride	EPA 9056A
Surface Water	PFAS	EPA 1633

Table 4 – Regulatory Criteria

Environmental Media	Regulatory Program	Title
Groundwater	Table 1(1)	Medium Specific Concentrations (MSCs) for Organic Regulated Substances in Groundwater(3)
Groundwater	Table 2(1)	MSCs for Inorganic Regulated Substances in Groundwater(3)
Surface Soil	Table 3a(1)	MSCs for Organic Regulated Substances in Soil: Direct Contact Numeric Values(3,4)
Surface Soil	Table 4a(1)	MSCs for Inorganic Regulated Substances in Soil; Direct Contact Numeric Values(3,4)
Subsurface Soil	Table 3b(1)	MSCs for Organic Regulated Substances in Soil: Soil to Groundwater Numeric Values(3,4)
Subsurface Soil	Table 4b(1)	MSCs for Inorganic Regulated Substances in Soil: Soil to Groundwater Numeric Values(3,4)
Surface Water	Table 5(2)	Water Quality Criteria for Toxic Substances

(1) Commonwealth of Pennsylvania Code, 2006, "Title 25, Environmental Protection, Department of Environmental Protection, Chapter 250, Administration of Land Recycling Program," Appendix A. Revised August 27, 2016.
(2) Commonwealth of Pennsylvania Code, 2018, “Title 25, Environmental Protection, Department of Environmental Protection, Chapter 93, Administration of Land Recycling Program.”
(3) Groundwater and soil analytical data will be compared to both residential and non-residential MSCs.
(4) The soil analytical data will be compared to the lower MSC between the soil to ground values and direct contact values.

Table 5 – Field Quality Control Summary

QC Sample	Frequency /Number	Acceptance Limits/Performance Criteria	Corrective Action	Data Quality Indicator
Field Blanks	One in 20 samples or fraction thereof	All target analytes < Reporting Limit (RL), except for common lab contaminants (acetone, 2 butanone, and methylene chloride) < 2x RL	Note in case narrative	Accuracy/bias (contamination)
Equipment Blanks	One per day	All target analytes RL, except for common lab contaminants (acetone, 2 butanone, and methylene chloride) < 2x RL	Note in case narrative	Accuracy/bias (contamination)
Field Duplicates (For VOCs)	One in 20 samples or fraction thereof	Relative percent difference (RPD) ≤ 30% (aqueous) when results for both samples are ≥5X RL, or absolute difference <2X RL for results <5X RL; RPD ≤ 50% (solids) when results for both samples are ≥5X RL, or absolute difference <4X RL for results <5X RL	Apply flag; Potential data usability issue; indication of sample heterogeneity	Precision
Field Duplicates (For Inorganics and PFAS)	One in 20 samples or fraction thereof	RPD < 20% (aqueous) when results for both samples are ≥ 5x RL, or absolute difference <RL when results for both samples are < 5x RL; RPD < 50% (solids) when results for both samples are ≥ 5x RL, or absolute difference <2xRL when results for both samples are < 5x RL	Apply flag; Potential data usability issue; indication of sample heterogeneity	Precision
Trip Blanks (For VOCs)	One per cooler per day	All target analytes < RL, except acetone, 2 butanone, and methylene chloride < 2x RL	Note in case narrative	Accuracy/bias (contamination)

Note: It is the responsibility of the Quality Assurance/Quality Control Officer to determine whether any corrective actions are required. If necessary, corrective actions may include re-analysis by the laboratory or re-sampling to address the flagged issue.

Table 6 – Types of Information Used to Evaluate Precision, Accuracy, Representativeness, Comparability, Completeness, and Sensitivity

QC Element	Laboratory Measures	Field Measures
Precision	Laboratory Control Sample/ Laboratory Control Sample Duplicate Pair	Field Duplicates
	Matrix Spike Duplicates	Matrix Spike/Matrix Spike Duplicate (MS/MSD) Pairs (extra bottle collected upon laboratory request, MS/MSD labelled on chain-of-custody) Matrix Duplicate (MD) (extra bottle collected upon laboratory request, MD labelled on chain-of-custody)
	Historical Data Trends	Appropriate Sampling Procedure
Accuracy	Laboratory Control Samples	Matrix Spike/Matrix Spike Duplicate Pairs (collect samples for)
	Matrix Spikes and Matrix Spike Duplicates	Inclusion of "Blind Samples"
	Internal Standards	Appropriate Sampling Procedures
	Surrogate Recovery	Appropriate Sample Containers
	Initial Calibration	Appropriate Sample Preservation
	Continuing Calibration	Handling and Holding Times
		Standard Reference Material
Representativeness	Laboratory Homogenization	Appropriate Sampling Procedures Appropriate Sample Containers
	Appropriate Sub-Sampling	Appropriate Sample Preservation
	Appropriate Dilutions	Incorporation of Field Screening Data
	"As-Received" Sample Preservation Meeting Hold Times	Appropriate Number of Samples
Comparability	Gas Chromatography/Mass Spectrometry Tuning	Comparison to Previous Data Points
	Calibration	Comparison to Similar Data Points
	Analytical Method Followed	Similar Methods of Analysis Used
Completeness	Percent Sample Per Batch Analyzed and Reported	Percent Planned Samples Collected
	All Critical Samples Reported and Unqualified	All Critical Samples Collected
Sensitivity	Method Blanks	Equipment Blank/Field Blanks
	Instrument Blanks	Appropriate Sample Volume or Weight
	Reporting Limit (Lowest Calibration Standard)	
	Appropriate Analytical Method	

Table Reference: New Jersey Department of Environmental Protection, Site Remediation Program, Data Quality Assessment and Data Usability Evaluation Technical Guidance, Version 1.0, April 2014

Table 7 – Summary of Quality Control Checks and Samples

QC Sample or Activity Used to Assess Measurement Performance	Frequency
Trip Blanks	One per cooler per day
Duplicates	One in 20 samples or fraction thereof
Field Blank	One in 20 samples or fraction thereof
Equipment Blank	One per day with non-dedicated equipment
Site Specific Matrix Spike, Matrix Spike Duplicate (MS/MSD) Pair	One in 20 samples or fraction thereof; Collect separate samples or additional sample volume as requested by the laboratory
Laboratory Control Sample, Laboratory Control Sample Duplicate (LCS/LCSD) Pair	One in 20 samples or fraction thereof; Samples prepared by the laboratory

Table 8 – Sample Containers, Sample Volumes, Preservatives, and Holding Times

Matrix	Analysis	Sample Container/Volumes	Preservation	Holding Time
Soil	TCL VOCs	Methanol kit, One 40 mL VOA vial (MeOH), Two 40 mL VOA vials (unpreserved)	Methanol	14 days
Soil	Total Metals	Soil jar 4oz - clear glass	None	180 days
Soil	Fluoride	Soil jar 4oz - clear glass	None	28 days
Soil	PFAS	Two 250 mL HDPE bottles	None	14 days
Groundwater	TCL VOCs	Three 40 mL VOA vials	HCL	14 days
Groundwater	Dissolved Metals	One 250 mL plastic bottle	Nitric Acid	180 days
Groundwater	Total Chromium	One 250 mL plastic bottle	Nitric Acid	180 days
Groundwater	Hexavalent Chromium	One 250 mL plastic bottle	Ammonium sulfate and ammonium hydroxide buffer solution	24 hours
Groundwater	Fluoride	One 250 mL plastic bottle	None	28 days
Groundwater	PFAS	Two 125 mL HDPE bottles	None	14 days
Surface Water	TCL VOCs	Three 40 mL VOA vials	HCL	14 days
Surface Water	Dissolved Metals	One 250 mL plastic bottle	Nitric Acid	180 days
Surface Water	Dissolved Calcium and Magnesium	One 250 mL plastic bottle	Nitric Acid	180 days
Surface Water	Total Chromium and Manganese	One 250 mL plastic bottle	Nitric Acid	180 days
Surface Water	Hexavalent Chromium	One 250 mL plastic bottle	Ammonium sulfate and ammonium hydroxide buffer solution	24 hours
Surface Water	Fluoride	One 250 mL plastic bottle	None	28 days
Surface Water	PFAS	Two 125 mL HDPE bottles	None	14 days

Appendix A – Standard Operating Procedures (SOPs)

- SOP FM-1.3 Controlling the Work Area
- SOP FM-1.2 Subsurface Clearance Protocol
- SOP FM-1.3 Controlling the Work Area
- SOP FM-1.5 General Instructions for Field Personnel
- SOP FM-1.6 Field Note Documentation
- SOP FM-1.7 Field Instrument Calibration and Documentation
- SOP FM-2.1 Field Logging of Subsurface Investigations
- SOP FM-2.2 Classification of Soils via Unified Soil Classification System (USCS)
- SOP FM 4.0 Drilling Protocol
- SOP FM-4.1 Soil Boring Advancement
- SOP FM-4.4 Boring / Well Construction Field Log Completion
- SOP FM-4.6 Per-and Polyfluoroalkyl Substances (PFAS) Investigation – Drilling
- SOP FM-5.4 Monitor Well Design and Construction
- SOP FM-5.6 Monitor Well Development
- SOP FM-7.3 Packer Testing
- SOP FM-8.1 Liquid Level Gauging
- SOP FM-8.13 Passive Groundwater Sample Acquisition
- SOP FM-9.1 Soil Sampling for Analysis
- SOP FM-9.3 Soil Sampling with an En Core Sampler
- SOP FM-9.4 Surficial Soil Sampling
- SOP FM-10.1 Surface Water and Sediment Sampling
- SOP FM-13.2 Sample Preservation and Handling
- SOP FM-13.3 Sample Identification and Labeling
- SOP FM-13.4 Chain-of-Custody Procedures
- SOP FM-13.5 Sample Management, Packing, and Shipping
- SOP FM-14.1 Decontamination of Non-Dedicated Sampling Equipment
- SOP FM-14.2 Decontamination of Heavy Equipment
- SOP FM-14.3 Field Personnel Decontamination
- SOP FM-15.1 Containerization and Removal of Remedial Investigation Derived Waste

- SOP FM-20.1 Waste Sampling
- SOP FM-22.0 PFAS Sampling
- SOP FM-22.2 PFAS Sampling - Groundwater
- SOP FM-22.4 PFAS Sampling - Surface Water and Surface Water Foam
- SOP FM-22.7 PFAS Sampling – Soil
- SOP QA-1.1 Collection of Field QA/QC Samples (Trip Blanks, Equipment Blanks, Duplicate Samples, Matrix Spike Samples)

Standard Operating Procedure

SOP #:	FM-1.2 Rev. 002
Review Date:	4/20/2023
Origin Date:	03/01/2016

Title: Subsurface Clearance Protocol

1. Purpose/Scope

The purpose of this standard operating procedure (SOP) is to prevent injury to workers and damage to subsurface structures (including tanks, pipe lines, water lines, gas lines, electrical service, etc.) during ground disturbance activities such as drilling, augering, sampling, use of direct-push technologies, excavation, trenching, concrete coring or removal, fence post installation, grading or other similar operations.

This protocol provides minimum guidance for subsurface clearance activities, which must be followed prior to and during ground disturbance activities at any and all GES project sites. However, even after completing the subsurface clearance activities required in this protocol, all ground disturbance activities should proceed with due caution.

Deviations from this protocol may be provided on an exception basis for specific situations, such as underground storage tank (UST) system removals, verified overhead services, undeveloped land, idle facilities, shallow ground water conditions, soil stability, well construction QA/QC concerns, etc. GES personnel must gain approval from the Regional Health and Safety Officer (RHSO) or the Vice President of HSSE before proceeding. In these instances, the review must be documented in the case file.

This protocol shall not override any site-specific client or site supervisor procedures that are more stringent or provide a greater degree of safety or protection of health or the environment.

This SOP shall be used in conjunction with an approved Health and Safety Plan (HASP). Consult the HASP for information on the selection and use of personal protective equipment (PPE).

2. Responsibilities

2.1 Project Manager (PM)

The responsibility of the Project Manager (PM) is to ensure that all activities performed by site personnel are completed safely, in compliance with all pertinent regulations and procedures, and with the necessary equipment and resources to accomplish the tasks described in the work plan and/or field work directive (FWD). The PM will also ensure that all individuals working on GES projects are adequately trained and supervised.

2.2 Regional Health and Safety Officer (RHSO)

The Regional Health and Safety Officer (RHSO), in consultation with the Vice President of HSSE and project representatives, will designate the appropriate level of PPE for field personnel to safely complete their work. The RHSO will also ensure this subsurface protocol has been reviewed and is understood by all site personnel involved.

2.3 Site Supervisor

The site supervisor is responsible for the safe completion of assigned tasks as described in the SOPs, HASP, and appropriate site-specific work plans and/or FWDs. He/she is required to document the work performed and alert the PM of any variances from procedures established in the documents referenced above.

3. General

The site supervisor must complete GES' Subsurface Clearance Checklist in conjunction with the following procedures. The checklist must be completed before initiating any ground disturbance activities. Once completed, it must be submitted to the PM and included in the project files.

3.1 Safety

A HASP must be available on-site and followed by all on-site personnel. GES' safety requirements must always be followed. All work areas shall be defined and secured with safety cones, safety tape, construction fence, and/or other barriers or signs, as appropriate.

Site work permits must be obtained as required by site procedures. Based on site conditions or classification, the use of intrinsically-safe equipment may be required. If applicable, the emergency shutoff switch, or other emergency equipment, shall be located for quick access and all workers must be familiar with its use.

4. Equipment/Materials

- Current site map
- As-built drawings
- Any other historical site information that may help locating subsurface features (see 7.2 below).

5. Preparation

Objective: To gather all relevant information about potential subsurface structures prior to the actual site visit.

5.1 Obtain Permits and Site Access

The PM is responsible for following all applicable laws, guidance and approved codes of practice; obtaining all necessary permits and utility clearances; and securing site access permission.

5.2 Obtain Historic Site Information

Obtain most recent as-built drawings and/or site plans (including UST, product and vent lines) as available.

> *Note: As-built drawings may not accurately depict the locations and depths of improvements and subsurface structures and should, therefore, not be solely relied upon.*

The site supervisor should obtain any other site information such as easements, rights-of-way (ROWs), historical plot plans, fire insurance plans, tank (dip) charts, previous site investigations, soil surveys, boring logs and aerial photographs, etc., as relevant to the planned ground disturbance activities. Where applicable, the site supervisor should also contact personnel who may have historic site knowledge.

6. Procedure

6.1 Mark-outs

Objective: To identify location of subsurface structures on surface.

The PM must ensure that a thorough subsurface structure mark-out at the site is completed to locate electrical, gas, communication, water, sewer, low voltage electric lines, product delivery pipelines and all other subsurface utilities/services.

Available public utility companies must be contacted at least three working days in advance to identify underground utilities. In addition, where available, a private utility/pipeline mark-out company should be contracted to perform an electronic subsurface survey to confirm the presence of subsurface structures.

Site supervisor should review all available subsurface information with private mark-out company to assist in line locates.

> *Note: Line location mark-outs may not accurately depict the locations of improvements and subsurface structures and should, therefore, not be solely relied upon.*

Where possible, the site supervisor is encouraged to be on-site during subsurface mark-outs. This is to ensure accuracy and understanding of subsurface structures identified, and provides an opportunity to exchange information with mark-out company personnel regarding planned work activities.

If they cannot be located by other means, water and sewer line locations/routings may be determined by alternative methods such as snakes, cameras, etc. Subsurface structures should be marked throughout the entire work area with adequate materials (e.g., site conditions may require paint and tape/flags). Ground disturbance activities must be started within 30 days of utility mark-out, unless local ordinances specify a shorter time period. If activities are not started within required time period or markings have faded, mark-outs must be redone.

The site supervisor should record time and date of mark-out request, list all companies contacted by the service, and the confirmation number. This should be available for review on-site and checked off after visual confirmation of markings.

6.2 Initial Site Visit

Objective: To compare the site plan to actual conditions based on information gathered in procedures described above, to obtain additional site information needed and to prepare a vicinity map.

The site supervisor shall document all findings and update the site plan with this information and provide updates to PM. On third party sites, close coordination with the site owner's representatives for mark-outs, review of as-builts, and other information reviews should be conducted prior to work.

The inspection should include the following activities and may include others as determined by the site supervisor and the PM:

6.2.1 Utilities

The site supervisor shall perform a detailed site walkthrough to identify all aboveground indicators of subsurface utilities/services that may be leading to or from buildings within the planned work area. The inspection shall include, but not be limited to, the following:

- Utility mark-outs
- Aboveground utilities
- Area lights/signs
- Phones
- Drains
- Junction boxes
- Natural gas meters or connections
- Other utilities including: fire hydrants, on-/below-grade electrical transformers, splice cages, sewer lines, pipeline markers, cable markers, valve box covers, clean-outs/traps, sprinkler

systems, steam lines (including insulated tanks that may indicate steam lines), cathodic protection on lines/tanks

- Observe paving scars (i.e., fresh asphalt/concrete patches, scored asphalt/concrete)

  Note: In many cases, low voltage electric lines and individual property water and sewer line branches are not marked by the utility companies. In these cases, determine an area or path where the utilities are likely located. First, locate the entry/connection location at the facility building. Next, attempt to identify utility connections for the mains (water, sewer, etc.) by locating cleanouts, valve manways, etc. The location/path of the utility is likely within the area between the main connection and the facility building connection. Also, subsurface electrical line locations from the facility building to signs, lamps, etc., can be estimated with the same process. In some instances, trench cuts are apparent on the surface/ roadways/berms, etc.

6.2.2 Product Systems

The site supervisor shall perform a detailed site walkthrough to identify all aboveground indicators of product systems within the planned work area. Speak with someone (retailer, field supervisor, person responsible for issuing permit, etc.) with historical site knowledge.

For UST systems:

- Inspect for the presence of a dispenser pan and determine piping materials and whether piping is rigid or flexible, as flexible piping runs may not be straight between connection points.
- Visually inspect the location of the tank field, observation wells, dispensers, vent stack(s), and UST fill points. Note the location of the emergency shutoff switch and become familiar with its use.
- Note the orientation, arrangement, location, size/capacity, etc., of the tanks and submerged turbine pump (STP) covers (associated with product lines) and extractor covers (associated with stage I/II vapor recovery). Determine the burial depth of the tank field to also estimate burial depth of product lines, etc.
- Observe paving scars that may indicate location of product piping or other subsurface structures.

For other sites (e.g., refineries/chemical plants, terminals, bulk plants, exploration & production facilities), inspect for the presence of underground pipelines associated with pumps and pump galleries, manifolds, tank fields, compressors, production wells, loading racks, underground valves and other process equipment types. Inspect for underground instrumentation cable runs, as well as process/storm sewers. Note location of programmable logic controllers (PLCs), remote instrumentation lines (process analyzers) leading to/from motor operated valves (MOVs), etc.

6.2.3 Existing Remediation Systems

Visually inspect the location of aboveground components. Note the locations of well covers, sparge points, etc. Observe new pavement/asphalt that may give indications of subsurface piping that is connected to recovery/injection wells and the aboveground components. Note that some injection, extraction, or sparge points may not have a surface expression, such as a well vault.

6.2.4 Other Pertinent Features

Note any other pertinent features that may be of relevance to the planned subsurface activities (e.g., underground private pipelines marked by aboveground designators, covers not associated with known lines that may be associated with historical underground tanks, hydraulic lifts, etc.).

6.3 Selection of Ground Disturbance Locations

Objective: To document, communicate and review the selected ground disturbance area locations.

6.3.1 Define 'Critical Zones'

The following minimum criteria should be applied to determine critical zones:

- 10 feet (3 meters) distance from the furthest edge of any tank, pump(s) and pump galleries, manifolds, on/below grade transformers, compressors, production wells, loading racks, and other process equipment types.
- 10 feet (3 meters) distance surrounding dispenser island canopy drip line.
- 10 feet (3 meters) distance from all suspected underground lines. Distance requirements may increase based on site conditions such as soil type, slope stability factors, and depth of subsurface ground disturbance activities to ensure that underground line integrity is maintained.
- Final critical zone determination shall be reviewed with the PM.
- For retail sites, the entire area between the tank field and dispenser islands.

Regional/site-specific modifications to the critical zone applicability can be requested by the PM/area manager through the management of change process. More restrictive measures shall supersede if required by regulation or client.

6.3.2 Select Ground Disturbance Locations

The site supervisor should utilize the information collected to this point in combination with regulatory requirements and project objectives to select ground disturbance locations. Ground disturbance locations should also consider the location of overhead obstructions such as power lines, etc. If possible, the site supervisor should avoid selecting locations within the critical zone.

6.3.3 Review Selected Locations with the PM

The site supervisor must review the selected ground disturbance locations with the PM.

Note: The site supervisor must not proceed with the subsurface activities until the plan has been discussed with the PM. If relocation of planned subsurface activities is necessary outside of previously reviewed and approved limits/areas, the site supervisor must contact the PM prior to proceeding.

6.4 Subsurface Structure Delineation Activities

Objective: To delineate to the fullest extent possible any subsurface structures prior to ground disturbance activities in order to prevent potential worker injuries, product release and/or damage to those structures.

6.4.1 Supervision

The site supervisor's on-site representative will be responsible for all ground disturbance activities and must have a copy of this protocol on-site.

All ground disturbance activities, including surface removal, will be performed, observed, or supervised by the site supervisor at all times. He/she will ensure that the work is performed with due caution and will be alert for warning signs that could indicate the presence of underground tanks, lines, or other subsurface structures. If any such indications arise, the work should immediately stop in this area and the PM shall be contacted immediately. The site supervisor may proceed with other pre-assigned work at other locations on the site.

The site supervisor is to ensure that all workers involved with subsurface ground disturbance activities have undergone appropriate training prior to working at the site. At retail sites, UST system training must also be completed.

6.4.2 Boring Sequence

If possible, the boring sequence should be planned such that the boring furthest from any suspected underground improvements is carried out first. This is done to determine the natural subsurface conditions and to allow the site supervisor to recognize fill conditions.

6.4.3 Warning Signs

The following warning signs may indicate the presence of a subsurface structure:

- Warning Tape (typically indicative of underground services)
- Pea Gravel/Sand/Non-indigenous Material (typically indicative of tanks or lines)
- Red Concrete (typically indicative of electrical duct banks)

- The abrupt absence of soil recovery in the hand auger. This could indicate pea gravel or sand that has spilled out of the auger. Except in areas where native soil conditions typically result in poor hand auger recoveries.
- Any unexpected departure from the native soil or backfill conditions as established in other on-site digging.

If any of the above warning signs or a suspicious condition is encountered, work in this area should immediately stop and the PM should be contacted.

6.4.4 Surface Removal for Paved Areas

Paving Removal

Sufficient paving or surface improvement should be removed to allow clear visibility of the subsurface conditions during clearance activities. Ground disturbance activities in an area of known subsurface structures may warrant a larger pavement opening.

- Monitoring well installations: 2 feet x 2 feet (60 cm x 60 cm) or 2-foot diameter minimum removal is suggested.
- Soil borings/push type samplers: 8 inches x 8 inches (20 cm x 20 cm) or 8-inch diameter minimum removal is suggested.

  Note: Coring and jack hammering should not take place directly over the location of known underground lines.

Surface Removal Technique

The technique used should not pose a threat to subsurface structures. Avoid use of heavy equipment if possible. In situations where heavy equipment must be used, additional precautions should be taken because subsurface structures could be located immediately below surface pavement. Final completion for holes in pavement shall be neatly saw-cut or cored unless otherwise directed by the PM.

6.4.5 Subsurface Delineation

The method used to delineate the subsurface should be compatible with the inherent associated risk given the type of facility/property, soil stratigraphy, and the location of the ground disturbance activity, such that the required delineation is obtained.

Subsurface Clearance Methods

The site supervisor should discuss clearance methods with the PM prior to start of field activities.

- Vacuum Digging: Soil should be broken up using an air knife (preferred) or water jet with subsequent vacuuming to remove loose soils. When using an air knife or water jet, the least amount of pressure possible to adequately breakup soil should be used, so as not to damage subsurface utilities.

- Probing: The probe should have a blunt or rounded tip and should be advanced by hand without excessive force.
- Hand Digging: Should be performed with a small shovel.
- Hand Augering: The auger is to be turned slowly and not forced through the soil. It is recommended that an auger without sharp points (some augers have rounded edges) be used. Note: For retail sites, probing is required prior to hand augering.
- Post-Hole Digging: A post-hole digger can be used for soil removal only and in soil that has been probed by one of the four methods noted above, and cannot be used to advance the hole depth or width.

Subsurface Clearance Procedures Based on Planned Subsurface Ground Disturbance Activities

Selected subsurface clearance methods that will achieve the highest level of precautionary investigation and/or safety based on site conditions should be reviewed with the PM prior to implementation.

1. **Drilling, Direct-Push Technologies, Augering, Fence Post Installation or Other Borehole Installation Activities:**

- In critical zones, a minimum delineation to a depth of 8 feet (2.5 meters) is required.
- In non-critical zones, a minimum delineation to a depth of 5 feet (1.6 meters) is required.

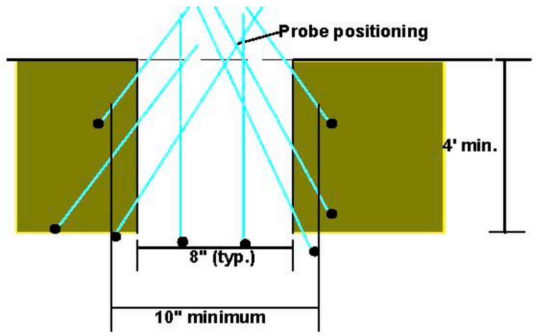
The first 5 feet (1.6 meters):

The area to be delineated shall exceed the diameter of the largest tool (drill auger, push type sampler, ream, or similar mechanical equipment) to be advanced and sufficiently large to allow for visual inspection of any obstructions encountered.

The first 1–2 feet (0.3–0.6 meters) can be delineated by hand digging to remove the soil.

Next, delineate the area to ensure that no obstructions exist anywhere near the potential path of the mechanical equipment by probing, augering, vacuum digging, or hand digging. Delineation shall extend as far laterally as possible and to a depth of 5 feet.

Probing Example



NOTE: Not drawn to scale.

Note: For retail sites, hand augering (or post-hole digging) can only be advanced to the depth that has been probed.

The next 3 feet (0.9 meters):

Critical Zones: For boring locations inside the critical zone, delineation is required to an additional 3 feet (0.9 meters) utilizing one of the four methods described above.

Non-critical Zones: For subsurface work outside the critical zone, delineation of an additional 3 feet (0.9 meters) may be prudent due to site conditions/climate (deep frost line), etc., but not required.

Note: For retail sites, hand augering (or post-hole digging) can only be advanced to the depth that has been probed.

2. Trenching/Excavation Activities:

- In critical zones— a minimum delineation of 5 feet (1.6 meters) for excavations of 4 feet (1.2 meters) or less, or a maximum of 8 feet (2.5 meters) for excavations exceeding 4 feet in depth. In areas where expected frost levels are greater than 4 feet, a greater delineation depth will be required.

The first 5 feet (1.6 meters) should be delineated by hand or vacuum digging to remove the soil unless an alternative delineation method has been reviewed with the PM.

- *Outside the critical zone*— site-specific conditions will determine the appropriate course of action and delineation requirements must be reviewed with the PM prior to start of ground disturbance activities.

Appropriate subsurface clearance methods should be conducted along the length and width of the excavation at a frequency sufficient to ensure adequate precautions have been applied to the entire work area. The frequency and density of investigations shall be based on site knowledge, potential hazards and risks of the site/work area, and surrounding locations (e.g., proximity to residential and public areas).

Whenever subsurface structures are exposed, work in area must cease until precautions (flags, cross-bracing, stakes, etc.) are taken to ensure that the integrity of those structures is maintained during the trenching/excavation and subsequent backfilling activities. A minimum 2-foot buffer zone must be maintained around exposed lines. No mechanical equipment may enter the buffer zone.

6.4.6 Subsurface Clearance Methods

The site supervisor must employ all means necessary to prevent damaging subsurface structures. Where natural subsurface conditions (e.g., cobbles/rocks, fill material, and/or bedrock) prevent adequate delineation utilizing methods identified above, the site supervisor must employ an alternative method of delineation following review with the PM.

6.4.7 Incident Notification

If any portion of a tank, line, utility, or other subsurface structure is encountered, and there is reason to believe that it has been damaged, the work is to cease in that area and the PM and client program manager must be notified immediately. If applicable, the emergency shutoff switch should be activated.

The PM will decide if additional uncovering by hand is required. If it is confirmed that an active UST system has been damaged, tightness tests will be performed. Under no circumstances is the area to be backfilled without notifying the PM and receiving an approval to proceed.

6.4.8 Scheduling

Since subsurface delineation may be time consuming, it may be appropriate to perform the surface removal and subsurface delineation in advance of planned subsurface ground disturbance activities. If these activities are conducted in advance, the clearance holes must be adequately covered with plates and/or backfilled. Care must be taken to prevent settlement of the material used to cover or backfill the holes. For remote, idled, or access controlled sites, clearance holes can be left open; however, hazard cones, fencing or other methods shall be used to identify the hazard.

7. Records

7.1 Field Notes

Record field notes in a standard bound survey-type field book issued for general note taking/field records and available from all GES equipment administrators. Make all field book entries black ink and make any changes/corrections with a single strikethrough line. Initial and date to indicate who made the change/correction and when it was made.

7.2 Photo Documentation

Encountered subsurface features not previously identified, should be photo documented, logged in the field notes, and maintained in the project file. Field measurements identifying its location within 3 horizontal feet shall be documented on the site map and maintained in the project files.

8. Follow-Up Activities

Clean/decontaminate all hand clearing tools as necessary and return to their proper storage location.

Standard Operating Procedure

SOP #:	FM-1.3 Rev. 003
Review Date:	06/03/2023
Origin Date:	03/01/2016

Title: Controlling the Work Area

1. Purpose/Scope

The purpose of this Standard Operating Procedure (SOP) is to provide controls to:

- Protect personnel against hazards present in the work area
- Prevent unnecessary personnel from entering the work area
- Regulate access to and egress from the work area
- Prevent the spread of potentially contaminated soil and debris from the work area
- Protect personnel from hazards surrounding the work area (traffic, parked vehicles, obstacles, etc.)
- Housekeeping
- Establish the work zone

2. References

- GES HSSE Policy #0037, Site Control Procedures

3. Materials

- Site-specific Health and Safety Plan (HASP)
- Site-specific traffic control plan (as needed)
- Personal Protective Equipment (PPE) as specified in the work plan and HASP
- Barrier materials: rope, caution tape, fencing, cones, etc.
- Barricades and work area signs

4. General Safe Work Practices

A controlled work area will be established in the immediate vicinity of site activities covered by this plan. Only those persons who comply with the requirements of the HASP and traffic control plan (if required) will be allowed into this area during any work activities that may result in exposure to the hazards associated with specific task being performed.

The following procedures relating to work area were taken from the HASP and are designed to reduce safety hazards to a minimum, to stop the spread of contaminated soils to clean areas, and to minimize personnel exposure to chemicals. These procedures will be employed for all work zone activities:

- Field crewmembers must be familiar with the physical characteristics of investigations, including:
  - Accessibility to associates, equipment, vehicles
  - Communications
  - Exclusionary zones (areas of known or suspected contamination)
  - Shut off or emergency kill-switches (on equipment or fixed on-site)
  - Site access
  - Nearest water sources
  - Routes and procedures to be used during emergencies
- Only properly trained personnel and equipment necessary for safe operations are allowed in the work zone.
- Prior to the start of any site activities, a tailgate health and safety meeting will be held to review the work plan, required certifications and all related health and safety issues. A related Job Loss Analysis (JLA) will be reviewed. The meeting will conclude with all site personnel signing in and with the site supervisor completing the appropriate checklists as required by the HASP.
- No breaking of the surface plane shall take place without first evaluating the absence of subsurface utility lines. Utility mark-outs will be completed by a state-approved One Call public utility mark-out service prior to the start of site activities, and other potential utility clearance activities, e.g., use of a private utility locating subcontractor, if deemed appropriate.
- The overhead area shall be inspected to ensure that the equipment will not contact overhead utility lines. A minimum of ten feet of clearance is required when overhead utilities are encountered. Additional clearance beyond ten feet should be provided if conditions warrant (line electrical rating, windy, slope, etc.).
- All drilling and sampling equipment must be cleaned before proceeding to the site.
- The minimum number of personnel necessary to achieve the objectives should be within 30 feet of the site activities.
- Emergency and back-up personnel, if present, should remain 30 feet from the drilling or sampling activity, where practical.
- Good housekeeping procedures should be followed to reduce the risk of slip/trip incidents.
- Eating, drinking, chewing gum or tobacco, and smoking are prohibited in the controlled work zone, or where the possibility for the transfer of contamination exists (i.e., the work zone). Controlled zones may be set up on an as-needed basis prior to the start of work.

- Contact with potentially contaminated substances should be avoided. Do not walk through puddles, pools, mud, etc., and avoid whenever possible kneeling on the ground, leaning, or sitting on equipment or the ground. Do not place monitoring equipment on a potentially contaminated surface (i.e., ground etc.).
- Splashing, spreading, and tracking of contaminated materials should be minimized.
- All field crewmembers should use their senses to alert themselves to potentially dangerous situations. They should report the presence of foreign odors.
- The size of the work zone and designated entry point can be expanded as necessary to accommodate work, but shall not be reduced until inspected and released from contamination controls by the field manager or other designated person.
- The PPE, as specified for work zone access, must be worn in the work area and it must be decontaminated or bagged prior to removal from the designated entry point.
- All potentially contaminated equipment must be decontaminated or contained as directed in the work plan prior to leaving the designated entry point.
- Monitoring equipment, sample bottles, and other small equipment will be placed on a clean surface upon entry into the controlled work zone.
- All wastes generated will be disposed of as approved by the site-specific Sampling and Analysis Plan, Containerization and Removal of Remedial Investigation Derived Waste (FM-15.1) or by other client-approved methods.
- Field work will be conducted during daylight hours only. When deviations are required, a review of the traffic control plan and HASP will need to be reviewed with all stakeholders prior to conducting the work.

Title: General Instructions for Field Personnel

1. Purpose/Scope

The purpose of this Standard Operating Procedure (SOP) is to provide general instructions to all GES personnel concerning required activities performed before, during, and after field investigations. These instructions are to ensure that field personnel understand: the site, the objective, and the schedule of the field program; their authority; and their responsibilities.

2. Equipment/Materials

An equipment checklist is provided in **Attachment A** of this document.

3. Preparation

3.1 Pre-Field Work Activities

3.1.1 Document Review

Document review should be performed prior to commencement of field activities. At a minimum, the following list of documents should be reviewed:

- Sampling or work plans/schedules. The sampling or work plan/schedule should contain sufficient detail to allow the proper completion of work, direction for time reporting, and direction on subsequent field reporting requirements. The sampling plan should include sample collection method, required sample analysis, hold times, and analytical laboratory. The sampling plan should be referenced in, and linked to, the Field Work Directive (FWD) that is part of the GES Project Implementation Process (PIP).
- Health and Safety Plan (HASP). The responsible Case Manager (CM) should provide field personnel with the site-specific HASP for the site. Work Assignments and Job Loss Analysis (JLA) forms should be reviewed with field personnel and documented as applicable.
- Applicable SOPs. The responsible Project Manager (PM) should direct field personnel to the SOPs that are applicable to the work being tasked.
- Equipment owner/operator instructions. Most equipment/tools come with owner/operating manuals. Field personnel should read and understand the manual and seek support from the manufacturer with any questions, comments, or concerns.

- Site maps. Obtain the most recent site map available. Once on site, make notations of any physical changes that differ from the current map. Notify the PM of any changes, and follow up with Graphics to ensure the updates are applied to the base map.
- Site documentation. For drilling activities, site data should be reviewed to estimate key parameters (e.g., sample target zones, depth, thickness, types of contaminants) and determine if a proposed borehole location is clear of underground utility lines.

3.1.2 Coordinate Schedules

- Arrange access to work sites. The PM or CM will make arrangements with the appropriate contact for access to the site prior to conducting work. The site contact gives approval prior to entering. In addition, if drilling is to occur on private property, authorization must be received in writing prior to entrance. Where applicable, refer to client contract or access agreements for access notice requirements.
- Acquire survey permits. The PM or CM will acquire any boring or well drilling permits required by state or local authorities.

3.1.3 Assemble Materials/Equipment

- Obtain the appropriate logbook and field data collection forms. Each client program varies. The PM is responsible for ensuring the proper method and/or forms are utilized during field events, such as the FWD, site-specific HASP details, and any other relevant forms or documentation.
- Assemble the appropriate supplies and/or equipment. The PM or CM will notify the appropriate laboratory and arrange for the delivery of sampling containers. Specific equipment checklists are provided in the applicable SOPs when necessary. If the sampling container and preservation requirements are not specified, refer to SOP 13.2, Sample Preservation and Handling or contact the laboratory for confirmation.
- Don appropriate field attire. Certain work conditions, such as sampling contaminated environmental media, may require various levels of Personal Protective Equipment (PPE) depending on the potential hazards. **Attachment B** displays appropriate PPE for various levels of protection. Generally, field work only requires PPE Levels C or D. Field personnel should contact the Site Safety Officer (SSO) before starting any new field work or if uncertain about the level necessary to safely conduct field work. Do not conduct any field work if the original level of PPE is believed to be insufficient—contact the SSO.
- Perform equipment maintenance, calibration, or calibration verification. Refer to the equipment manual for direction. If a manual is not present, contact the manufacturer for guidance and a copy of the manual. If the unit is rented, contact the rental agency for

guidance or a copy of the manual. Online resources may also provide copies of the necessary manuals.

3.2 Health and Safety

It is the responsibility of all field personnel to carefully read the site-specific HASP, understand its contents, and perform the field tasks in accordance with the methods and procedures outlined. Any areas of uncertainty should be discussed with the Regional Health and Safety Officer (RHSO) and the PM until the intent of the HASP is fully comprehended, and the dangers involved and the proper means to safely proceed are understood.

The HASP is developed in accordance with all federal OSHA regulations, GES' policies and procedures, and site owner's requirements. Copies of the OSHA regulations are available. Field staff must be familiar with the sections of these regulations that are applicable to their task. In cases where an uncertain situation develops in the field, field staff must stop work and immediately contact the RHSO to determine the proper course of action to take.

When work by others is observed that does not appear to be consistent with the HASP, or within the bounds of good judgment, these observations must be reported immediately to a senior site representative (i.e., GES PM or operations manager). If necessary, field staff can report directly to the other workers if no one else is on site and should make sure that appropriate corrective measures are taken promptly. Individuals are not only responsible for their own safety, but also the safety of co-workers, the general public, and the environment.

General or site-specific health and safety inquiries may also be directed to the GES Director of health and safety.

3.3 Compliance with Governing Codes, Rules, and Regulations

All GES personnel will comply with all governing codes, rules, and regulations at all times. Any questions that arise should be discussed and resolved with the GES PM.

4. Procedure

4.1 Procedure Violations

When field personnel observe work being done by others that does not appear to be consistent with the governing codes, rules or regulations or within the bounds of good judgment, they must report these observations immediately to a site supervisor (e.g., GES Project Coordinator, or GES operations manager). Prompt corrective measures must be taken when safety and/or policy deviations are observed.

4.2 GES as Waste Generator

GES IS NOT AND CANNOT BE A WASTE GENERATOR. GES personnel are not permitted to sign waste manifests, hazardous or otherwise.

> *Note: There are isolated cases where a client, providing proper documentation and indemnification, gives GES the authority to sign as an agent for the client ("agent for the generator"). These instances are very rare, however, and you will be made aware of them when this applies.*

In no case is an employee's name or GES' name to appear on any drum or waste shipment. All arrangements for waste handling are to be coordinated with the client and will be the client's responsibility. All sample records, cuttings, and excess soils (including geologic soil record samples) must remain on site or in the client's possession.

4.3 Client Relations

GES expects all GES personnel to treat all clients courteously and with respect. It is also expected that they be fully informed of project status, problems encountered, and resolutions implemented. However, each client employee may not be associated with the office or division of the client company which is contracting and responsible for the work. The specifics of our purpose and findings must be considered confidential to our contractual contact with the client, not every employee of the client. Be aware of their status, and do not release information to anyone unless certain they have a right to know.

While planning field events be sensitive to minimizing disruption to the normal work flow at the site and to scheduling disruptive activities at a time least inconvenient to the location. This requires that GES personnel review the on-site activities with the client and coordinate the sequence of work with the on-site contact.

4.4 Subcontractor Relations

Whenever a GES employee is placed in an oversight position with a contractor, it is paramount to remember that oversight is provided on behalf of GES' client and they are entitled to the best service possible. Administer the contract fairly and at the same time ensure that all of the rights and privileges afforded GES' client by the terms and conditions of the contract are taken into consideration. Any improprieties or failures on the part of the contractor are to be reported immediately to senior GES staff.

4.5 On-site Regulatory Agency Representative Relations

GES personnel must be professional, courteous and respectful of the on-site representatives. In the event that an OSHA inspector visits the site and requests information, field employees are expected to answer questions about which they are knowledgeable. For any areas of uncertainty, the employee should inform the OSHA inspector that they will obtain the answer immediately from the HASP or by contacting a GES RHSO or PM for assistance.

4.6 Public Relations

When approached by a member of the community, media, or unknown site personnel, field personnel should respond courteously as follows:

"I would be happy to record your name and contact information and a representative of GES will contact you to address your questions."

Field personnel should not answer any specific questions regarding the site or personnel activities. Field personnel should record their full name and contact information as well as who they represent.

Following such an encounter, field staff should immediately notify the GES PM and provide the details of the encounter and the tasks being performed at the time.

4.7 Utility Clearance

Field activities that penetrate the ground surface (e.g., test pits, boreholes, well installations, and new construction) must have a utility clearance performed in advance of any subsurface work. The utility check itself does not prevent all incidents but is one component of many activities that, if all performed correctly, will minimize the potential for a utility conflict. Typically, GES field personnel are responsible for coordinating utility clearances and documenting completion of utility checks. GES personnel cannot approve utility clearances; all utility clearance approvals must originate from a client, its authorized agent, or an outside utility group.

On public or private property, the following must occur:

- GES must carefully select the proposed drill or excavation site (e.g., during a pre-drilling or pre-construction meeting)
- Site selection must be conducted after a careful review of all available utility plans

- Site selection must involve a physical examination of the proposed work area, checking for utility indicators (this cannot be performed from an office)
- Site selection must be well marked in the field using wooden stakes and/or white paint such that the proposed location is easily identified
- Site selection must be documented in writing (i.e., field book sketches), noting field ties to the proposed location such that the location can be reproduced/laid out again if the marker is lost or moved
- Site utility clearance (by landowner, private utility locator, and One-Call Service) should be performed in the presence of GES personnel and contractor personnel whenever possible, which will enable GES/contractor personnel to hear and see first-hand the utility concerns present
- Site utility clearance results should be documented by GES for future reference.

5. Records

5.1 Field Records

All activities undertaken in the field must be factual, accurately and legibly recorded in bound field books, quality system field data record forms, or in some other GES-approved format. All records will be kept in the GES-approved format specified for the activities undertaken.

These field records may be called as evidence in a court of law.

In addition to the formal field records, field personnel are expected to keep running tables that summarize the field activities so that when questioned at any time during the program they can provide a detailed status of the work completed and that yet to be done. These lists are also expected to serve as checklists to confirm that the correct number and sequence of samples, wells, boreholes, etc., have been collected or completed.

Upon completion of each project, all field documentation is to be brought back and properly stored at the appropriate GES office.

5.2 Spill Reporting

All spills must be recorded in the field book and reported to the PM as soon as is practicable and definitely before leaving the site. The requirements for reporting spills to the regulatory authorities may depend on the state or country where it occurs.

GES personnel should make reasonable efforts to stop and contain a spill. These efforts should not include measures that put the individual at risk of injury. If the chemical composition of the spill is unknown, Level B or A personal protective equipment is required. Where possible, the source of the spilled material should be isolated and ditching or berms used to contain it. Follow-up actions will depend on the nature of the material spilled and the size of the spill. If necessary, local emergency response personnel (fire, emergency planning) should be contacted. Field staff must communicate as soon as site conditions are contained with the PM, program manager, operations manager, or RHSO to coordinate client and emergency response personnel notifications.

Senior management will coordinate with client program leads to contact the client. Following contact with a client representative, field staff will be given directions on how to proceed. GES' clients may also have internal notification requirements. These requirements must be confirmed to have been met by the PM before GES notifies any outside agencies.

6. Follow-Up Activities

Perform the following once field activities are complete.

- Review Work Plan to ensure that all work has been completed and confirm this with Project Coordinator.
- Clean and return equipment to the equipment administrator or notify the necessary equipment rental company to call off the rental.
- Complete the appropriate forms, logs and data sheets. Scan the FWD and accompanying notes, logs, data sheets chain of custody, and/or figures for electronic filing in accordance with PIP requirements.

Attachments

Attachment A – Equipment Checklist

Attachment B – Personal Protective Equipment List

Attachment A – Equipment Checklist

The purpose of the list presented below is to aid field personnel in identifying those supplies necessary to conduct a particular field operation. It is not intended to be all inclusive. It is the responsibility of field personnel to determine and obtain the supplies required for successful performance of assigned tasks.

☐	Airtight plastic bags	☐	Any necessary packaging (i.e., bubble wrap)
☐	Any necessary protective equipment required by Hazards Control Department	☐	Chain-of-Custody forms
☐	Field Sheets	☐	Sample containers
☐	Shipping forms	☐	Site Safety Plan
☐	Barricades	☐	Blue ice or bagged ice
☐	Calculator	☐	Camera (authorized personnel only)
☐	Caution tape	☐	Clipboard
☐	Cold weather gear	☐	Coolers
☐	Distilled (organic-free) water	☐	Drinking water
☐	Duct tape	☐	Ear plugs
☐	First aid kit	☐	Flagging
☐	Hand lens	☐	Hard hat
☐	Health and Safety Plan	☐	Lath/stakes
☐	Overshoes	☐	Organic Vapor Analyzer (OVA) and/or photoionization Detector (PID)
☐	Pens, pencils, permanent markers	☐	Preprinted labels
☐	Protractor	☐	QAPPs
☐	Radio	☐	Rain suit (if necessary)
☐	Safety shoes/boots	☐	Sampling, field, or facility logbook
☐	Sampling plan	☐	Snake guards
☐	SOPs	☐	Sample preservative
☐	Stop watch	☐	Sun screen
☐	Tape measure (tenths)	☐	Toolbox
☐	Water-level indicator	☐	Well specification table
☐	Work gloves/sampling gloves		

Attachment B – Personal Protective Equipment

Level A	Level A Protection
Should be worn when the highest level of respiratory, skin and eye protection is needed.	Supplied-air respirator (MSHA/NIOSHA approved) Fully encapsulating chemical-resistant suit Coveralls (optional) Long cotton underwear (optional) Gloves (inner and outer), chemical resistant Boots, chemical resistant Hard hat (optional) Disposable gloves and boot covers (optional) Cooling unit (optional) Two way radio communications (optional)
Level B	**Level B Protection**
Should be worn when the highest level of respiratory protection is needed, but a lesser level of skin protection.	Supplied-air respirator (MSHA/NIOSHA (approved) Self-contained breathing apparatus Chemical resistant clothing Long cotton underwear (optional) Coveralls (optional) Gloves (inner and outer), chemical resistant Boots (outer), chemical-resistant, steel toe and shank Boot covers (outer), chemical resistant Hard hat (face shield) (optional) Two way radio communications (optional)
Level C	**Level C Protection**
Should be worn when the criteria for using air-purifying respirators are met.	Air-purifying respirator, full face, canister equipped (MSHA/NIOSHA (approved) Chemical resistant clothing Long cotton underwear (optional) Coveralls (optional) Boots (outer), chemical-resistant, steel toe and shank Boot covers (outer), (optional) Hard hat (face shield) (optional) Escape mask (optional) Two way radio communications (optional)
Level D	**Level D Protection**
Should be worn only as a work uniform and not on any site with respiratory or skin hazards. It provides no protection against chemical hazards.	Protective Clothing (e.g. safety vest, high visibility / fire retardant clothing, rain slicker, coveralls) Hand Protection (Various Gloves) Foot Protection (Boots/shoes, leather or chemical-resistant) Eye Protection (Safety glasses/chemical splash goggles (optional)) Head Protection (Hard hat /face shield)

Standard Operating Procedure

SOP #:	FM-1.6 Rev. 002
Review Date:	04/20/2023
Origin Date:	03/01/2016

Title: Field Note Documentation

1. Purpose/Scope

This Standard Operating Procedure (SOP) describes procedures for documenting the required field activities prior to, during, and after completing any field tasks. These notes will serve the following purposes:

- To maintain a written documentation of scope of work events/accomplishments/problems related to the field work;
- To monitor the actual progress of field tasks in comparison to the planned schedule, and take appropriate corrective action (if required);
- To inform project managers of progress/accomplishments for inclusion into the weekly work assignments; and
- To prepare change orders to seek client approval in case of scope of work changes and maintain a written record of field work modifications.

The importance of note taking entries cannot be over-emphasized. Notes must be neat, specific, concise, factual, and of professional content. Field notes are an important element in the accurate reporting of events on a job site. Information recorded is used to evaluate and make project decisions, prepare reports for submittal to clients and regulators and, in some instances, notes can become evidence in legal cases.

2. References

ASTM D5792-10: Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives, 2018

USEPA, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, November 2001

USEPA, Guidance for the Data Quality Objectives Process (EPA QA/G-4, EPA/600/R-96/055, August 2000)

3. Responsibilities

3.1 Project Manager

The responsibility of the Project Manager (PM) is to ensure that all activities performed by site personnel are completed safely and in compliance with all pertinent regulations and procedures.

The PM is also responsible to ensure that all site personnel are adequately trained to successfully accomplish the field activity, are equipped with an updated field work directive, and have the necessary equipment to accomplish the desired tasks.

3.2 Regional Health and Safety Officer

The Regional Health and Safety Officer (RHSO), in consultation with the Corporate HSO and client representative, will designate the appropriate level of Personal Protective Equipment (PPE) for field personnel to safely accomplish their work.

3.3 Field Personnel

Field personnel are responsible for the safe completion of assigned tasks as described in the SOPs, Health and Safety Plan (HASP) and appropriate site-specific work plans and procedures. They are required to document the work performed and to alert the PM and immediate supervisors of any variances from procedures in the required time-frame.

4. Equipment/Materials

A basic checklist of suggested equipment and supplies needed to implement this SOP include, but is not limited to:

- Field book (bound)
- Task-specific data sheets (if applicable);
- Indelible ink pen (black or blue only)
- Watch or clock
- Mobile phone

5. Preparation

Prior to solo performance of field note taking, all field personnel will have performed a minimum of three site visits under the direct supervision of experienced personnel.

6. Procedure

Field notes are an important element in the accurate reporting of events on a job site. Field notes are intended to document the sequence of events so those events can be reconstructed later for future reference. They shall be recorded in legally bound field notebooks, or other designated platform, with references to other task specific data sheets. Field book entries will be made in waterproof, permanent ink (e.g., black or blue ink pen, Sharpie). Corrections to logbook entries will be made by drawing a single line through the erroneous entry, initialing the mark out, and entering the correct information.

The type of information recorded in field books will vary depending on the site visit purpose. Prior to departing for the site, discuss task specific documentation requirements with the PM

Field notes shall be recorded for each site visit conducted. Each day's documentation should begin at the top of a new page. The following items, at a minimum, shall be documented for each scheduled site visit:

- Date (day, month, year) on top first page.
- Site location (city, state) on top of first page.
- On the top of each page, indicate project name or number.
- On the bottom of each page, indicate page number for each project regarding the on-site day's entries (e.g., page 1 of 4, page 2 of 4, etc.).
- Time of arrival and departure on top of first page (time should always be recorded as either military time or followed by am or pm).
- Weather conditions on top of first page (including approximate temperature, visibility conditions, type of precipitation if any, etc.).
- GES personnel on site on top of first page.
- Purpose of site visit including a list of tasks to be performed on top of first page. Prior to site departure a notation should be made as to task status (completed or incomplete).
- Names, time of arrival/departure, questions and comments, and affiliation of additional personnel on site in association with the site visit (subcontractors, clients, media, and visitors).
- Documentation of Health and Safety issues, including but not limited to, time and content of tailgate safety meeting, documentation of required safety training (e.g., Loss Prevention System (LPS), OSHA, etc.), equipment calibration, air quality measurements, and near loss or loss reporting.
- Documentation of important conversations with clients, subcontractors, regulator, etc., that summarize topics discussed, agreements, and conclusions.
- A single diagonal line across the unused portion of the final page of day’s entry.
- Logbook editor's signature and date at the bottom of the final page for the day's entry.

7. Records

7.1 General Documentation Requirements

In general, the body of the page should include such items as:

- If applicable, documentation that field instruments were calibrated.
- Chronology of completed activities.
- Sketches where appropriate.
- Observations (e.g., number and contents of drums on site).
- Changes in weather conditions.
- For the first visit to a site, document specific driving or site access directions.
- References to standardized spreadsheets, figures, or logs.

7.2 Operation & Maintenance Visits

- Reference to standardized remediation system spreadsheets (i.e., running or not, if not, state reason).
- Time that a significant event occurred (i.e., start or stop pump).
- Readings collected, include location, instrument type, and serial number.
- Observations.
- Repairs or changes in equipment status.
- Flow rates. Distinguish between meter type, manual, or interpolation from performance curve.
- Record readings in the notebook and refer to system check sheets for additional system operation data.
- Samples collected and analyses requested.

7.3 Environmental Monitoring

- Time, location, and sequence from where and how samples were collected.
- Analyses requested.
- Monitoring well condition.
- Occurrence of Light, Non-Aqueous Phase Liquids (LNAPLs) and Dense Non-Aqueous Phase Liquid (DNAPLs) (e.g., free product). Document procedure of confirming presence of LNAPL, DNAPL thickness, color, and volume of LNAPL and DNAPL recovered.

- Liquid level and field parameter measurements.
- Record readings in the notebook and refer to task-specific log sheet.

Photographic documentation should be performed when appropriate. A brief description of each photo should be documented in the logbook.

7.4 Quality Control

The field book editor will review each day's entry for completeness and accuracy. At completion of field activities, the editor will provide copies of applicable logbook entries and task specific logsheets to the Case Manager / PM for review.

8. Follow-Up Activities

Perform the following once field activities are complete.

- Complete the appropriate forms and data sheets and document in field book.
- Compile all field notes, forms, checklists, and maps for submittal. Follow local field note submittal instructions, which may include electronic scanning to the local project management assistant (PMA) email address.

Title: Field Instrument Calibration and Documentation

1. Purpose/Scope

The purpose of this Standard Operating Procedure (SOP) is to provide general guidance regarding field instrument calibration and associated calibration records.

The scope of this SOP is to outline the significance of the calibration of field instruments used for sampling a variety of media such as air, groundwater, potable water, soil, surface water, etc. At GES, we use a variety of instrumentation to collect data in the field during groundwater sampling, drilling, Operation, Maintenance, and Monitoring (OM&M), excavation, pump testing, and other site activities. Each of these instruments requires calibration to provide accurate defensible data.

2. References

U.S. Environmental Protection Agency - Region 1 – Quality Assurance Unit SOP, Calibration of Field Instruments

3. Common Type of Field Instruments

The list below presents some common field instruments and materials that require calibration

- Air velocity/flow meters
- Combustible Gas Indicators (CGI meters, individual and multi-gas meters)
- Photo Ionization Detectors (PID)
- Flame Ionization Detectors (FID)
- Landfill gas monitors
- Liquid level indicators (water level indicators and Interface probes-meters)
- Water chemistry meters (individual parameter and multi-paramaters meters for temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction potential [ORP], turbidity meters, etc.)
- Sound level meters

4. Procedure

Instrument calibration is important to ensure the data accuracy and precision. Data generated by field instruments is used to protect human health of the site workers and the public; monitor breathing zones; and monitor for hazardous conditions (e.g., Lower Explosive Limit (LEL), Oxygen enriched or deficient environments, etc.). Accurate data is critical in making sound technical decisions and demonstrating compliance with permits and regulations.

Calibrating an instrument ensures that the results/data generated from the instrument are accurate and reliable. Some equipment may be factory-calibrated or calibrated by a rental firm prior to delivery for use. GES also maintains an inventory of owned and rented instruments. In all cases, confirming accuracy of the data through calibration and documenting the calibration is needed to ensure data reliability and accuracy. Calibration is a routine maintenance task that is detailed in the manufacturer's manual for each instrument. Even meticulously cared for instruments experience "slip" in calibration over time. Accordingly, calibration is necessary regardless of equipment age or condition.

Bad or unreliable data introduces uncertainty, which causes a variety of problems – putting people at risk, inability to definitely demonstrate compliance with permits, and adversely affecting decision making. These factors can lead to potential fines and notices of violation for various projects, loss of reputation with clients, and may lead to potential accidents and injuries to people. Therefore, it is very critical that we collect accurate data with calibrated field instruments.

4.1 Field Instrument Calibration Requirements

- For any field instrument that you are using to collect data, GES recommends that field instrument calibration is performed and documented per manufacturer's recommendations. At a minimum, a "bump test/check" is needed to determine that equipment is functioning properly. Bump test can also be referred to as function test.

- Project plans such as a Site Specific and Project Specific Quality Assurance Project Plan (QAPP), Sampling and Analysis Plan (SAP), Data Quality Objectives (DQO) plan, or permit requirements may indicate the prescribed calibration requirements for field data and instruments. In such cases, it is imperative that GES employees fully comply with the calibration requirements outlined in the plan(s), permits, and applicable regulations.

4.2 Frequency of Calibration

- The frequency of the field instrument calibration shall be based on the manufacturer's recommendations or regulatory/permit requirements.
    - Equipment calibration can sometimes be overlooked or staff may assume that the equipment was calibrated prior to delivery by the manufacturer or equipment rental vendor. At a minimum, a "bump check" is needed to

determine that equipment is functioning. Do not assume that the instrument is already calibrated.

- Calibration may be necessary to calibrate instruments during the progress in the field during the day if the data appears to be inaccurate/anomalous. This may be triggered by project plan requirements, data that appears anomalous (e.g., pH on a water quality meter is indicating a low or high pH compared to earlier use or when compared to historical data), or when the range of the device is exceeded (e.g., a PID has read over-range due to high vapor concentrations)

- If you cannot successfully calibrate the equipment, do not use it. GES' preferred equipment rental firms provide remote support and can be contacted to resolve many instrument issues. Return the instrument to the rental vendor, manufacturer, or service center. Obtain properly working equipment before proceeding. Do not just return it to the warehouse to allow for other employees to use the out-of-calibration equipment

4.3 Documentation

Equipment calibration records shall be clearly documented with the following basic information:

- Name of person conducting the calibration/ bump test/ calibration check
- Manufacturer model name/number and equipment ID and/or serial number
- Time of calibration
- Calibration solution/gases used
- Post-calibration reading
- Comments if equipment is unable to be calibrated or if calibration fails

Note: Additional information may be necessary based on permit or regulatory requirements.

5. Records

Instrument calibration records are critical documents and are legal records.

5.1 Field Notes

- Complete the field documentation for calibration in the Project Implementation Plan (PIP) Field Work Directive (FWD). Project Managers are responsible to outline and communicate GES specific or regulatory/permit specific instrument calibration requirements in the FWD. All field personnel are responsible to follow and document calibration data in the FWD.

- Record all information pertinent to instrument calibration in the project field notebook or in the appropriate calibration sheets if they are included in the FWD. If no specific calibration documentation is included in the FWD, document instrument calibration in the field notebook.

- If you are following a Site Specific and Project Specific QAPP, SAP, or DQO plan, or have to meet permit compliance requirements, check and conform with the specific calibration documentation requirements per regulatory or permit compliance requirements.
  - You may be required to document instrument calibration records in a project specific binder or on permit logs
  - You may be required to tabulate instrument calibration data and include them in your technical reports

Standard Operating Procedure

SOP #:	FM-2.1 Rev 003
Review Date:	06/12/2023
Origin Date:	03/01/2016

Title: Field Logging of Subsurface Investigations

1. Purpose/Scope

This standard operating procedure (SOP) describes the type of information that will be recorded during subsurface investigations: e.g., drilling of boreholes to document procedures used and observations made, test data, descriptions of materials and depths where encountered, groundwater conditions, and other information. All boreholes advanced in the field will be logged by the field supervisor. Additional information related to completion of the borehole as a monitor well shall also be recorded. Logs will be recorded in a field logbook and scanned for electronic filing.

2. References

ASTM D5434-12: Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock, 2012.

ASTM D2488-17e1: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), 2018.

ASTM D2487-17e1: Standard Classification of Soils for Engineering Purposes, 2020.

GES SOP FM-2.2: Classification of Soils via Unified Soil Classification System (USCS)

3. Equipment/Materials

- Field logbook or other client assigned method of data collection.
- Photoionization Detector (PID) instrument
- Method of timekeeping
- Unified Soil Classification System (USCS) Field Guide
- Munsell Soil Color Chart
- Tape measure
- Long, heavy-duty tool such as a screwdriver for probing and prying open soil cores
- Decontamination items such as distilled water, brush, phosphate-free detergent (e.g., Alconox) and a 5-gal. bucket.
- Folding table (recommended)

- Camera

4. Procedure

4.1 Boring Logs

General field notes must include, as a minimum:

- Name and location of the project
- Name(s) of on-site personnel (including drilling personnel)
- Date and time for all entries
- Recorder's name and signature
- Weather conditions
- Drilling method, drill-string tools and boring diameter
- Organic vapor measurements
- Groundwater conditions, during drilling and groundwater levels

4.2 Soil Classification

Soil material descriptions shall follow Unified Soil Classification System procedures as described in ASTM D 2487-17e1 (Standard Classification of Soils for Engineering Purposes), GES SOP FM 2.2, and shall include:

- Sample depth interval
- Standard penetration test (SPT) blow counts for each of the four 6-inch intervals
- Split-spoon length and recovery percent
- Soil color(s) including staining and mottling
- Description of the grain size distribution
- Description of the composition of coarse grain (if present)
- Consistency and cohesiveness (for intact fine-grained samples)
- Moisture content
- Soil type (residual, alluvial, fill, etc.)
- Depth of the contact(s) between various soil types based on an interpretation of all drilling and sampling observations

4.3 Monitor Wells

Monitor well completion detail logs will include the following minimum items:

- Monitor well identification
- Total depth of monitor well
- Construction material used to complete the monitor well
- Diameter of monitor well
- Diameter of borehole
- Type and slot size of monitor well screen
- Length of well screen and riser
- Length of filter pack and description of filter pack material
- Length of seal and description of seal material
- Description of locking cap
- Surface completion details (flush mount, stick-up, etc.)
- Sketch of boring and well completion details
- Top of casing elevation as measured to a known benchmark elevation
- Location of monitor well on site map with corresponding horizontal distance references

After the installation of a monitor well, a detailed boring log will be completed using Rockware©, LogPlot© or other suitable logging program that summarizes the installation procedure, observations and construction details.

Title: Classification of Soils via Unified Soil Classification System (USCS)

1. Purpose/Scope

The purpose of this standard operating procedure (SOP) is to provide guidance in the identification and description of soils based on the Unified Soil Classification System using procedures and terms taken from ASTM Standards.

2. References

U.S. Army Engineer waterways Experiment Station, The Unified Soil Classification System. Technical Memorandum No. 3-357, April 1982, Vicksburg, Miss.

ASTM D2487-17e1: Standard Classification of Soils for Engineering Purposes

Field Guide for Soil and Stratigraphic Analysis, Midwest Geosciences Group (www.midwestgeo.com)

Munsell Color Chart (https://munsell.com/about-munsell-color/how-color-notation-works/how-to-read-color-chart/)

3. Burmister Soil Identification System Procedure

3.1 Introduction

3.1.1 Identification and Description of Soils

Soil samples recovered from borings, test pits, and grab sampling should be classified immediately upon collection, using accepted terms to describe the physical characteristics of the sample in a grain-size based system (e.g., Burmister and/or USCS).

The Burmister Method is a common-sense system used to describe “Grain Size, Gradation, and/or Sorting” and “Plasticity”. The system is based on the in-field assessment of three key soil characteristics: relative compositions of the granular matrix (gravel, sand, and/or silt); gradation of the granular components; and plasticity of the sub-granular components (silt and clay).

Composition is defined by designating principal (or MAJOR) and subordinate (or minor) components, the relative abundance of the latter, based on a percentage range represented by the simple language terms with, and, some, little, and trace. Gradation refers to the relative fractions of coarse, medium, and fine granular components. Composition and gradation are modified by (+) and (-) notations, indicating the fraction being in the upper or lower end of its range. Plasticity defines the relative fractions of clay versus silt in the sample, as it affects the physical characteristics of the entire sample, designated as low, medium, and high.

3.1.2 Unified Soil Classification System (USCS)

The USCS two-letter designations, while useful for general field categorization of like soils (particularly for engineering or construction purposes), are not as geologically descriptive as the Burmister language, and do not provide the same level of detail regarding grain size distribution, texture, density, etc., that may prove useful in after-the-fact reviews of logs or hydrologic calculations. The USCS designations (Attachment A) are best applied in addition to the Burmister descriptions, typically while compiling the logs after the field event.

Further, it is recommended that a Munsell color chart be utilized for noting soil colors for logging purposes as this allows for a standard description that is widely used and can assist in diagnostic evaluations (i.e., saturation, oxidation state and evidence of high-water horizons, etc.).

The standardized order of field description is:

Primary Description

- Color, Mottling
- Moisture Content
- Density/Consistency
- Elasticity/Plasticity (if appropriate—e.g., for silt/clay soils)
- Grainsize (Burmister Soil Classification), Gradation, Sorting, and/or Angularity

Secondary Description

- Structure
- Geologic Interpretation
- Visual Evidence of Contamination
- Other notable factors, such as Organic Content, Fill material, & Dry Strength
- Non-geologic Inclusions, such as Urban Debris, Artifacts, etc.

Where standard penetration tests are being performed in conjunction with split-spoon sampling, a constancy in the standard penetration resistance with depth might reflect a soil of essentially similar type; however, a marked change in standard penetration resistance requires extremely careful study of the sample to seek an explanation for the change.

Examples:

- SILTY SAND, uniform, fine, 15-20% non-plastic fines, dense saturated, light brown (SM).
- SILTY SAND, same as above (SM).
- SILTY SAND, similar to above, except 25-30% slightly plastic fines (SM).

As the first step in USCS classification, a soil is considered to be either predominantly coarse-grained (gravel or sand) or predominantly fine-grained (silt or clay) depending on whether more or less than 50 percent by weight of the material would be retained on a No. 200 sieve—a particle just passing the No. 200 sieve (0.075-mm openings) is the smallest sand size and is slightly coarser than the smallest particle (about 0.050 mm) visible to the unaided eye. For all gradation estimates of soils, particles larger than 3 inches are not included.

If the soil is predominantly coarse-grained, it is classified as either gravel or sand depending on whether more or less than 50 percent of the coarse-grained fraction (retained on the No. 200 sieve) would be retained on a No. 40 sieve (4.75 mm or 3/16-inch openings). If a soil classified as either gravel or sand contains less than 5 percent fines (material passing the No. 200 sieve), it is considered to be well- or poorly-graded depending on the shape of its gradation curve. However, if a sand or gravel contains more than 12 percent fines (5–12 percent constituting the borderline region), further classification is based on the plasticity characteristics (defined by Atterberg limits) of the fraction passing a No. 40 sieve. Visual-manual procedures for evaluating gradation characteristics are given in Section 3.1.1.

If the soil is predominantly fine-grained, further classification is based solely on the plasticity characteristics of the fraction passing the No. 40 sieve. The overall characteristic of the soil is that of silt if Atterberg limits result in a point below the A-line on the plasticity chart or if the plasticity index (PI) is less than four.

The soil is clay if the point lies above the A-line and the PI is greater than seven (the range of PI from 4 to 7 constituting a borderline region). Further subdivision of both silt and clay depends on whether the liquid limit is less or greater than 50. A common field test is to determine if the soil can be rolled into a tube of diameter 1/8 inch or smaller – in which case it is all or predominantly clay.

Organic silts and clays are also classified with respect to their locations on the plasticity chart, in addition to evidence of significant organic content. Highly organic soils, such as peat, are given a completely separate classification.

With the exception of organic soils, any material can be placed automatically into one of the groups of the USCS by numerical criteria based on simple laboratory tests. Even when only visual-manual methods are possible, many soils can be quickly and confidently placed into correct groups, especially when gradation is the controlling characteristic. But the number of groups is small; many soils will have gradation or plasticity characteristics close to the borderlines between groups, such as the No. 200 sieve and the A-line. In these cases, visual-manual classification becomes less certain, though it can be improved by experience and comparison to laboratory test data. Also, borderline classifications (with dual group symbols) can be given.

Residual soils can be difficult to classify where they retain the relict structure of the parent rock or where the decomposition of the parent rock is incomplete. The problems evaluating residual soils are discussed in later sections.

3.2 Soil Names

The basis name of a soil is that of the predominant constituent (GRAVEL, SAND, SILT or CLAY) as defined by the Unified Soil Classification System. A single-word modifier indicating the major subordinate constituent (GRAVELLY, SANDY, SILTY, CLAYEY, or ORGANIC) is placed before the basic name when required by the USCS, or whenever it is considered helpful in conveying a significant characteristic of a soil with the very first words of the description.

For example, a soil given a classification of SP might be a clean fine sand properly named SAND, or it might contain a complete range of all sand sizes plus sufficient gravel-size particles to be better characterized by the name GRAVELLY SAND. Except where required by the USCS, a modifier should be added only if the subordinate constituent is at least 10 to 15 percent of the soil. All possible basic soil names and modifiers are given in **Attachment A**. Example soil descriptions are presented in **Attachment B**.

According to ASTM, a modifier is used when the subordinate component exceeds 12%. In most cases this is not a practical criterion when applied to field-visual classification. The use of a 10 to 15 percent estimation will determine the use of a modifier. There is also some confusion as to when a modifier is used when the subordinate component falls within the 5 to 12 percent borderline area. The following is a guideline for the use of a modifier:

3.2.1 Coarse-Grained Soils

- 10-15% fines –a modifier is always used
- 8-12% fines –a modifier is used only to emphasize a change from very clean sands and gravels
- 5-12% fines –no modifier is used
- 5-8% fines –no modifier is used

3.2.2 Fine-Grained Soils

Fine-grained soils use the same criteria as coarse-grained soils.

Further estimation of coarse-grained particles into gravel and sand may be required—the larger estimation between the two is always used as the modifier.

For unusual or interlayered soils, such as fill or varved clay, an introductory name should precede the basic name or names to clarify the subsequent description. Possible introductory names would include TILL, TOPSOIL, LAYERED SAND AND CLAY, FLY ASH, CLAY SHALE, DECOMPOSED LIMESTONE, VARVED CLAY, etc. Such names should be used whenever the name or names derived from the USCS would tend to be misleading without reading the entire soil description. Where the basic name clearly expresses the character of the soil, a local or special name of this type should be withheld until the end of the description. When two or more distinct soil types are present (and one is not considered merely an inclusion in the other), each should be described separately, starting with the predominant type, after the introductory name.

The presence of oversize material (boulders and cobbles, excluded from the USCS) can be so overwhelmingly important that an introductory name is required in most cases. A name like SAND WITH BOULDERS could precede a basic name of SILTY SAND for a widely graded glacial till.

3.3 Gradation

For a predominantly coarse-grained soil, the name is followed first by an evaluation of the overall gradation of the fraction smaller than 3 inches. Gradation is the inverse of sorting for geologists, so a well-graded soil is poorly sorted and vice-versa. If the sand or gravel is considered to be clean (<5% fines), the soil should be described as either well- or poorly graded. When a soil is not well-graded because it is uniform (well sorted) or gap-graded, it can be described as uniform or gap-graded rather than just poorly graded. However, if a sand or gravel has a significant percentage of fines, the designations of well-graded and poorly graded should not be used because of their specific restriction to clean materials in the USCS. Instead, the overall gradation of a soil with fines can be described as uniform, widely graded, gap-graded, or omitted altogether for a somewhat narrowly graded soil.

Next, the percentage of each of the subordinate constituents of a predominantly coarse-grained soil is given, starting with the coarsest fraction and proceeding to the finest, as outlined in **Attachment A**. At this point, the percentage and maximum size of any boulders (larger than 12 inches) or cobbles (3–12 inches) should be indicated. Characteristics such as angularity and strength of individual particles in that fraction smaller than 3-inches can be included. Finally, the percentage of fines and the plasticity of the fraction passing the No. 40 sieve (smaller than sand) are added.

When percentages of subordinate constituents are estimated from visual examination, a range should be given for each percentage to prevent misinterpretation as the result of sieve analyses. The width of the range given also serves to express the confidence of the field inspector in the accuracy of his or her estimate. For example, in the case of a clean sand, an inspector might estimate with confidence “5 to 10 percent gravel to 0.8 inches max” or “2 to 4 percent fines”, but might not do better than “30 to 60 percent non-plastic fines” in a very uniform silty sand.

If all possible characteristics of individual particles within every fraction of a predominantly coarse-grained soil were mentioned, the description would be intolerably lengthy. The reader must be asked to assume that unmentioned characteristics meet common expectations. For example, the word “sand” conveys an idea of bulky, sub-angular to sub-rounded, hard quartz particles, but it would be inadequate, by itself, for a sample of freshly broken sand-sized flaky fragments of weak slate. Any important differences from common characteristics must be identified and included in the description. Self-restraint and good judgment by the field inspector are needed to eliminate unnecessary information while retaining the essential.

The *shape* of a particle refers to the ratios of overall dimensions. Particles might be bulky, flat, rod-like, or lath-like. Unless explicitly indicated to have an unusual shape, coarse-grained particles are assumed to be essentially of uniform dimensions.

The *angularity* of a particle refers to the degree of rounding of the corners. Particles might be angular, sub-angular, sub-rounded, rounded, or well-rounded.

The *soundness* of a particle refers to both crushing strength and resistance to abrasion or wetting. Mineralogical composition can be an important indicator of soundness. Particles might be weak, friable, rotten, slate, sandstone, limestone, slakable, etc. Sand and gravel particles are assumed to be hard and sound unless contrary conditions are explicitly noted.

Examples:

- SAND, well-graded, 5-10% sub-rounded gravel to 0.5 in. max, 5% non-plastic fines (SW).
- SILTY SAND, widely graded, 15-20% gravel to 1.0 in. max, mostly medium and fine sand, 20-30% slightly plastic fines (SM).
- SILTY SAND, uniform, fine, very angular, 8-12% non-plastic fines (SM-SP).

3.4 Plasticity

For a predominantly fine-grained soil, the name is followed first by an evaluation of the plasticity of the fraction passing the No. 40 sieve and, second, the percentage and limitations in sizes of any particles retained on the No. 200 sieve. The two-parameter indication of location on the plasticity chart is divided between the basic name ("clay" if above the A-line and "silt" if below) and the degree of plasticity. A soil is described as non-plastic, slightly plastic, moderately plastic, highly plastic, or in a range spanning two of these groups.

Reaction to shaking is described as sudden if instantly produced by a single blow, fast if produced by less than five blows, slow if produced by more than five blows, or none if no change can be seen after many blows. The thread of the plastic limit can be described as very weak (and possibly spongy), weak, firm, tough, or very tough. Dry strength can be described as none, low, medium, high, or very high.

The location on the plasticity chart of the fraction of a predominantly coarse-grained soil passing the No. 40 sieve is given by the modifier preceding the basic name and the degree of plasticity of the fines.

Examples:

- SILTY CLAY, slightly to moderately plastic, 5-10% fine sand (CL).
- SANDY SILT, non-plastic, sudden reaction to shaking, 30-50% very fine sand (ML-SM).
- CLAY, highly plastic, very tough at plastic limit (CH).
- CLAYEY SAND, medium to fine, 30-35% moderately to highly plastic fines (SC).

3.5 Relative Density and Consistency

In-situ strength and compressibility characteristics are indexed by relative density for a non-cohesive or only slightly cohesive soil, and by consistency for a cohesive soil. Both are difficult to measure as they are sensitive to sampling disturbance, though relative density is the more difficult of the two. The natural density of a non-cohesive soil is not only very susceptible to disturbance, but it cannot be evaluated except as compared to the minimum and maximum densities. Reliable determinations of relative density and consistency can be obtained only by testing undisturbed samples or by *in situ* measurements such as the standard penetration test performed in conjunction with split-spoon sampling.

Ensuring proper performance of each standard penetration test with an accurate recording of the blow counts is an important responsibility of the field inspector. The standard penetration resistance, interpreted with regard to the soil description, can usually be correlated with the relative density of a non-cohesive soil or the consistency of a cohesive soil. However, the field inspector should not include a relative density or a consistency soil description derived from the standard penetration resistance.

Only evaluations of the soil sample itself are to be given and, even then, only when the sample is judged to be free of excessive disturbance. If no sensible evaluation of *in-situ* conditions is possible, due to disturbance, no descriptor for relative density or consistency should be included in the field log; this will be inserted in the final boring log after interpretation of the standard penetration resistance.

Most sands and gravels, especially at the lower relative densities, cannot be sampled during the standard penetration test without excessive disturbance. Some widely graded sands at the higher relative densities can be found essentially intact in a split-spoon sample. In such cases, a dense or very dense condition can be seen and felt in the soil.

Consistency can be readily evaluated by feel or with a pocket penetrometer (PP) or vane shear instrument (such as a "Torvane" TV). Many cohesive soils can be sampled during the standard penetration test with relatively little loss of *in-situ* consistency, especially those soils having higher consistencies. When a sample is found to be of a consistency in reasonable agreement with the standard penetration resistance, this consistency should be included in the description.

When a sample has been badly disturbed, either no consistency should be given in the description or only a remolded consistency should be given. Soft or very soft samples should be viewed suspiciously, as well as any that are sticky or lack rigidity.

Sensitivity of a cohesive soil can be described most usefully by giving the consistency (and possibly the stickiness) after thoroughly remolding the soil without changing its water content. The consistency after remolding also provides a comparison of the natural water content to the liquid limits—a soil with a water content near the liquid limit becomes soft and sticky when remolded, while one with water content near the plastic limit may crumble when remolded.

Examples:

- Very stiff and brittle undisturbed, becomes very soft and very sticky when remolded.
- Hard (PP = 5.0) undisturbed, crumbles when remolded

- Stiff (TV = 0.9) undisturbed, remains stiff (TV = 0.6) when remolded.

3.6 Moisture Condition

The water content of a cohesive soil is reflected, to a certain extent, in the evaluation of consistency—but only if the soil is fully saturated. An important item in the description is the evaluation of whether the soil is partially saturated (that is, taken from above the groundwater table) or fully saturated (from below the groundwater table). A reliable measurement of groundwater level in the boring can be helpful in this evaluation.

Partially saturated soils are described as dry, damp, or moist with increasing degrees of saturation. When a sample can be seen as completely saturated—such as a sand from which water flows freely—it should be described as saturated, and the moisture condition of samples below it in the same boring should be omitted.

3.7 Color

The color imparted to a soil by its fine-grained fraction can be useful in distinguishing between different strata, interpreting the geological history of a site, and possibly identifying over-consolidated cohesive soils. While this part of the description should be as terse as possible, it should not be limited to only gray and brown. Also, the wording of the color description must not be permitted to obscure the overall visual impression of the soil by emphasizing unimportant details.

Dull or drab colors, possible affected by colloidal organic matter, should be distinguished from bright colors typical of completely inorganic soils. Mottling or marbling of colors can be indicative of *in-situ* desiccation or oxidation of metals and should be described adequately. Staining or discoloration associated with discontinuities, however, should be withheld until such discontinuities are described.

Once color descriptions have been established for the different strata of a site, these should be used consistently from one boring to another across the site. For instance, if a stratum is described as green-gray in one boring it should not be described as olive gray or gray-green in the next boring.

Examples:

- Bright medium gray
- Chalky white
- Light gray finely veined with dark red-brown
- Dull yellow-brown mottled with brown-red and dark brown

3.8 Structure

Discontinuities and inclusions can be extremely important, and must be detected and fully described, even when obscured by sampling disturbance. These features include joints, laminations, slickensides, veins, pockets, lenses, layers, partings, root holes, roots, wood, shells, fragments, isolated gravel particles, cementation, etc. Such irregularities can markedly increase or decrease the standard penetration resistance.

In general, discontinuities are described with regard to their spacing, orientation, surface texture, luster, discoloration, and, where present, infilling material. Inclusions are described by giving their number, size, type, and contents. Key words in descriptions of significant structural features should be underscored to ensure emphasis.

Examples:

- Random <u>slickensides</u> spaced 0.2 to 0.4 inches with striated and highly polished surfaces
- Very few almost vertical <u>joints</u> with dull surfaces discolored light yellowish brown
- Thinly (0.1–0.2 in.) <u>laminated</u>
- 5-10 percent small pockets or lenses dark brown fine silty-sand
- Many (about 20% of sample) 0.1–0.5-inch layers, light gray slightly to moderately plastic silty clay
- 2-inch layer dark gray stiff highly plastic clay
- Some 0.05–0.10-in. vertical root holes discolored dark brown
- 20-25% shell fragments
- 0.8 in. particle angular gravel
- Weakly cemented, calcareous
- Swampy odor

3.9 Geological and Local Names

The description should contain the geological origin or name of the soil, such as aeolian, basal till, lacustrine, marl, fill, etc. When known and considered helpful, any local name for the soil, such as gumbo, bull's liver, rock flour, etc., may be included. As indicated earlier, a geological or local name might best serve as an introductory name whenever such use clarifies the description.

3.10 Group Symbol

Each soil description is concluded with the symbol or symbols indicating the group in the USCS. A dual symbol is required for any of the several defined borderline classifications, and also may be used to show that a soil is close to any of the gradation or plasticity boundaries separating groups. For example, a highly plastic clay, which plots only slightly above the A-line, might be given the symbol CH-MH, while a similar clay containing 40 percent sand might be given CH-SC. These group symbols are always enclosed in parentheses, unless the classification is based upon laboratory determination of the soil characteristics.

3.11 Estimation of Gradation Characteristics

A visual gradation analysis is more difficult to explain than to perform, and quite reliable estimates can be made for many soils with only a little practice (for example, the soil yielding could be accomplished by spreading fines over the palm of one hand or on a flat surface and manipulated by the fingertips of the other hand). The gravel-sized particles can be felt as they are moved aside to estimate their total volume. Close examination of the sand remaining will reveal the shortage of fine sand (all finer than typical granulated sugar) and the cleanness of the sample. A small amount of water added to the sand in the cupped hand would be scarcely clouded by the fines and would rapidly clear.

A poorly graded sand can be identified in many instances by its feel as well as its appearance. When a small sample, wetted to eliminate any capillary tension, is packed by the fingertips into the cupped palm of the other hand, it will not cease deforming and moving out ahead of the probing fingers. Treated similarly, a well-graded sand can be felt to densify, stiffen, and resist penetration by the fingers. Unless there are clear signs of being poorly graded, a widely graded soil generally should be considered well-graded; this is the preferable direction in which to err.

3.12 Estimation of Plasticity Characteristics

Atterberg limits on soils from a single geologic origin produce points on a plasticity chart which form a straight line parallel to the A-line which was drawn to be parallel to such groups (Casagrande, 1948). The relative activity of the predominant clay minerals in the soil are expressed by the vertical distance of the straight-line group from the A-line, especially when compared to the vertical distance from the A-line to the U-line (the upper limit for test data on natural soils). Predominantly illitic clays fall in the lower half of the zone between the A-line and the U-line, largely montmorillonitic clays approach the U-line, and kaolonite forms a group below the A-line; mixtures of these or other clay minerals result in locations with respect to the A-line that reflect the relative proportions among the predominant clay minerals.

Within any linear group of points on the plasticity chart, the location of an individual sample along the A-line is determined by the percentage of clay minerals in the sample. A small percentage of clay minerals produces a low liquid limit while a larger percentage gives a higher liquid limit, though the vertical distance above the A-line remains constant.

The most meaningful plasticity characteristics of an individual soil sample are:

- the vertical distance from the A-line, which distinguishes clay-like soils (CL and CH) from silt-like soils (ML and MH);
- the distance along the A-line from the origin which separates soils having low liquid limits (CL and ML) from those having high liquid limits (CH and MH).

For classification purposes, these two characteristics can be evaluated somewhat independently by repeatedly rolling a lump of the soil into a thread 1/8 inch in diameter until the water content reaches the plastic limit—that is, when the thread crumbles at a diameter of 1/8 inch. As this water content is approached, the toughness or weakness of the thread reflects the vertical distance above or below the A-line. At or below this water content, the degree of luster which results from rubbing the lump of soil against a non-porous surface indicates the position along the A-line from the origin; the rubbed surface is dull for a soil plotting near the origin and becomes more lustrous as the distance from the origin increases. In other words, “clay” is differentiated from “silt” by the toughness of the thread, while liquid limits below 50 are detected from liquid limits above 50 by the shine which can be produced on the thread.

A small lump (no more than 2 mm in diameter) of the soil with a water content above the plastic limit is taken between the tips of the thumb and index finger. The lump is slowly compressed and then tightly squeezed between the fingertips; as it is squeezed, the presence of medium sand articles can be felt. Then, with the pressure still applied, the thumb is allowed to slide over the fingertip, smearing the soil across the thumb surface. As it is smeared, the presence of fine sand particles can be felt. If the smear of the soil across the thumb is permitted to dry completely, a plucking at the skin would be caused by a soil which would plot above the A-line, while none could be detected from a soil which would plot below the A-line. A very small amount of the soil smeared on the thumb can be bitten between the front teeth to detect the presence (and even to evaluate the relative amount) of coarse silt particles (this procedure should be used only when the inspector is confident that the soil does not contain a hazardous chemical or biological material).

The main focus is now on the soil smeared on the tip of the index finger—and only a very small amount of material is needed. Repeatedly press, smear, and deform this soil with a fingernail or the blade of a spatula near the handle—gently at first, but then with increasing pressure as the soils dries to the plastic limit water content. The object of the manipulation is to produce the highest luster possible at the plastic limit by applying as much smearing pressure as needed. As the water content decreases (blowing on the soil will accelerate the process), the pressure of the fingernail must be increased as if trying to smear the soil into a layer only one particle thick; with some clays, fingertip pain will occur before the maximum shininess is produced.

The effort required to produce the maximum possible shininess, of course, is a measure of toughness or weakness at the plastic limit.

Even after the soil on the fingertip has dried to below the plastic limit, further information can be gathered. Observe how the soil shrinks into flakes or plates and peels from the skin. As drying lightens the color of the soil, the dry strength can be evaluated, and the ease with which the completely dried soil can be rubbed or brushed from the fingertip provides additional input.

All these observations and responses must be synthesized to make the final decision as to where the soil should be placed on the plasticity chart—though the most important one is the toughness at the plastic limit. The presence of even a small percentage of active clay minerals gives the soil an authoritative character at the plastic limit that organic colloids or finely divided mica can never impart. A highly plastic silt (MH) may at first appear to be a clay, but at the plastic limit its lack of strong inter-particle forces will reveal its true nature.

More often than not, when a soil possesses plasticity due to the presence of something other than active clay minerals, this other material tends to impart a high plasticity rather than a low to medium plasticity. In other words, soils plotting below the A-line are more likely to be MH or ML.

Many soils of low plasticity which might be rated by visual-manual procedures as falling below the A-line will plot above the A-line, but contain so small a percentage of clay minerals that the PI is less than four.

Detecting the presence of active clay minerals in a soil when the PI is less than 10 is difficult by visual-manual methods because the water content will decrease quite rapidly past the plastic limit and the toughness of the thread can be felt for only a brief period. Transient though this toughness might be, it can be detected nevertheless.

Another type of problem lies in estimating the plasticity characteristics of the fine-grained fraction of a predominantly coarse-grained soil. If the fraction of the soil passing a No. 40 sieve were repeatedly pressed and smeared upon the fingertip as described above, most of the fine sand particles would be pushed aside, so the evaluation of the shininess of the plastic limit would incorporate only the fraction passing a No. 200 sieve. In such a case, the estimate of plasticity based on luster must be downgraded by knowing that the entire fraction passing a No. 40 sieve would be used for a liquid limit determination and, therefore, contain considerable inert material.

3.13 Evaluation of Organic Soils

The Unified Soil Classification System, as described in ASTM D 2487-17e1, is not specific on the distinction of organic soils from inorganic soils. According to this reference, a predominantly fine-grained soil is classified as organic when the liquid limit determined after the soil has been oven-dried is less than three-fourths of the liquid limit determined before drying. This criterion, however, provides no immediate help to the field inspector. Also, color and odor may be misleading guides to either the presence or absence of a significant percentage of colloidal organic matter.

Most fine-grained soils contain at least a small quantity of organic matter, and a marine clay typically will have a detectable percentage. The problem is to define what amount of organic matter is significant—that is, imparts to a soil those undesirable behavioral characteristics associated with organic soils. An organic soil is typically an unsatisfactory foundation material because of excessive long-term (secondary) compression. This soil will have a high natural water content and void ratio due to the organic colloid throughout its structure, but these colloids will not provide the strong inter-particle bonds (as would clay minerals) to resist deformation of the soil structure and a reduction in void ratio. While it is essential that a truly organic soil be properly identified as such, it is also important that satisfactory foundation soils are not rejected by the classification of organic by the poorly-discerning field inspector.

When a stratum is classified as OL or OH, this classification should not be recorded on the filed boring log without further action by the field inspector. Misidentification of a soil as organic must be avoided—it must appear later on a final boring log where it will be interpreted as a fact. Instead, the field inspector should communicate this classification verbally to the geotechnical engineers so that all personnel will be aware of the presence of this stratum.

> *Note: The most helpful organic soil field indicator may be a simple test for compressibility (or sponginess). When a small (5 to 10 mm) cube from an intact—if not undisturbed—sample of a truly organic soil is compressed strongly on all sides by the tips of the thumb and first two fingers of each hand, a drop of clear water may be seen between the fingertips at a corner of the cube. In some instances, the response to all-around compression may be only a wetting of the fingertips—water can be squeezed from an organic soil as from a sponge, but a real clay will not release water so readily.*

In the remolded state, highly plastic organic silt gives a first impression of being clay or, perhaps, silty clay. However, as a small sample is manipulated and the water content is allowed to approach the plastic limit, it will be felt that the clay-like first impression was false. The thread at the plastic limit is weak and perhaps spongy: the soil is without real character, and the perceived high plasticity is a false indicator caused by the organic colloids rather than indicating the mineral constituents.

The classification of a soil as peat (Pt), as opposed to organic silt (OL or OH), is somewhat arbitrary, and the name might be applied to a soil with an organic content as low as 25 percent. A soil should always be classified as peat when its organic content exceeds 50 percent. Furthermore, a soil classified as peat would have a very dark to black color and a strong odor, together with an apparent absence of mineral constituents. Fibrous peat contains incompletely decomposed vegetative material in which the original plant forms can still be recognized, while amorphous peat is completely decomposed, showing no trace of the original plant forms.

3.14 Evaluation of Residual Soils

A residual soil is decomposed rock which has not been eroded and, therefore, has never been subjected to the separating, sorting, rounding, and blending given a transported soil. Instead, each soil particle is found in the same position it occupied in the intact rock mass embedded among particles of widely varying mineralogy and degrees of decomposition. The material cannot be considered rock, yet it retains the structure of the original material and, to a certain extent, it defies description in the terms ordinarily applied to soils. Geologically, these materials can be defined as saprolite or regolith.

Gradation analyses of residual soils can be quite arbitrary. Where there are many weak particles, the measured gradation can be affected by the type and amount of effort used to disaggregate the material. Sand-sized aggregations of fine-grained soil may become so strongly bonded by oven-drying that it is misinterpreted as sand particles in a sieve analysis. The percent of fines in a residual soil may increase with the duration of washing the soil in a No. 200 sieve as the water erodes material from weak particles. Atterberg limits can produce points that are widely scattered over a plasticity chart, in contrast to the linear grouping of points common to most deposits of transported soil.

The erratic character of a residual soil is aggravated by the disturbance inherent in split-spoon sampling. For example, when thinly bedded slate has weathered to a clay along the bedding planes, producing a system of hard slate layers separated by soft clay layers; penetration of the system by a split-spoon sampler may result in a sample comprised of gravel- and sand-sized slate fragments thoroughly mixed with clay. In this example, the field inspector's expertise must be sufficient to avoid classifying the disturbed sample as "clayey gravel" and, instead, to mentally reassemble the pieces to the condition that existed before sampling. Assumptions and interpretations included in the description, however, should be followed by a question mark contained within parentheses to distinguish them from discernable characteristics.

The field inspector must be aware that the contrary nature of most residual soils will tend to produce uncertain classifications and descriptions, leading to misunderstandings and the possibility of making mistakes. Descriptions of samples should be preceded in most cases by an introductory name, such as WEATHERED SLATE, DECOMPOSED GRANITE, SAPROLITE, etc., to emphasize the uncertainty of the words to follow. Then, the soil should be named and described as well as possible in accordance with the USCS, with particular attention given to the soundness of the coarse-grained particles.

A complete description of relict structural features such as joints, slickensides, bedding planes, and foliation is especially important in evaluating the mass strength properties of a residual soil. As in the parent rock, failure can occur along preexisting planes of weakness in an otherwise adequately strong soil. These features, however, can be seen clearly only in undisturbed samples and in test pits and trenches.

Attachments

Attachment A – Format for Description of Soils

Attachment B – Examples of Soil Description

Attachment A – Format for Description of Soils

1. NAME

The three main soil divisions are: coarse grained soil (e.g., sand and gravel), fine grained soil (e.g., silt and clay), and soil with high natural organic matter content (e.g., peat and marl). A brief description of the criteria, procedures, and terminology used to identify and describe coarse and fine-grained soil is presented here.

The basic name, indicating the predominant constituent, will have a modifier, when required, indicating the major subordinate constituent. Both names will be preceded, when required, by introductory names for unusual or mixed soils.

Introductory name: Fill, Topsoil, Varved Clay, Layered Sand and Silt, Till, Saprolite, etc.

Modifier: Gravelly, Sandy, Silty, Clayey, or Organic

Name of predominant constituent: Gravel, Sand, Silt, Clay, or Peat

2. GRADATION AND/OR PLASTICITY

2.1 For predominantly coarse-grained soil

The USCS group symbols for coarse-grained soil are primarily based on grain or particle size, grain size distribution (gradation), and percent fines (silt and clay content).

Coarse-grained soil is made up of more than 50 percent by weight, sand size, or larger grains (75 µm diameter, No. 200 sieve size or larger). There are other definitions for coarse-grained or coarse-textured soil and for sand size such as soil having greater than 70 percent particles equal to or greater than 50 µm diameter (Guidelines for Contaminated Sites in Ontario) or 60 µm diameter (Canadian Foundation Manual), but this procedure will not follow that guidance.

Descriptions for grain size distribution of soil include: poorly graded (i.e., well sorted or soil having a uniform grain size, SP and GP) and well graded (i.e., poorly sorted; having wide range of particle sizes with substantial intermediate sizes, SW and GW).

Coarse-grained soils are further classified based on the percentage of silt and clay it contains (fines content). Coarse-grained soils containing greater than 12 percent fines is commonly described as dirty. This description arises from the soil particles that adhere when the soil is rubbed between the hands or adhere to the sides of the jar after shaking or rolling the soil in the jar. The jar shake test that results in segregation of the sand and gravel particles is also used as a visual aid in determining gravel and sand percentages.

Examples of the group symbol, name, and adjectives used to describe the primary, secondary, and minor components of soil are: GW - Sandy Gravel (e.g., 70 percent gravel and 30 percent sand) or Sandy Gravel trace silt (less than 10 percent silt), and SP - Sand, uniform.

2.2 For predominantly fine-graded soil

A soil is fine-grained if it is made up of half or more of clay and silt (i.e., fines greater than 50 percent by weight passing the 75 μm, No. 200 sieve size). A description of visual-manual field methods and criteria that are used to further characterize and group fine grained soil (e.g., CL, CH, ML, or MH) including dry strength, dilatancy, toughness, and plasticity (thread or ribbon test) follows.

2.3 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High	The dry specimen crumbles into powder with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

2.4 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in small wetted specimen when rapidly shaken in palm of hand.
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 or stretching.

2.5 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

2.6 Criteria for Describing Plasticity

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 re rolled after reaching the plastic limit, and 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 re rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Examples of group symbol identification based on visual-manual procedures and criteria for describing fine grained soil are:

Group Symbol	Dry Strength	Dilatancy	Toughness	Plasticity
ML	None to low	Slow to rapid	Low (or thread cannot be formed)	Slight
CL	Medium to high	None to slow	Medium	Low
MH	Low to medium	None to slow	Low to medium	Low
CH	High to very high	None	High	High

A requirement for positive classification by USCS group symbols (as described in ASTM D2487) is laboratory determination of particle size characteristics, liquid limit and plasticity index. The need for this type of testing will be determined by the project geologist, hydrogeologist, or geotechnical engineer.

3. RELATIVE DENSITY OR CONSISTENCY (for undisturbed soil only)

3.1 For Non-cohesive or Low-cohesion Soil

Relative density is an important parameter in establishing the engineering properties and behavior of coarse-grained soil. Relative density of non-cohesive (granular) soil is determined from standard penetration test (SPT) blow counts (N values) from ASTM Method D1586.

The SPT gives a reliable indication of relative density in sand and fine gravel. N values in coarse-grained soils are influenced by a number of factors that can result in overestimates of relative density (e.g., in coarse gravel and dilatant silty fine sand) and can be conservative and underestimate the relative density (e.g., sand below the groundwater table and uniform coarse sand). These effects will be assessed by the project geotechnical engineer, if required, and need not be taken into account by field personnel.

Relative density terms: very loose, loose, compact, dense, or very dense.

3.2 For Cohesive Soil

The correlation between N value and consistency for clays is rather unreliable. It is preferable to determine consistency using more appropriate static test methods, particularly for very soft to stiff clay soil. N value estimates of consistency are more reasonable for hard clay.

Unconfined compressive strength (Su) may be estimated in the field from the pocket penetrometer test method. To obtain a penetrometer estimate of consistency and compressive strength, cut the soil core perpendicular to the core length. Hold the length of core (minimum 4 inches) in the hand and apply a moderate confining pressure (not sufficient to deform the core); then slowly insert the penetrometer piston tip into the perpendicular face of the core until the penetrometer indents into the soil core to the mark indicated on the tip. The penetrometer estimate of soil compressive strength (Su) is the direct reading of the value mark on the graduated shaft (in tons per square foot or other unit of pressure as indicated) indicated by the shaft ring marker, or in some models, by the graduated piston reading at the shaft body. To obtain an average estimate, this procedure is completed several times on both ends and mid-cross-section of the core. For Shelby Tube (or thin wall sampler) samples, the pocket penetrometer tip is applied to the exposed bottom of the sample at several locations.

Estimates of compressive strength for clay soil of very soft to stiff consistency are better established by *in-situ* shear vane tests or other static test methods.

Consistency terms: very soft, soft, firm, stiff, very stiff, hard.

4. Natural Moisture Condition

The water content of a cohesive soil is reflected, to a certain extent, in the evaluation of consistency—but only if the soil is fully saturated. An important item in the description is the evaluation of whether the soil is partially saturated (that is, taken from above the groundwater table) or fully saturated (from below the groundwater table); a reliable measurement of groundwater level in the boring can be helpful in this evaluation.

Partially saturated soils are described as dry, damp, or moist. When a sample can be seen to be completely saturated, such as sand from which water flows freely, it should be described as being saturated, and the moisture condition of samples below it in the same boring should be omitted.

5. **COLOR** (noted at natural water content)

6. **STRUCTURE** (including discontinuities and inclusions)

7. **GEOLOGIC ORIGIN AND/OR LOCAL NAME** (where applicable)

8. **UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL**

Placed in parentheses unless based upon laboratory determination of soil characteristics.

Attachment B – Examples of Soil Description

SAND, uniform, fine, well-rounded, 2-5% fines, loose, damp, light brown (SP)

CLAY, highly plastic, stiff dark gray (CH)

SILT, non-plastic, 5-10% very fine sand, very loose, saturated, light greenish gray, some mica, lacustrine (ML)

GRAVELLY SAND, well-graded, 15-20% sub-angular gravel to 0.6 in. max, sub-angular sand, <5% fines, dense moist, reddish brown, alluvial (SW)

SILTY CLAY, moderately plastic, tough at plastic limit, 5-10% fine sand, hard undisturbed, becomes stiff when remolded, saturated, medium brown, calcareous throughout (CL)

SAND, uniform, medium to fine, mostly medium, 5-10% non-plastic fines, compact, white, non-calcareous (SP-SM)

ORGANIC SILT, highly plastic, weak at plastic limit, 3-8% coarse to fine sand, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, dull dark olive streaked with dark brown, many fine roots, trace mica (OH)

TILL: SILTY GRAVEL, widely graded to 1.2 in. max, sub-rounded, 30-40% mostly medium to fine sand, 15-20% slightly plastic fines, very dense, damp, brownish red (GM-SM)

LAYERED SILT AND CLAY: SILT, non-plastic, sudden reaction to shaking, 2-4% fine sand, medium greenish gray, layers mostly 1.5 to 8.3 inches thick, 85% of sample: CLAY, highly plastic, firm and brittle undisturbed, becomes very soft and sticky when remolded, dull dark gray, layers 0.2 to 1.2 inches thick (ML and CH)

VARVED CLAY: SILTY CLAY, slightly to moderately plastic, firm, medium gray, grade downward within varve to SANDY SILT, non-plastic, 10-15% very fine sand, light gray: varves 0.3 to 0.4 inches thick (CL to ML)

BOULDER TILL: SILTY SAND, widely graded, 10-15% rounded boulders and cobbles to 3 feet max, 20-25% sub-rounded gravel, 15-20% non-plastic fines, dense, saturated, olive gray (SM)

SILTY SAND, widely graded, 15-25% freshly broken fragments well-rounded flat particles weak sandstone to 1.0 in. max, mostly fine sand, 20-30% slightly plastic fines, compact moist, light yellowish brown, very few small particles coal, fill (SM)

SANDY CLAY, moderately plastic, 15-20% medium to fine sand, hard undisturbed, crumbles when remolded, bright medium gray marbled with light yellowish brown, some 0.3 to 0.6 in. layer or lenses light brown fine silty sand (CL)

CLAYEY SAND, coarse to fine, mostly medium to fine, 35-45% moderately plastic fines, very stiff, dark greenish gray, some mica, many shells (SC)

SANDY SILT, highly plastic, 25-30% fine sand, stiff, saturated, very light gray to white, weak calcareous cementation, marl (MH)

Title: Drilling Protocol

1. Purpose/Scope

The objective of this standard operating procedure (SOP) is to prevent damage to subsurface structures (including tanks, product lines, water lines, gas lines, electrical service, etc.) during drilling, Geoprobing/direct push sampling, augering, sampling, or other advancement operations.

This protocol establishes the requirements for on-site drilling operations, addressing the key issues and activities associated with safe drilling and boring operations.

2. References

ASTM D6235-18: Standard Practice for Expedited Site Characterization of Vadose Zone and Groundwater Contamination at Hazardous Waste Contaminated Sites, 2018

ASTM D5434-12: Guide for Field Logging of Subsurface Explorations of Soil And Rock, 2012

ASTM D5781-18: Guide for Use of Dual-Wall Reverse-Circulation Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices, 2018

ASTM D5782-18: Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices, 2018

ASTM D5783-18: Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices, 2018

ASTM D5784-18: Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices, 2018

ASTM D5872-18: Guide for Use of Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation Of Subsurface Water-Quality Monitoring Devices, 2018

ASTM D5875-18: Guide for Use of Cable Tool Drilling and Sampling Methods for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices, 2018

ASTM D5876-17: Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices, 2017

ASTM D6169-21: Standard Guide for Selection of Subsurface Soil and Rock Sampling Devices for Environmental and Geotechnical Investigations, 2021

ASTM D4700-15: Guide for Soil Sampling from the Vadose Zone, 2015

ASTM D1586-18e1: Test Method for Penetration Test and Split Barrel Sampling of Soils, 2018

ASTM D1587-15: Practice for Thin Walled Tube Geotechnical Sampling of Soils, 2016

ASTM D4220-14: Practices for Preserving and Transporting Soil Samples, 2014

ASTM D6001-20: Guide for Direct Push Groundwater Sampling for Environmental Site Characterizations, 2020

3. Responsibilities

3.1 Project Manager

The Project Manager (PM) will be responsible for fulfilling the objectives of this protocol by ensuring that this procedure is carried out by all of the employees, subcontractors, and any other person acting on behalf of Groundwater & Environmental Services, Inc. (GES). The PM will also ensure that the Loss Prevention System (LPS) is implemented during the drilling project that will include but not be limited to: ensuring staff understand the need to conduct Loss Performance Self Assessments (LPSAs), review and understand activity-specific Job Loss Analysis (JLA) forms, and schedule Loss Prevention Observations (LPOs) as necessary.

The PM will ensure that all individuals working on drilling projects are adequately trained and supervised.

3.2 Site Supervisor

The Site Supervisor will practice sound investigation and drilling practices and employ all necessary measures to avoid damage to subsurface product systems and structures. The supervisor will also be responsible for ensuring that each appropriate JLA is reviewed by the project staff prior to project activities each day and immediately following the lunch-time break.

A LPO must be conducted by the PM on the individual who is providing oversight for the first time during the first or second day of the project. Depending on the outcome of the LPO, additional LPOs may be necessary.

The PM will be the point of contact for the Site Supervisor in the event an exception to this protocol is requested.

3.3 Case Manager

The Case Manager (CM) is responsible for providing field personnel with a sampling work plan and schedule. In addition, the PM or CM will provide field personnel with enough information to perform the work safely and correctly. This information should include the operational and safety procedures that are applicable to the work being performed.

4. Equipment/Materials

- Drilling rig appropriate to investigation goals and site conditions.
- Drilling tools required to complete borehole of required depth and diameter.
- Pavement saw or jackhammer to cut asphalt or concrete, if required.
- Hand tools required to clear drilling location.
- Air knife and air compressor to hand clear drilling location, if applicable.
- Minimum personal protective equipment (PPE): Steel-toed safety shoes, safety glasses, hard hat, reflective vest or safety orange or yellow clothing, gloves (leather work gloves, Kevlar gloves, latex or nitrile gloves).
- Plastic sheeting or steel drums to stage drill cuttings.
- Plastic trash bags for refuse.
- Cones, flags, caution tape, and signage appropriate for site control.
- Apparatus and materials required for the completion of split-spoon soil sampling (see SOP FM-9.2).
- Decontamination equipment (potable water, pressure washer, steam cleaner, scrub brushes, detergent, wash buckets) as appropriate.
- Sand, bentonite, grout, or materials appropriate for borehole abandonment.

- Cold patch asphalt, concrete, or materials appropriate for pavement restoration, if required.
- Materials required for proper soil sample management (see SOP FM-13.5).

5. Preparation

- Review site-specific Work Plan and field work directive with PM.
- Obtain client approval of selected soil boring locations, if applicable.
- Notify One-Call system or appropriate agency to mark-out utilities a minimum of 72 hours in advance.
- Conduct site visit, if appropriate, to check proposed drilling locations, map utilities, establish traffic control plan, and notify site personnel of upcoming work.
- Notify property owner, site manager, or appropriate site personnel at least 24-hours in advance of completing field activity.
- Locate all subsurface utilities according to GES' Subsurface Clearance Protocol.
- Locate all overhead utilities.
- Workers shall wear appropriate PPE as specified in the site specific Work Plan. Additional PPE may be required based on air monitoring results, contaminants of concern, or site-specific conditions.
- The work area shall be appropriately secured according to the practices outlined in SOP FM-1.3.
- The Site Supervisor shall conduct air monitoring in accordance with the site-specific Health and Safety Plan (HASP).
- If drill cuttings are expected to be generated, set up a staging area for drums or build a containment pad for a cuttings pile with plastic sheeting. All soil piles shall be covered with plastic sheeting at the end of each work day. Refer to SOP FM-14.1.

6. Procedure

6.1 Pre-Drilling Procedure

6.1.1 Preparation Tasks

The Site Supervisor is responsible for reviewing the site-specific Work Plan and field work directive with the PM.

6.1.2 Obtain Permits

The PM is responsible for following all local, state, and federal laws, obtaining all necessary permits and utility clearances, and securing site access permission.

6.1.3 Obtain Site Plans

The PM or CM shall obtain as-built drawings and/or site plans as available.

> *Note: As-built drawings may not accurately depict the locations of improvements and subsurface features should therefore not be solely relied upon to determine drilling locations. Visually check positions when drilling near sewers. Personnel should also be alert to the presence of additional piping if the plans are outdated.*

6.1.4 Mark-outs

The PM is responsible to ensure the One-Call system or appropriate agency is notified to mark-out utilities a minimum of 72 hours in advance.

The Site Supervisor must conduct a walkthrough of the site to locate all main electrical, gas, telephone, and all other subsurface utilities. A Site Walkthrough Utility and Service Line Determination Record (Attachment A) was developed to assist the Site Supervisor in identifying above ground and subsurface utilities. On third party sites, close coordination with the site owner's representatives for mark-outs, review of as-builts, and other information reviews should be conducted prior to work.

A private utility mark-out company should be contracted prior to performing subsurface activities so that the approximate location of any potential subsurface utility line is identified near the areas to be drilled. For any utility line identified, a “soft-dig” contractor should be utilized to verify the location and depth of the lines, as well as the size and type of line.

> *Note: If subsurface improvements are identified within an area, the method utilized during the private utility mark-out must be adequate to identify the utility prior to any subsurface activities (e.g., GPR survey).*

6.1.5 Pre-Drilling Meeting

Prior to the start of the project, a pre-drilling meeting must be held onsite that includes the local Operations Manager (OM) or their designee (i.e., PM), the Regional Health and Safety Officer (RHSO), designated site supervisor, and the subcontractor(s) procured to perform the work. The property owner, site manager, or appropriate site personnel is to be notified at least 24-hours in advance of completing any field activity.

The pre-drilling meeting activities shall include but not be limited to: a site walk to delineate and determine all above ground utility and service lines, review project health and safety requirements, review planned drilling or boring locations, discuss the anticipated project schedule and other pertinent project information.

6.1.6 Utilities

The locations of the following should be determined:

- Electrical lines, control boxes, and appliances
- Electrical breaker boxes
- Gas lines
- Pipelines
- Fiber optic lines
- Steam lines, water lines
- Sanitary and storm-water sewer lines
- Pressurized airlines
- Underground storage tanks and associated vent and dispensing lines
- Cable lines

  Note: Drill Rigs and vehicle super structures shall be a minimum of 10 feet from overhead electrical lines for lines rated 50 kV or below. For lines over 50 kV the clearance must be 10 feet PLUS 0.4-inches for each 1 kV over 50 kV (1926.550(a)(15)(i&ii) Subpart N).

6.1.7 Product Systems

If possible, speak with someone with historical site knowledge to gain information about the site (locations of former tanks, lines, etc.).

6.1.8 For Underground Storage Tank (UST) systems

- When possible, inspect for the presence of a dispenser pan and determine whether piping is rigid or flexible.
- Visually inspect the location of the tank field, observation wells (if present), dispensers, and vent stack(s).
- Document the orientation, arrangement, location, sizes, etc. of the tanks and manholes. Determine the burial depth of the tank field.
- Observe paving scars (i.e., fresh asphalt/concrete patches, scored asphalt/concrete).

Note: This may indicate the location of product piping or other utilities.

- Document the location of the emergency shut off switch to the dispensers and become familiar with its use.

6.1.9 Existing Remediation Systems

- Visually inspect the location of above ground components.
- Document the location of well manholes, sparge points, etc.

6.2 Selection of Drilling Locations

Document, communicate and review the selected drilling locations.

6.2.1 Define Critical Zones

A critical zone is defined as an area within:

- 10 feet of the perimeter of the UST area,
- 10 feet of the drip line of the dispenser/rack canopy,
- 10 feet of product/vent/instrument lines, gas lines, electrical conduits, sewer lines, water supply lines, telecommunications lines,
- All areas between the UST and the dispensers, between the dispensers/rack and the store/office building and within street utility corridors (typically within a right-of-way easement).

6.2.2 The Site Supervisor shall establish the following drilling critical zones

- 10 feet from the furthest edge of any operating tank
- 10 feet surrounding operating dispenser islands
- 10 feet surrounding marked or know utility locations
- At active service station sites, the entire area between the tank field and the dispenser islands and the area between two or more dispenser islands

The Site Supervisor should utilize the information collected to this point in combination with regulatory requirements and investigation objectives to select drilling locations. If possible, the Site Supervisor should avoid selecting locations within the critical zone.

Review Selected Locations with the Client and with the PM.

Note: The Site Supervisor must not proceed with the investigation until the plan has been discussed with the client and approval to proceed has been granted. If relocation of a boring is necessary at any time and for any reason outside approved limits, the Site Supervisor must contact the client and GES PM prior to proceeding.

6.2.3 Required Notifications

Notify affected parties of planned work and avoid scheduling conflicts with other remediation or facility activities at the site. The Site Supervisor will notify the following persons as applicable:

- PM
- Site Manager/Operator for active locations
- Property Owner for private properties, when possible

6.3 Procedure for On-Site Drilling

Identify, to the fullest extent possible, any improvements present in the subsurface prior to advancing drilling tools in order to prevent damage to the improvements.

6.3.1 Safety

- A HASP must be available onsite at all times and all employees and subcontractors must be familiar with attached JLAs and other information.
- All work areas shall be secured with safety cones, safety tape, construction fence, other barriers, or signs as appropriate. If construction of the drilling water containment is necessary, it must be completed in accordance with guidance provided in **Attachment C**.
- The Site Supervisor should locate the emergency shut off switch for the dispensers and shall ensure all site personnel are familiar with their use.
- A fire extinguisher and "No Smoking" signs must be present at all times.
- The Site Supervisor shall complete the Drilling Protocol Checklist (**Attachment B**) prior to commencing drilling operations.

6.3.2 Supervision

- The Site Supervisor will be responsible for drilling operations and must have a copy of the Drilling Protocol on-site.
- All surface removal, hand auger digging, and drilling will be performed, observed, or supervised by the Site Supervisor at all times.

- The Site Supervisor will ensure that the work is performed with due caution and will be alert for warning signs that could indicate the presence of underground lines or other subsurface structures (i.e., tanks).
- If any such indications arise, the work should immediately cease in the area and the PM shall be contacted.

6.3.3 Warning Signs

The following warning signs may indicate the presence of subsurface structures (i.e., tanks/lines):

- Pea Gravel, Sand, or other fill material.
- The absence of soil recovery in the hand auger. This could indicate pea gravel that has spilled out of the auger.
- Any unexpected departure from the native soil conditions as established in other onsite excavation/trenching digging.
- If any of the above warning signs or a suspicious condition is encountered, drilling in this area should immediately cease and the PM shall be contacted.

6.3.4 Drill Boring Sequence

- If possible, the boring sequence should be planned such that the boring furthest from any suspected underground improvements is carried out first. This is done to determine the natural subsurface conditions and to allow the Site Supervisor to recognize fill conditions.
- Least impacted locations should be completed first if possible to prevent possible cross contamination.

6.3.5 Surface Removal for Paved Areas - Paving Removal

- Sufficient paving or surface improvement should be removed to allow clear visibility of the subsurface conditions during hand augering and/or air knifing.
- Drilling in an area of high risk may warrant a larger pavement opening.
- Monitoring Well Installations: 2ft x 2ft minimum removal is suggested.
- Soil Borings/Push Type Samplers: 8 inches minimum removal is suggested.

6.3.6 Surface Removal Technique

The technique used should not pose a threat to subsurface structures. The only approved methods for completing holes within a paved area shall be to neatly saw-cut or core unless otherwise directed by the Client.

6.3.7 Subsurface Evaluation

Ensure that no subsurface improvements exist where drill or auger will penetrate.

- In critical zones, a minimum evaluation to a depth of 8 feet utilizing a non-destructive method such as hand clearing or vacuum digging is required.
- In non-critical zones, a minimum evaluation to a depth of 5 feet utilizing a non-destructive method such as hand clearing or vacuum digging is required.
- Areas where utility or service lines have been identified or within site critical zones, a minimum evaluation to a depth of 8 feet shall be completed utilizing a non-destructive method such as hand clearing or vacuum digging.

  Note: Client-specific specifications must always be satisfied with regard to hand clearing requirements. Therefore, the most conservative approach either GES or our client's requirement must be implemented.

6.3.8 Approach

The method used to identify the subsurface should be compatible with the inherent risk associated with the type of facility / property, and the location of the drilling. Only tools approved shall be used for probing, and digging.

Note: The Site Supervisor should discuss tool requirements with the Client. Also, no subsurface activities are permitted within a critical zone until the client and the GES client Program Manager is notified of the planned activity.

- Vacuum Digging: Vacuum digging has proven to be a very effective and safe means of digging and should be used unless the soil or other material prevents the use of a vacuum digging device.
- Probing: If probing is necessary, it should occur by using a blunt or rounded tip and should be advanced by hand without excessive force. Digging bars, pry bars or other digging tool that may result in damage to subsurface utilities are not permitted.
- Hand Digging: Should be performed with a small spade shovel.
- Hand Augering: The auger is to be turned slowly and not forced through the soil. It is recommended that an auger without sharp points (some augers have rounded edges) be used.

- Post Hole Digging: Can be used for soil removal only in soil that has been probed and cannot be used to advance the hole beyond the depth or width of probing.

  Note: In the event a drilling location is selected where it's apparent that additional soil or other fill material has been placed/added to the original ground surface level where utility or service lines have been identified (i.e., sloped area next to an existing building, landscaped area, etc.), the depth of the added soil will need to be taken into account or added to the required hand clearing depth.

Approval to deviate from this work scope may be granted on an exception basis for specific situations, such as undeveloped land. In addition, the GES Site Supervisor (oversight person) must stop all project activities and discuss the situation with the GES PM or OM when client or GES requirements cannot be implemented or when site conditions result that are not consistent with normal conditions.

Evaluation of the subsurface should ideally be accomplished by probing followed by soil removal using critical and non-critical zone guidelines as a minimum.

Additional exploratory methods (e.g., water drilling, electronic screening), which will achieve at least the same level of precautionary investigation and/ or drilling safety, should be reviewed with the PM prior to implementation.

The First 5 Feet:

The area to be evaluated shall not exceed the diameter of the largest tool (hand auger, drill auger, sampling tube, etc.) to be advanced and sufficiently large to allow for visual inspection of any obstructions encountered.

- The first 1–2 feet can be cleared by hand digging to remove the soil.
- Next, probe throughout the area to ensure that no obstructions exist anywhere near the potential path of the drill auger or push type sampler.
- Probing shall extend as far laterally as possible. Hand auger or vacuum digging can then proceed but only to the depth that has been probed.
- The soil in the area shall be fully removed during this step. Alternate probing with soil removal until the first 5 feet has been evaluated. If subsurface characteristics prohibit effective probing; a hand auger may be carefully advanced past the point of probing.
- In this event, sufficient soil borings must be placed to ensure that the soil in the area is fully removed.

The Last 3 Feet:

- For boring locations outside the critical zone, probing an additional 3 feet is recommended.

- For boring locations inside the critical zone, probing an additional 3 feet is required.
- If probing is met with refusal, then trained personnel should advance a hand auger without excessive force.

6.3.9 Refusal

Where natural subsurface conditions (e.g. cobbles/rocks, fill material, and/or bedrock) may prevent adequate probing and augering, a practical and sensible evaluation by the Site Supervisor will be the basis for determining if continuation of probing and augering is feasible.

In all cases the Site Supervisor must employ all means necessary to prevent damaging subsurface product lines and tanks.

When conventional means of probing and augering cannot be utilized or the Site Supervisor feels that additional probing/augering is not feasible, they must cease work in that specific area and contact the PM to discuss the matter.

6.3.10 Event Notification

If any portion of a utility or other subsurface structures is encountered or if there is suspicion that one has been encountered, all work shall be halted, emergency conditions secured, and the client notified immediately.

If there is suspicion that the structure has been damaged, the emergency shut-off switch should be activated if applicable, and the PM should be notified immediately.

The client should decide if additional hand clearing is required. If it is confirmed that utilities have been encountered, the client should be consulted to determine what actions should be taken, such as performing a tightness test(s).

Note: Under no circumstance is the area to be backfilled without notifying the client and receiving an approval to proceed.

6.3.11 Scheduling

Since evaluating the subsurface may be time-consuming, it may be appropriate to perform it prior to the drill rig's arrival on-site.

If these activities are conducted prior to the actual drilling day, the augered holes must be adequately covered with road plates and/or backfilled. Care must be taken to prevent settlement of the material used to cover the holes.

In remote, idled, or access controlled sites, augered/probed holes can be left open during fieldwork. A red hazard cone shall be placed over each penetration that will not be drilled the same day.

7. Disposal of Contaminated Materials

All materials and equipment used for decontamination must be disposed of properly as outlined in the Sampling and Analysis Plan (SAP). Clothing (PPE), tools, buckets, brushes, and all other equipment that cannot be reused will be disposed of as discussed in the SAP.

8. Records

8.1 Field Notes

The field notes must document all the events, equipment used, and measurements collected during the activities. The field notes must be legible and concise so that the entire sample event can be reconstructed later for future reference. The number and types (e.g., soil cutting, purge water) must be accurately reported in field notes on a daily basis with a total provided at completion of the work.

Record field notes in a standard bound survey-type field book issued for general note taking/field records and available from all GES equipment administrators. Make all field book entries black ink and make any changes/corrections with a single strikethrough line. Initial and date to indicate who made the change/ correction and when it was made.

9. Follow-Up Activities

Perform the following once field activities are complete.

- Clean and return equipment to the equipment administrator and sign and date the appropriate form.
- Complete purge water and cleaning fluid disposal requirements per the Work Plan.
- Complete the appropriate forms and data sheets. Send a copy to file, along with any field notes.
- Return site/well keys.

Attachments

Attachment A – Site Walkthrough: Utility and Service Line Determination Record

Attachment B – Drilling Protocol Checklist

Attachment C – Containment Construction

Attachment A – Site Walkthrough: Utility and Service Line Determination Record

Name of Person Performing Walkthrough:____

Project / Site Location:____ Date:____________________

Utility	Description of Location Found Onsite	Approximate Depth Below Ground Surface	Method Used to Determine Location
Electrical lines			
Gas lines			
Pipelines			
Stream lines			
Water lines			
Sanitary and Stormwater Sewer lines			
Pressured air lines			
Tank vent lines			
Optical fiber lines			
Underground Storage Tanks			
Other			

Attachment B – Drilling Protocol Checklist

Site Supervisor:_______________________________________ Date:_____________

Prior To Site Visit:	YES	NO	N/A
Obtained necessary permits			
Obtained Site Plans			
Visually inspected location of above ground components			
Note location well manholes, sparge points, etc.			
Document selection of drilling locations			
Define the “Critical Zones”			
Review selected locations with PM			
Conduct Utility Mark Out			
Site Visit:			
Note location of utility mark-outs and above ground utilities (Complete Walkthrough Record)			
Compared Site Plan to actual conditions			
Updated Site Plan, if necessary			
UST Systems:			
Inspected for presence of dispenser pan			
Inspected location of tank field			
Noted orientation, arrangement, location of tanks, manholes			
Noted location of Emergency Shut Off Switch			
Determined burial depth of tank field			
Noted paving scars			
Existing Remediation Systems:			
Visually inspected location of above ground components			
Note location well manholes, sparge points, etc.			
Document selection of drilling locations			
DEFINE THE “CRITICAL ZONES”			
Notified all affected parties of planned work			
Copy of Pre-Drilling Protocol available for site			

HASP available for site			
Fire extinguisher and First Aid Kit available for site			
“No Smoking” signs available for site			
Safety Cones, Safety Tape, Construction Fence, other barriers available for site			
Developed Scope of Work and reviewed with all concerned			

Attachment C – Containment Construction

JOB LOSS ANALYSIS	DATE 7-22-05	☒ NEW ☐ REVISED	PAGE 1 of ____

JLA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (DESCRIPTION)
Monitoring well drilling	Well Construction Preparation	Containment Cell Construction

Development team	Position / Title	Reviewed By:	Position / Title
D. Demko	Project Coordinator		
T. Baylis	Director of Health & Safety		

Required and / or Recommended Personal Protective Equipment			
☐ LIFE VEST ☒ HARD HAT ☐ LIFELINE/BODY HARNESS ☒ SAFETY GLASSES	☐ GOGGLES ☐ FACE SHIELD ☐ HEARING PROTECTION ☒ SAFETY SHOES ______	☐ AIR PURIFYING RESPIRATOR ☐ SUPPLIED RESPIRATOR ☐ PPE CLOTHING ______	☒ GLOVES ______ ☐ OTHER ______

[1]Job Steps	[2]Potential Hazards	[3]Critical Actions
Determine type of drilling to occur at job site (ie: air rotary, auger etc.)	None	Review with drilling contractor type, method and needs of drilling technique to be used.
Review background geology and anticipated contaminant to be encountered at job site. Inspect job site location.	None	Collection of accurate data on site specific hydrogeology and contaminants for analysis.
Define the management and disposal process for collection and removal of drilling returns	None	Set up containment, transportation and storage logistics for management of drilling returns.
Assess site specific location for containment cell construction	Hazards relative to the proposed drilling location	Assess topographic slope and land surface features; assess potential receptors in area of activity

Design containment cell to hold the desired volume of drilling fluids; select appropriate materials to maintain cell integrity and install containment cell	Hazards associated with handling materials, working with building tools.	Must design the containment cell to hold sufficient volume of fluids for rate of drilling fluids return/collection; must select the proper materials for cell construction based on cell volume and cell location.
Ready the components of fluid removal from the cell, transport and storage/disposal locations to ensure adequate capacity	Hazards associated with equipment movement and handling of drilling return materials.	Proper assessment and inspection of the containment cell construction and review of transport/storage elements for fluids management prior to drilling startup.
Preparation of a contingency and response plan based on containment cell failure	Loss of cell contents may pose hazard to personnel working near the cell structure.	Assess risk to personnel and the environment based on cell location and potential migration of contents from a loss scenario.
Develop a communication protocol between the driller and site geologist to cease drilling when a pre-determined level of fluids in containment cell is reached.	Hazards associated with monitoring well construction and operation around a drilling rig.	Must determine an appropriate level for cell volume liquid containment/storage based on cell construction characteristics and placement location.

[1]Each Job or Operation consists of a set of tasks / steps. Be sure to list all the steps needed to perform job.

[2]A hazard is a potential danger. Break hazards into five types: **Contact** - victim is struck by or strikes an object; **Caught** - victim is caught on, caught in or caught between objects; **Fall** - victim falls to ground or lower level (includes slips and trips); **Exertion** - excessive strain or stress / ergonomics / lifting techniques; **Exposure** - inhalation/skin hazards.

[3]Using the first two columns as a guide, decide what actions or procedures are necessary to eliminate or minimize the risk. List the recommended safe operating procedures. Say exactly what needs to be done - such as "use two persons to lift". Avoid general statements such as, "be careful".

Title: Soil Boring Advancement

1. Purpose/Scope

This standard operating procedure (SOP) provides detailed instructions to serve as guidance during site investigations involving soil borings. This procedure is not intended to satisfy or replace regulatory or client-specific requirements.

2. References

ASTM D1452-16: Standard Practice for Soil Investigation and Sampling by Auger Borings, 2016

ASTM D5784M-18: Standard Guide for Use of Hollow Stem Augers for Geo-environmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices, 2018

3. Equipment/Materials

- Drilling rig appropriate to investigation goals and site conditions
- Drilling tools required to complete borehole of required depth and diameter
- Pavement saw or jackhammer to cut asphalt or concrete, if required
- Hand tools required to safely clear drilling location
- Air knife and air compressor to hand clear drilling location, if applicable
- Minimum personal protective equipment (PPE): Steel-toed safety shoes, safety glasses, hard hat, reflective vest or safety orange or yellow clothing, gloves (leather work gloves, Kevlar gloves, latex or nitrile gloves)
- Air monitoring equipment, including soil headspace scanning instrument (PID or FID). See SOP FM-9.7
- Plastic sheeting, roll-off container, or steel drums to stage drill cuttings
- Poly totes or steel drums to stage drilling fluids, if applicable.
- Plastic trash bags for refuse
- Cones, flags, caution tape, and signage appropriate for site control (see Health and Safety Plan [HASP] for traffic control guidance)
- Apparatus and materials required for the completion of split-spoon soil sampling (see SOP FM-9.2)

- Decontamination equipment (potable water, pressure washer, steam cleaner, scrub brushes, detergent, wash buckets) as appropriate to SOP FM-14.1 and 14.2
- Sand, bentonite, grout, or materials appropriate for borehole abandonment
- Cold patch asphalt, concrete, or materials appropriate for pavement restoration, if required
- Apparatus and materials required for field logging of subsurface investigations (see SOP FM-2.1)
- Materials required for proper soil sample management (see SOP FM-13.5)

4. Preparation

- Review investigation Work Plan and field work directive with Project Manager (PM).
- Obtain client approval of selected soil boring locations, if applicable.
- Notify Underground Facilities Protection Organization (UFPO) or appropriate One Call utility mark-out agency of intended subsurface work and follow appropriate mark-out notice requirements.
- Conduct site visit, if appropriate, to check proposed drilling locations, map utilities, establish traffic control plan, and notify site personnel of upcoming work.
- Locate all subsurface utilities according to GES' Subsurface Clearance Protocol.
- Locate all overhead utilities.
- Workers shall wear appropriate PPE as specified in Section 5 above. Additional PPE may be required based on air monitoring results, contaminants of concern, or site-specific conditions.
- The work area shall be appropriately secured according to the practices outlined in the HASP and SOP FM-1.3.
- The Site Supervisor shall conduct air monitoring in accordance with the site HASP.
- If drill cuttings are expected to be generated, set up a staging area for drums or build a containment pad for a cuttings pile with plastic sheeting. All soil piles shall be covered with plastic sheeting and secured at the end of each workday.
- If drilling fluids are expected to be generated, set up a staging area for drums, totes, or other container. Container should be liquid tight and/or lined with plastic sheeting. Container should be able to close or be covered at the end of each workday.

5. Procedure

No intrusive work should be attempted until (1) a utility marking service has marked all known subsurface utilities, (2) all available as-built plans have been consulted and subsurface utilities marked (if different from the mark-out service's), and (3) boring sites have been cleared to a depth of at least 5 feet using safe methods, such as air knifing or similar technology.

1. Select first soil boring location. In general, this boring should be the location expected to be the least impacted by contaminants of concern and most representative of native soil conditions (i.e., away from areas where fill materials are suspected).
2. Saw cut or jackhammer existing pavement at soil boring location, if required. Make pavement cut large enough to account for the required hand cleared width and depth. Once pavement thickness is known, do not cut deeper than the bottom of the pavement. Remove pavement materials.
3. Hand clear boring location at a minimum according to GES' Subsurface Clearance Protocol. Additional client or site-specific requirements should be followed while completing this task. No drilling tools shall be advanced without hand clearing, unless the requirements have been waived by the client, GES Corporate Health and Safety, GES Regional Health and Safety, and the GES PM.
4. After boring location is hand cleared, work can proceed with the appropriate drilling tools—either direct-push, or hollow stem auger/split-spoon sampler methods. Record lithology using USCS terminology as outlined in FM-2.2.
5. Advance drilling tools to appropriate depth and collect soil samples according to the project Work Plan. Complete field logging activities in accordance with SOP FM-2.1. Collect all drill cuttings that will not be used as backfill and stage for future disposal.
6. Conduct soil sampling activities in accordance with SOP FM-9.1, -9.2, and -9.3. Handle all soil samples in accordance with SOP FM-13.5.
7. General information to collect during advancement of the soil boring includes, but is not limited to: soil moisture content, first occurrence of groundwater, lithology description, lithology changes, presence of confining layers, visual and/or olfactory evidence of contamination, headspace readings, split-spoon blow counts (if applicable).
8. Continue advancing drilling tools and collecting soil samples until the termination depth of the soil boring is reached, bedrock is encountered, or drilling tools are refused.
9. Remove drilling tools from boring. Decontaminate tools as appropriate upon removal.
10. If no monitor well is to be installed at the soil boring location, abandon borehole according to regulations and/or client requirements and the Work Plan. Drill cuttings, sand, bentonite, or cement/bentonite grout are all acceptable materials. Refer to SOP FM-5.7.
11. If a monitor well is to be installed, refer to SOP FM-5.4.
12. Decontaminate all drilling and sampling tools per SOP FM-14.2

6. Records

6.1 Field Notes

The field notes must document all the events, equipment used, and measurements collected during the sampling activities. The field notes must be legible and concise so that the entire sample event can be reconstructed later for future reference.

Record field notes in a standard bound survey-type field book issued for general note taking/field records and available from all GES equipment administrators. Make all field book entries black ink and make any changes/corrections with a single strikethrough line. Initial and date to indicate who made the change/ correction and when it was made.

The logbook should document the following for each boring sampled:

- Soil Boring ID
- Location of boring.
- Boring depth
- Static water level depth and measurement technique, if applicable
- Sounded well depth
- Presence of immiscible layers and detection/collection method
- Sampling sequence
- Sample appearance using USCS methodology
- Sample odors (if respiratory protection is not required)
- Headspace readings with a PID/FID
- Types of sample containers and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data and method(s)
- Sample distribution and transporter
- Laboratory performing analysis
- Chain-of-custody number
- If shipping samples via third-party vendor (FedEx etc.) record tracking number in field notes.
- Field observations on sampling event

- Name of collector(s)
- Climatic conditions including air temperature
- Problems encountered and any deviations made from the established sampling protocol, and if applicable deviation guidance provided by the PM.

If a monitor well was installed, refer to FM-5.4, Monitor Well Design and Construction and FM-5.6, Monitor Well Development. Follow these guidance prior to colleting a groundwater sample.

7. Follow-Up Activities

Perform the following once field activities are complete.

- Double check Work Plan to ensure all samples have been collected and confirm this with Project Coordinator.
- Clean and return equipment to the equipment vendor (call off rentals as soon as possible if applicable).
- Complete soil cutting disposal requirements per the Work Plan.
- Complete decontamination (decon) water and cleaning fluid disposal requirements per the Work Plan.
- Notify the contract laboratory as to when to expect the samples. Enclose the chain of custody and covering letter, indicating the parameters and number of samples, in the sample cooler.
- Complete the appropriate forms and data sheets. Send a copy to file, along with any field notes.

Standard Operating Procedure

SOP #:	FM-4.4 Rev. 003
Review Date:	06/12/2023
Origin Date:	03/01/2016

Title: Boring / Well Construction Field Log Completion

1. Purpose/Scope

This standard operating procedure (SOP) provides general minimum procedures for completing soil boring and well construction logs in the field.

2. References

GES SOP FM-2.1: Field Logging of Subsurface Investigations

GES SOP FM-2.2: Classification of Soils via USCS

GES SOP FM-4.1: Soil Boring Advancement

GES SOP FM-5.4: Monitoring Well Design and Completion

3. Equipment/Materials

- Site plan with soil boring and/or monitoring well locations shown
- Field notes with soil boring and/or monitoring well location information
- Field log book, site-specific event logging sheets, site-specific bore logs previously completed
- Field guide for soil and stratigraphic analyses (e.g., www.midwestgeo.com)
- Apparatus and materials required for field logging of subsurface investigations (see SOP FM-2.1)

4. Preparation

Ensure that soil boring and well construction logs/notes are completed in accordance with other SOPs and applicable federal, state, local and site/client-specific requirements.

5. Procedure

5.1 Completing Soil Boring Logs

For each soil boring log to be completed, include the following information, at a minimum:

- Soil boring ID

- Date and time soil boring was started/completed
- Drilling method and type of drill rig
- Drilling company
- Sample collection method
- Blow counts (as applicable)
- Sample recovery
- Field screening measurements (as applicable)
- Borehole diameter
- Borehole completion depth
- Depth to water (if encountered)
- Lithologic description for each sample interval (SOP FM-4.1 and SOP FM-2.2). If monitoring for chemical constituents, note the depth intervals, field screening results, and visual description of sample.
- Note time and depth interval of any samples collected and submitted for laboratory analysis (SOP FM-4.1, -9.1, -9.2, and -9.3)
- Backfilling/completion method and materials
- Sketch of boring location in field notes including appropriate measurements from fixed objects
- GPS coordinates and coordinate system used for each location
- Surveyed elevation of ground surface at borehole location
- Waste handling/management activities
- Any additional relevant comments/notes

5.2 Completing Monitoring Well Construction Logs

1. Refer to SOP FM-5.4 for monitoring well installations.

1. Obtain lithologic information for boring and complete a lithologic log as described above.

2. The following additional information should be included, at a minimum, on each monitoring well construction log.

- Well diameter (include diameter of riser, screen, casing, etc.)
- Total well depth
- Screen or open hole depth, construction material and slot size

- Riser depth and construction material
- Casing depth and construction material (if applicable)
- Measured static water level in monitoring well after constructed
- Ground surface, top of well (riser), and casing (i.e., pro-casing stickup, if applicable) survey elevation (Notch/mark survey and measurement point on north side of well for all future measurements)
- Sketch of monitoring well location in field notes including appropriate measurements from fixed objects
- GPS coordinates and coordinate system used for each location
- Details (or labeled drawing in notes) of well construction including:
  - Screen interval in feet below ground surface (ft bgs)
  - Riser interval in ft bgs
  - Casing interval (if applicable) in ft bgs
  - Depth interval of sand-pack in ft bgs
  - Type and depth of well seal in ft bgs
- Flush-mount (road box) diameter and collar depth in ft bgs
- Stick-up (i.e., pro-casing) height in ft above ground surface (if applicable)
- Size and depth of concrete pad
- Document monitoring wells completed with locking cap, well lock and well I.D. tag
- Document any applicable monitoring well permit numbers

6. Records

6.1 Field Notes

The field notes must document all relevant information, equipment used, and measurements collected during the boring and/or well construction activities. The field notes must be legible and provide enough detail so that the entire event can be reconstructed later for future reference.

7. Follow-Up Activities

Upon returning from field activities, generate a boring or well construction log in LogPlot or other applicable program.

Standard Operating Procedure

Title: **Per- and Poly-Fluoroalkyl Substances (PFAS) Investigation – Drilling**

1. Purpose/Scope

This standard operating procedure (SOP) is intended to be used as a supplemental companion to FM 4.0 Drilling Protocol. SOPs for sampling at PFAS sites (e.g., FM 22.0 PFAS Sampling, FM 22.2 PFAS Sampling – Groundwater, and FM 22.7 PFAS Sampling – Soil) should be followed for sample collection. The objective of this SOP is to provide specific direction and guidance for drilling that includes investigation for per- and poly-fluoroalkyl substances (PFAS) that may be present in soil and groundwater.

2. References

- Interstate Technology & Regulatory Council (ITRC) (2022): Per- and Polyfluoroalkyl Substances (PFAS)
- Michigan Department of Environment, Great Lakes, and Energy (EGLE) (2018): Soil PFAS Sampling Guidance
- Naval Facilities Engineering Systems Command (NAVFAC) (2023): Best Practices for PFAS Sampling and Data Evaluation

3. PFAS Specific Procedures

This section presents practices that are applicable for drilling to investigate for PFAS. Potential sources of PFAS introduction from the drilling process include materials used in the clearance and advancement of boreholes; construction of wells; developing wells; and sampling soil and groundwater. Use PFAS-free water for all steps during drilling (e.g., decontamination, hydrating bentonite, well development). Due to the potential presence of PFAS in shallow soil (i.e., 0 – 2 feet below ground surface [bgs]) from air deposition, PFAS can be introduced into groundwater from shallow soil (e.g., falling into the borehole during well drilling and construction).

Additionally, the use of temporary monitoring wells to characterize PFAS is not recommended. Water samples collected from temporary wells typically have high turbidity, and turbid samples may be biased high for PFAS. A maximum turbidity of 10 Nephelometric Turbidity Units (NTUs) is recommended for collection of representative groundwater samples.

- Acceptable materials for field equipment include stainless steel, HDPE, PVC, silicone, acetate, and polypropylene.

- Use PFAS-free drilling fluids, lubricants, and materials during drilling (e.g., RectorSeal No. 5, LOCTITE No More Leaks Plastic Pipe Sealant [PTFE Free], Gasoila Blue NT pipe thread sealant).
- Use only non-coated bentonite products (e.g., pellets, chips) during well construction. Avoid the use of coated bentonite products as the coatings may contain PFAS or PFAS pre-cursors. Use PFAS-free water to hydrate bentonite.
- When constructing concrete well pads, avoid the use of shrink- and crack-resistant formulations as they may contain PFAS or PFAS pre-cursors. When using water reducing admixtures (WRAs) or dyes, review the safety data sheet (SDS) to identify if fluorinated chemicals are present. If forms are used, untreated wood is preferred; preformed cardboard forms are typically coated and may contain PFAS or pre-cursors. Used PFAS-free water when mixing concrete.
- During hand clearing, air knives and hand tools may be used when the materials of construction are in accordance with this SOP.
- Consider installing an outer casing (e.g., steel or PVC) to a minimum depth of 2 feet bgs that is at least 2-inches larger in diameter than the well being constructed to prevent shallow soil from falling into the borehole during drilling and well construction. If an additional organic layer (e.g., peat) is encountered above the water table, consider extending the steel outer casing to at least 6 inches below the organic layer. The presence of shallow groundwater or perched water may preclude the use of a steel outer casing when the water is to be characterized.
- Decontaminate drilling equipment between sample and drilling locations using the PFAS-free water and a PE or PVC brush to remove particulates. Use detergents such as Alconox, Liquinox, or Citranox. Do not use DECON 90.
- Collecting a sample of the PFAS-free water used during drilling is recommended unless the drilling contractor provides laboratory data demonstrating that the water is PFAS-free.

Standard Operating Procedure

SOP #:	FM-5.4 Rev. 005
Review Date:	01/20/2025
Origin Date:	03/01/2016

Title: Monitor Well Design and Construction

1. Purpose/Scope

This standard operating procedure (SOP) provides instructions to design and install monitor wells in various types of subsurface materials.

2. References

ASTM D5092 / D5092M-16: Standard Practice for Design and Installation of Ground Water Monitor Wells, 2016

ASTM D5092-04: Standard Practice for Design and Installation of Ground Water Monitor Wells in Aquifer, 2004

ASTM D6724 / D6724M-16: Standard Guide for Installation of Direct Push Groundwater Monitoring Wells, 2016

ASTM D5474-93: Guide for Selection of Data Elements for Ground Water Investigations, 2012

ASTM D5787-20: Standard Practice for Monitor Well Protection At or Near Land Surface, 2020

ASTM F480-14: Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

3. Equipment/Materials

- Equipment and materials necessary to complete soil and/or bedrock drilling of boreholes where the wells will be installed (FM-4.1).
- Well slot sized to match the filter pack material, and the filter pack material sized to match the geologic strata as outlined in the Work Plan or in discussion with the Project Manager (PM).
- PVC, stainless steel, or steel well screen and/or riser pipe.
- Protective steel riser and locking cap or flush mount cap, as required by Work Plan.
- Bentonite chips to place above filter pack materials in annulus as per Work Plan.
- Grout, grout mixer, and tremie pipe to install grout in borehole annulus.
- A commonly keyed well lock.
- A water level gauge.

- A field notebook or other field form to record well construction information.
- Proper personal protective equipment (PPE) per site-specific Health and Safety Plan (HASP).

4. Preparation

- Written specifications for design and construction of wells should be prepared and in accordance with regulatory requirements, client standards, GES practices, and industry best practices. A written request for proposal/quotation (RFP/RFQ) should be provided when subcontracting drilling services.
- Review investigation and/or corrective action Work Plan with PM.
- Ensure availability of subcontractors, equipment, and materials necessary to complete soil and/or bedrock drilling of boreholes where the wells will be installed (FM-4.1).
- Confirm well design and constructing from PM and/or Work Plan.
- Confirm contaminants to be monitored and ensure compatibility with well materials.
- Confirm geologic/hydrogeologic conditions at the site.
- Confirm the anticipated total depth and desired screen interval of the well.
- Confirm if the well is going to serve for monitor, pumping test, injection, or extraction purposes.
- It is to be noted that the selection of well locations prior to drilling should always avoid low areas, which are subject to surface water ponding.

5. Procedure

The following presents the field procedure requirements and techniques for the completion of overburden and bedrock monitor well installations.

5.1 Well Installation - Standard

- The borehole shall be drilled as close to vertical as possible. Slanted boreholes shall not be acceptable unless specified in the design.
- Ensure the borehole diameter is sufficient for well construction – local requirements may apply.
- Ensure a minimum 2-inch (5 cm) annular space between the well casing and borehole wall.
- Measure the well assembly (i.e., well screen and riser components) to record its total length, and the length of each component prior to insertion into the augers or borehole.

- The well casings and the well screen shall be placed into the borehole and plumbed to be vertical.
- No lubricating oils or grease shall be used on casing threads.
- No glue of any type shall be used to secure casing joints.
- Welded joint construction is acceptable.
- Centralizers may be used to plumb a well greater than 50 feet (15 m) deep, but they shall be placed below the well screen and above the bentonite seal such that the placement of the filter pack, bentonite seal, and annular grout will not be hindered.

5.2 Well Installation – Double Casing/Bedrock

Double-cased wells shall be constructed when there is reason to believe that interconnection of two aquifers by well construction may cause cross contamination or if overburden needs to be isolated from bedrock well installations.

- Drill a boring through the overburden and/or the contaminated zone into a confining layer (clay) or bedrock.
- Extend the borehole and outer casing a few feet into the upper layer of the confining layer or into competent bedrock. The depth of penetration will depend upon the thickness of the confining layer and regulatory requirements but usually only a few feet are needed.
- Place an outer casing (sometimes called surface casing) into the borehole and grout in place using either of the Immersion or the Pumping Methods.
- Outer casing and grout should be allowed a 24-hour period to cure prior to resuming drilling.

5.2.1 Immersion Method

- Drill borehole.
- Fill borehole with grout.
- Insert casing that has bottom end plugged with grout (previously placed and set) into borehole (water may be added inside casing to overcome buoyancy).
- Tap casing into confining layer or bedrock.

5.2.2 Pumping Method

- Drill borehole.
- Insert casing into borehole.
- Insert grout pumping tube and inflatable packer into casing.
- Inflate packer (with grout pumping tube extending through center of packer).

- Pump grout through packer until grout return is noted at surface from around outside of casing.
- Tap casing into confining layer or bedrock.
- Remove packer and grout tube.

5.3 Filter Pack Placement – Primary Filter Pack

- Select the elevation for the top of the filter pack in the field based upon the geologic conditions encountered.
  - For shallow overburden wells, it is common to extend the filter pack to the top of the water table plus a few extra feet to account for the anticipated seasonal fluctuation of the water table.
  - For deeper overburden wells, it is common to select a specific hydrogeologic unit to monitor.
- The filter pack should span that specific hydrogeologic unit only.
- The filter pack should never extend through a confining layer causing two or more separate permeable layers to become connected.
- Whenever practical, the filter pack should extend a minimum of 2 feet above the top of the well screen.
- The filter pack should be placed by the tremie method (placing the primary filter pack by pouring directly into the wellbore may be acceptable if you are sure that the filter pack is reaching the assigned depth).
- Primary filter pack placement must be performed concurrent with the removal of the augers when collapsing borehole conditions exist.
- The filter pack level must be maintained within the augers or temporary casing to ensure that the pack fully surrounds the well screen.
- If sand or filter pack is flowing up into the augers, add potable water within the augers to maintain a positive pressure head on the formation materials.
- If potable water is added, the volume used must be recorded and additional purging volumes may be required.

5.4 Filter Pack Placement—Secondary Filter Pack

Deeper wells (>60 feet) should consider a Secondary Filter Pack to avoid contaminating the well screen with grout leaking through the Primary Filter Pack under higher head pressures.

- Use a finer grained version of the same or similar materials as Primary Filter Pack.

- Install on top of Primary Filter Pack using tremie methods.
- Secondary Filter Pack should be minimum 2 feet if used.

5.5 Annular Seal (Plug)

- The grout shall be prepared in accordance with the manufacturer's specifications.
- Place a solid, pure bentonite chip pellet seal on top of the filter pack. Bentonite in either pellet (chip) or granular form is acceptable as long as it does not expand too fast under water and cause a bridging in the annular space. Pour bentonite chips in shallow boreholes [less than 50 feet (15 m)] where the annular space is large enough to prevent bridging and to allow measuring to ensure that the bentonite has been placed at the proper intervals.
- The bentonite seal should be placed above the filter pack to the designated depth or a minimum of at least 2 feet (0.6 m) above the filter pack.
- Allow the bentonite to hydrate before initiating the next backfilling operation (grouting).
- Hydrate the chips with potable water.

5.6 Annular Seal (Grout)

- The annular space between the well casing and the borehole wall should be filled with either a neat cement grout or cement/bentonite grout.
- The grout shall be placed into the borehole using positive displacement techniques and the tremie method.
- The grout shall be placed from the top of the bentonite seal to within 2 feet (0.6 m) of the ground surface or below the frost line, whichever is greater.
- The grout shall be allowed to set for a minimum of 24 hours before a surface pad is installed.
- After 24 hours, check grout level and add additional grout, if necessary.
- In cases where surface pads are not used, the grout should be brought to within 6 to 12 inches of the ground surface with the remaining height to be backfilled to match the surrounding surface conditions (i.e., asphalt, topsoil).
- The end of the grout pipe should always be submerged in the grout to ensure positive displacement.

5.7 Aboveground Riser Pipe and Outer Protective Casings

- The well casing, when installed and grouted, shall extend above the ground surface a minimum of 2.5 feet (0.75 m).
- A protective casing shall be installed over the completed well and grouted into place.

- The outer protective casing shall be of steel construction with a hinged, locking cap that is waterproof and tamper proof.
- The protective casing shall have sufficient clearance around the inner well casing, so that the outer protective casing will not come into contact with the inner well casing after installation.
- A concrete security collar shall be installed flush with the ground surface around the outer protective casing.
- The collar will be sloped to promote surface drainage away from the monitor well.
- The protective casings shall have a minimum of two weep holes for drainage and pressure equilibration to outside atmosphere.
- These weep holes shall be a minimum 1/4-inch (6.4 mm) in diameter and drilled into the protective casing just above the top of the level of concrete inside to prevent standing water inside the protective casing.
- After the wells have been installed, the protective casings shall be permanently marked with the well number on the cover or inside. When multiple wells are installed in the same borehole (nested wells), it is important to label each well during construction.

5.8 Flush Mounted Wells

- In cases where wells must be located in traffic areas, the wells will be flush-mount installations.
- When multiple wells are installed in the same borehole (nested wells), it is important to label each well during construction.
- Flush mounted wells will have a waterproof protective casing to ensure the integrity of the groundwater formation.
- A concrete pad must be installed surrounding the well manhole.
- The protective casings are grouted in place and fitted with bolts and rubber gaskets.
- The well tops are to be fitted with locking caps.
- Well caps shall be watertight screw-on connections as referenced in ASTM F-480.
- For at-grade completions, well caps shall provide a means of locking using a standard padlock.
- For above-grade completions, the well cap or well casing shall be vented with a 1/4-inch (6.4 mm) drilled hole.

5.9 Protective Posts

Protective posts (bollards) may be required in high traffic, or otherwise sensitive entry areas.

- Protective posts shall consist of either 4-inch-diameter carbon steel pipe or 4-inch by 4-inch untreated wooden posts.
- The posts shall be 5 feet (1.4 m) in overall length, and installed at least 3 feet (0.86 m) above grade.
- Up to four posts shall be provided for each monitor well and they shall be installed in concrete separate from the concrete security collar.
- The posts shall be located at the corners of the concrete collar, 4 feet from the center of the monitor well at 90-degree increments.

5.10 Weather Considerations for Concrete Pads

Restoration during or immediately prior to rain events should be avoided. Concrete typically requires 4-8 hours for initial curing. It is recommended to reschedule placing concrete if rain events are predicted for the next one to two days. If work must be completed, newly-installed concrete pads should be covered with plastic and means to divert water away from the restored area(s) should be used as needed. Proper crowning concrete pads can eliminate the need for storm water diversion. Additionally, concrete products with enhanced resistance to rain during or after installation may be selected.

Cold and freezing temperatures (i.e., when ambient temperature is less than 40° F) can adversely affect paving materials such as asphalt and concrete. When paving must be conducted in these conditions within 24 hours of paving, use cold weather methods such as insulated concrete curing blankets. Paving products (e.g., concrete) designed for cold conditions may be selected.

6. Records

Details of each overburden well installation may be recorded on the Stratigraphy Log (Overburden) or within a standard GES field book. Well Construction Detail is provided for recording the overburden well instrumentation details, and must note the following:

- Overburden and/or bedrock lithology per FM-4.1
- Well screen depth and interval
- Filter pack interval
- Bentonite seal/plug interval
- Grout interval
- Surface cap detail
- Well material, including screen size and type (i.e., factory slot or continuous)
- Any well instrumentation (e.g., pump setting, riser and screen length)

- Well diameter
- Filter pack material
- Type of seal
- Type of grout
- Stick-up/flush-mount detail
- Date installed
- Development record
- Permit information (if applicable)
- Surveyed well location and elevation per state guidelines or requirements (at minimum, develop accurate field ties to the center of the well from three adjacent permanent features and permanently marked to identify the well number designation).

7. Follow-Up Activities

Once the monitor well(s) have been installed, complete the following activities:

- Submit logs to the GES PM, who will be responsible for the review and completion of the final well log.
- Plot well locations onto site plan map, since locations may be altered in the field due to underground/overhead interferences or other conditions.
- Tabulate monitor well details.
- Prepare a summary write-up on field activities including, but not necessarily limited to such items as drilling method(s), well construction material, site geology, well development and waste management.
- Keep field log book on file at the appropriate GES office.

Title: Monitor Well Development

1. Purpose/Scope

This standard operating procedure (SOP) provides instructions for developing a monitoring well after installation is completed (FM-5.4 Monitoring Well Design and Construction).

2. References

- ASTM D5092 / D5092M – 16. Standard Practice for Design and Installation of Groundwater Monitoring Wells. 2017.
- ASTM D5521 / D5521M-18. Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers. 2018
- ASTM D5978 / D5978M-16. Standard Guide for Maintenance and Rehabilitation of Groundwater Monitoring Well. 2016.
- Driscoll, F.G., Groundwater and Wells, 2nd Edition. Johnson Division. 1986.
- Freeze, R.A. and Cherry, J.A., Groundwater. Prentice Hall, Inc. 1979.
- Resource Conservation and Recovery Act Ground Water Monitoring Technical Enforcement Guidance Document by the Environmental Protection Agency (EPA) Report 530/SW-89-055 (1986) and the EPA Handbook (1991).

3. Equipment/Materials

A checklist of suggested equipment and supplies needed to implement this SOP would be based on the selected method of development in addition to general field equipment. **Attachment A** (Drilling Geologist Equipment Checklist) presents a complete list of equipment. The general field equipment includes:

- Water interface probe
- Specific conductance/temperature/pH meter
- Surge block equipped with submersible pump
- Decontamination materials
- Wire brush and extended handle
- Plastic sheeting/towels/garbage bags

- Transportable, purged water storage container
- Bottom-loading stainless steel bailer with nylon cord
- Well construction details
- Photoionization detector (PID)
- Field book
- Proper personal protective equipment (PPE) per the site-specific Health and Safety Plan (HASP)

4. Preparation

- Review the Work Plan with Project Manager (PM) and select the method of development. Common methods are listed in **Attachment B** (Well Development Methods).
- Perform the applicable preparation activities described in SOP FM-1.5 (General Instructions for Field Personnel).
- The PM or Case Manager (CM) should obtain relevant information on each well to be developed (e.g., drilling technique, drilling fluid losses, anticipated aquifer yield, screened interval, anticipated contaminants).
- Obtain the specific equipment and materials from the Drilling Geologist Equipment Checklist (**Attachment A**).
- Decontaminate equipment used in well development per SOP FM 14.1 (Equipment Decontamination), or the Work Plan.
- Obtain sufficient containers for temporary storage of well development water. If temporary storage containers are employed on-site, Site personnel shall ensure that:
  - Containers have no leaks
  - Containers, such as 55-gallon drums, are stabilized to prevent spillage
  - Containers are field manageable (The use of truck or trailer-mounted tanks may be necessary for larger volumes of water)
  - Containers are labeled as non-potable purge water
- Obtain any necessary temporary discharge permits for on-site treatment and on-site discharge of any development water.
- Coordinate and arrange development water treatment with GES engineering division.
- Check any source(s) of water to be introduced into the borehole. Use only analyte-free water.

5. Procedure

Well development should be completed as soon as practical after well installation, but no sooner than 48 hours, unless another timeframe is specified or required by the regulatory agency.

- Open the surface protective casing and remove the well cap (if applicable).
- Where volatile organics are suspected to be present, monitor air quality at the top of the casing and in the breathing zone using a PID or other suitable monitoring instrument. Record readings in appropriate site-specific field book.
- Measure depth to water and total depth of the well according to SOP FM-8.1 (Fluid Level Gauging).
- Measure and record initial field chemical parameters (e.g., pH, specific conductivity, oxidation reduction potential (ORP), and temperature).
- Begin development activities to remove water and sediment from the well.
- Remove residual drilling mud from the casing by bailing or flushing with potable water through a tremie pipe. Introduce just enough water to remove the drilling mud.
- Segregate removed drilling mud from the formation water, if possible. Use drilling contractor's mud tank to collect un-thinned drilling mud and initial muddy formation water.
- Begin well development using a surge block/bailer/pump or approved method based on the number of well casing volumes and follow with additional development until (1) the development water becomes visually clear of suspended sediment, (2) minimum of three to five calculated well volumes of the initial standing water column has been purged, and (3) field parameters of the last three field chemical parameter measurements have stabilized to within +/-10%. Criteria for completing well development are described as follows:
    - *Turbidity criteria* – Well development shall continue until the turbidity has improved from the initial static conditions. Be sure to document all turbidity conditions in the field notes. If the well is not visually clear of sediment after the required volume of water has been removed, continue well development until twice the initial purge volume has been purged or approval to cease development activities is agreed upon by the PM or CM.
    - *Purge volume criteria* – Purge a minimum of three to five volumes of the initial standing water column, as specified in the field work directive (FWD), in each well prior to discontinuing well development. In situations where the groundwater flow from the screen interval is exceeded by the development pumping rate, the well may

temporarily dry up. Inform the PM or CM when it is determined that three to five casing volumes cannot be purged within a 12-hour period.

  - *Field parameter criteria* – This criterion for well development has been met when field chemical parameters (e.g., pH, specific conductivity, ORP, and temperature) have stabilized within +/-10% over the final three series of monitoring measurements.

- If one or more of the above criteria for well development cannot be met regardless of the amount of pumping, coordinate with the PM to select an alternate procedure for verifying that the well is adequately developed.
- Record estimated drawdown and well development pumping rate. Using flow and recovery rates, estimate the discharge rate the well can be pumped while not allowing (if possible) the water level to fall below the top of the screened section of the casing. Report unsustainable or low yield estimates, or dry wells to the PM or CM.
- Collect any samples of the discharge requested by the PM or CM or required by the Work Plan.
  - Well development (WD) samples are identified differently than routine samples and should be named using the well name followed by WD (e.g., W-123-WD).
  - Well development samples should be collected after full recovery of the static water level, if practical. The static water level should be measured before sampling.
  - Note and record water volume produced during development.
- In cases where water was added to the monitoring well during the drilling activities, or air development methods were used, groundwater samples (other than WD samples) should not be collected for at least seven days after the well development activities were completed. Place purge water into an appropriate container for transport to the on-site storage area or for on-site treatment and discharge.
- Waste generated during well development activities shall be handled as outlined in FM-15.1 (Containerization and Removal of Remedial Investigation Derived Waste) and FM-20.1 (Waste Sampling) or as directed in a site specific Waste Management Plan.

6. Records

Details of each well that is developed should be recorded in a standard bound survey-type field book issued for general note taking and on the Well Development Data form (**Attachment C**). Records should include the following items:

- Chain-of-custody forms
- Well development data forms

- Well ID
- Well depth
- Static water level depth and measurement technique
- Sounded well depth
- Presence of immiscible layers and detection/collection method
- Well yield (high or low)
- Purge volume and pumping rate
- Time well purged
- Measured field parameters
- Purge device used
- Well water clarity before and after development
- Field analysis data and method(s)
- Field observations
- Name of person developing the well(s)
- Climatic conditions including air temperature
- Problems encountered and any deviations made from the established protocol

7. Follow-Up Activities

Perform the following once field activities are complete.

- Review Work Plan to ensure all work has been completed and confirm this with Project Coordinator.
- Clean and return equipment to the equipment administrator and sign and date the appropriate form.
- Complete purge water and cleaning fluid disposal requirements per the Work Plan.
- Complete the appropriate forms and data sheets. Send a copy to file, along with any field notes.
- Return site/well keys.

Attachments

Attachment A – Drilling Geologist Equipment Checklist

Attachment B – Well Development Methods

Attachment C – Well Development Data Form

Attachment A – Drilling Geologist Equipment Checklist

Date: **Reference #:**

Instruments			
☐	Water level indicator	☐	Steel measuring tape
☐	300-ft weighted tape	☐	Stopwatch or watch w/ second hand
☐	Air monitoring equipment (PID, FID, etc.)		
Supplies			
☐	Aluminum foil	☐	Core boxes
☐	Disposable Teflon or polyethylene bailers	☐	Cooler with ice
☐	Glass jars w/ preservative as req'd (w/ labels)	☐	Grain-sized sieves
☐	Imhoff cone	☐	Munsell soil/rock color chart
☐	pH paper	☐	String
☐	Teflon tape (4-inch wide)	☐	Paper towels
☐	Zip-lock bags	☐	Trash bags
☐	Plastic spray bottles	☐	Decontamination fluids
			☐ 2-Propanol ☐ Hexane (pesticide-grade)
			☐ Deionized water ☐ Methanol (pesticide-grade)
			☐ Acid rinse for metals ☐ Other
Miscellaneous			
☐	Well cap keys	☐	Spare locks/keys
☐	Toolbox	☐	Knife
☐	Steel spatula	☐	Rock hammer
☐	Buckets and brushes	☐	Camera
☐	Spare batteries	☐	Pen/pencil/permanent marker
☐	Bolt cutters	☐	Reinforced packing tape
☐	On-site transportation (ATV, snowmobile)	☐	Fire extinguisher
☐	GES ID sign for vehicle	☐	Lock deicer (winter)
Documentation			
☐	Document control logbook	☐	Well logs
☐	Notebook/field book	☐	Applicable permits
☐	Previous well logs/historical well data	☐	Site pass/badge
☐	Blank well data and other field forms	☐	Photographic log
☐	Site map		
Personal Protective Equipment			
☐	Safety glasses (or side shields w/ OSHA-approved glasses)	☐	Tyvek: ☐ White ☐ Yellow ☐ Other
☐	Nitrile or latex gloves	☐	Hearing protection
☐	Hard hats/liners	☐	Respirators
☐	Field overboots	☐	First aid kit
☐	HASP checked for other PPE	☐	Safety signage

Completed By: **Date:**

Attachment B – Well Development Methods

1. Well Development Methods

There are various techniques that may be effective in developing wells depending on the hydrogeologic conditions encountered in the aquifer, drilling method used, and well design. Hydrogeologic conditions may be complex and unpredictable; therefore, a single SOP cannot be developed to apply to all possible situations. Rather, the methods discussed briefly below are intended to be used as alternatives or as a series of steps to achieve acceptable well development results. Refer to the site-specific work plan for more information on the scope of work activities for determining the most appropriate method to be used for existing conditions.

1.1 Wire brushing

Running a tight-fitting wire brush up and down the interior of the well casing, screen, and sump serves to remove sediment and debris and clears the screen openings.

1.2 Bailing

In relatively clean, permeable formations where water flows freely into the well, bailing is an effective development technique. The bailer is allowed to fall freely through the monitoring well until it strikes the surface of the water. The contact of the bailer produces a strong outward surge of water. This tends to break up bridging that has developed within the formation. As the bailer fills and before it is rapidly withdrawn, the bailer is to be surged upward and downward a minimum of three feet within the water column for at least three complete cycles. The upward and drawdown effect created in the borehole causes the particulate matter outside the well intake to flow through the well intake and into the well. Subsequent bailing removes the sand and other particulate matter from the well. This is to be repeated throughout the entire screened area of the well and continued until the water is free from suspended particulate matter.

After wire brushing the well interior, the well is bailed to remove sediment and debris. The bailing method is also used as an alternative when the formation or water-producing zone fails to supply water at sufficient rates to sustain development by pumping.

1.3 Mechanical surging

Surge blocks can be used effectively to destroy the bridging of the fine formation particles and to create the agitation that is necessary to develop a monitoring well. A surge block is used alternatively with either a bailer or pump so that material that has been agitated and loosened by the surging action is removed. The surge block assembly must be of sufficient weight to freefall through the water in the well and create a vigorous outward surge. Surging begins at the top of the well intake so that sand or silt loosened by the initial surging action cannot cascade down on top of the surge block and prevent removal of the surge block from the well. Surging is initially gentle, and the energy of the action is increased during the development process. A combination of surging and pumping should continue until the water is free from suspended particulate matter.

1.4 Swabbing

A swab is a mechanical surging device that is pulled upward through the water column in a well. Swabbing may be done with single- or double-swab flanges and with or without water bypass vents. Water may be injected into the well to the formation through the swabbing tool. In this method, water flows into one part of the screen, through the filter pack and adjacent formation, and out in another part of the screen. Swabbing is an aggressive development method that may be suitable if the introduction of water is acceptable. Swabbing is not recommended for wells with plastic casing or screens.

1.5 High-velocity jetting

Jetting, or forcing water through the screen from nozzles on a pipe assembly, can clear screen openings. The jetting method is not always advisable as it forces the fines back into the filter pack and formation, and adds large volumes of water to the system.

1.6 Over-pumping

A simple method of removing fines from a water-bearing formation is by over-pumping. This method involves alternately pumping the well at a rate that will force it to become dry and allowing it to recover. Over-pumping causes an increase in the flow velocity of the water to the well intake and creates a rapid and effective migration of particulates toward the well. The over-pumping method is not always effective, particularly in unconsolidated formations, and may result in a formation that is partially developed.

Where there is no backflow prevention valve (check valve) installed, the pump can be alternately started and stopped. This backwashing produces a surging action in the well and tends to loosen the bridging of the fine particles in the formation. Backwashing can only be performed using dedicated pumps and hoses or those that have been cleaned prior to use at the well being developed. The types of pumps commonly used for well development are BK pumps, Grundfos submersible pumps, Red-jacket submersible pumps, etc.

1.7 Pump development

Pump development is commonly used as the final phase of well development after wire brushing and bailing methods have been performed. A submersible pump and packer assembly, if applicable, is installed and pumping at a sustainable rate is conducted until the water attains acceptable criteria to complete well development.

Attachment C – Well Development Data Form

By:____ Sheet # ________of___________
Well No./Locator:____________________________________ Date:_________________________
Job Name:____ Job Number:_____________________
Development Method(s):____
Depth to Water before Development (ft):___________________ Sounded Depth (ft)________________
Screened Interval:___________ Spec. Depth (ft):____________ Well Diameter (ft):_________________

Time	Depth to Well (ft)	Gallons Pumped	Flow Rate (gpm)	Comments

Well Development Summary			
Depth to water during pumping (ft):		Approx. yield:	
Depth to water after development (ft):		Average pumping rate (gpm):	
Sounded depth after development (ft):		Pumping rate range (gpm):	
Total pumping time (min):		Total H_2O injection (gal):	
Total amount excavated (gal):			

Note: All depths measured in feet below ground surface (bgs)

Standard Operating Procedure

SOP #: FM-7.3 Rev. 002
Review Date: 06/03/2023
Origin Date: 03/01/2016

Title: Packer Testing

1. Purpose/Scope

Hydrogeologic testing (frequently referred to as pump testing) is a common method for determining geologic formation parameters (transmissivity, storativity/specific yield).

Another method of hydrogeologic testing commonly used in bedrock is packer testing, consisting of either pumping tests, where water is removed from the formation, or injection testing where potable water is injected into the formation. This method allows determination of the formation parameters for individual intervals of the formation. Typically, the interval length is approximately 15 feet (4.3 m).

This procedure will be limited to describing the procedure to be used for packer testing only.

The importance of proper and consistent field methods, as well as proper documentation, cannot be over-emphasized.

This standard operating procedure (SOP) shall be used in conjunction with an approved Health and Safety Plan (HASP). Also, consult the HASP for information on the selection and use of Personal Protective Equipment (PPE).

2. References

Heath, Ralph C., *Basic Ground-Water Hydrology*, U.S. Geological Survey Water-Supply Paper 2220, 1983. (Excellent basic summary of testing objectives and analysis methods)

Driscoll, Fletcher D., *Groundwater and Wells, Second Edition*, Johnson Filtration Systems, Inc., 1986.

D4043-17 Standard Guide for Selection of Aquifer-Test Method in Determining of Hydraulic Properties by Well Techniques, 2017

Kruseman, G.P. and deRidder, N.A., *Analysis and Evaluation of Pumping Test Data, Second Revised Edition*, International Institute for Land Reclamation and Improvement, June 1990.

Fetter, C.W., *Applied Hydrogeology, 4th Edition.* Macmillan Publishing Company, Fifth Edition, January 11, 2022.

3. Responsibilities

3.1 Project Manager

The project manager's (PM) responsibility is to ensure that all activities performed by GES personnel are performed safely, comply with all pertinent regulations and procedures, and have the necessary equipment and resources to accomplish the tasks describe in this procedure.

3.2 Field Operator

The designated operator of this and all other field equipment must understand the operating parameters, limitations, and safety concerns of the equipment he/she intends to operate before attempting to use in the field. The field operator is solely responsible for the proper calibration, operation, and care of the unit.

4. General

4.1 Packer-Pumping vs. Injection Testing

4.1.1 Packer Pumping

Advantages of the packer pumping test include that it provides an indication of the water-bearing capacity of the interval being tested and that, after the test, groundwater can be submitted for chemical analysis without additional purging of the formation as required for injection tests. Disadvantages include the handling/disposal of significant volumes of potentially contaminated groundwater (see also SOP 7.1 for additional details regarding pumping tests). A typical packer pumping test is performed for one hour.

4.1.2 Injection Test

Advantages of the injection test are that it does not require the disposal of large quantities of water that may be produced by a pumping test. Typically only the injection well is monitored, and it is usually completed in a shorter time period than the pumping test described in SOP 7.1. This is of special importance when testing a potentially contaminated formation. A typical injection test consists of injecting water at four to five different pressures or flow rates for a total duration of approximately one hour. A disadvantage of the injection test is that while providing a good estimate of the formation's hydraulic conductivity, it may not provide a good indication of its water-bearing capacity (i.e., how much water is obtainable). Other potential disadvantages include the following:

- After injection testing, an extended time period (generally about one month), is required to allow the groundwater in the well to return to pre injection conditions prior to sample collection.
- More purging may be required to achieve stabilization prior to sample collection.
- A sufficient source of potable water is required.
- The injection test may force contaminants from the site to areas not previously impacted.

Due to the cost of performing hydrogeologic tests, especially of contaminated formations, the specifics of each testing program are usually defined in a site-specific Work Plan. However, this SOP may be used as a guide for the performance of packer tests. Full details of the packer testing program for any site should be provided by the project coordinator prior to implementation of field activities.

5. Equipment/Materials

Typical devices are as follows:

- Calibrated electronic water level indicators (e.g., Solinst or ORS interface probe)
- Pressure transducers (In-Situ Inc. miniTrolls or similar)
- Portable control device for transducer (e.g., pocket-situ kit or laptop computer)
- Submersible pump (electric or pneumatic depending upon anticipated well yield and site power supply)
- In-line fluid totalizer meter
- Down-well piping, discharge tubing or hose and appropriate valve and fittings
- Water sample collection materials, flow-through cell and multi-meter
- Water storage tank and/or on-site water treatment equipment
- Field data sheets

The pressure transducers, associated portable control devices or computer software have manuals which describe their use. This procedure will provide an overview of this equipment use and data recording options.

6. Preparation

6.1 Prior Planning and Preparation

The following shall be considered prior to conducting a packer test.

- Review the Work Plan and HASP with the project coordinator.
- Assemble all equipment and supplies per the Aquifer Slug Testing SOP 7.2). Ensure that the pumps are adequate to perform the tests (i.e., flow and hydraulic head requirements) and that the psi range of the pressure transducers is sufficient.
- Obtain information on each pumping or injection well and monitoring well, if any, to be included in the test. Information shall consist of inside diameter of the well screen and casing, borehole diameter, depth of well, static water level, and the length and depth setting of the screen.
- Arrange access to the site. Assemble well keys and site keys. Also consider site conditions (i.e., is snow removal required? Is it muddy or overgrown?)
- Establish groundwater and spent decontamination fluid handling and disposal methods before testing activities start. Do not mix groundwater and decontamination fluids. Also, it may be beneficial to keep extracted groundwater from each interval from each pumped well separate because of varying treatment requirements depending on chemical characteristics.
- Pre plan the testing sequence to insure “clean” wells are tested before “dirty” wells to reduce the potential for cross contamination.
- Determine testing notification requirements with the project coordinator. Have the client, landowner, and appropriate regulatory agencies been notified?
- Determine if local conditions may cause water level changes in the formation (e.g., tidal fluctuations, water supply wells, controlled rivers or lakes) and arrange to collect data to determine the effect of these potential sources of fluctuation. In addition, fluctuations in barometric pressure and rainfall events can affect groundwater levels. Therefore meteorological data from the closest meteorological station (e.g., airport) must be obtained. In addition, any local lakes, ponds, rivers, and lagoons must be monitored.
- If NAPL has been observed or is suspected to be present at the pumping or injection well, no pumping or injection test should be performed for the intervals where NAPL was observed unless required by the site specific Work Plan. The project coordinator must be notified of the NAPL presence before testing. If it is decided to test an interval with NAPL, consider the following:

- Potential adverse effect of NAPL on the pump, packer, transducer, electrical cable, discharge or injection line, and all other downhole components of the packer-pumping or injection assembly.
- For packer-pumping test, separate NAPL from the pumped water to assist with proper disposal of the pumped fluid.

These considerations should have been incorporated during development of the site-specific Work Plan and should be discussed with the project coordinator.

Note: Make sure packer does not straddle the overburden casing/top of bedrock to prevent potential damage to the packer.

7. Procedure

7.1 Packer-Pumping Tests

Packer pumping tests are usually performed in bedrock formations to find the appropriate interval to be monitored by estimating the hydraulic conductivity and groundwater chemical characteristics of the bedrock formation in preselected lengths (typically 15 feet). The packer pumping test assembly includes a test pump and a sample collection pump. Because of the pump size, the borehole is typically of larger diameter than that needed for an injection test. Each test interval should extend a small distance (□0.2 feet) into the previous interval to provide small overlap, thereby ensuring that no segments of the formation are missed. To prevent the carry-down of chemicals from overlying formations, the borehole is typically cored, tested, sampled, and grouted (if required) for each preselected interval length before continuing to the next interval.

7.1.1 Discharge Rate Measurement

Procedures regarding discharge rate measurement are described in SOP 7.1. These procedures, with the following modifications, are applicable to packer pumping tests. The modification is because the packer pumping test is typically performed for one hour and discharge rate measurements need to be obtained every five minutes.

7.1.2 Checking Pressure Transducer Operation

The next step is to check the operation of the pressure transducer. This is accomplished by measuring the static water level and then inserting the packer pumping test assembly to the bottom of the drilled hole. The pressure recorded by the pressure transducer is then checked prior to inflation of the packer with the theoretical water pressure due to the column of water above the pressure transducer. (Note: 1 foot of water = 0.433 psi.)

If the observed and theoretical values do not correspond, it is still possible to use the packer pumping test assembly if the pressure transducer monitors pressure changes correctly. This is easily checked by raising the assembly and checking the change in observed pressure (i.e., raising the assembly 10 feet would correspond to a pressure decrease of 4.33 psi).

If the pressure transducers do not perform either of the above correctly, check the connections and/or calibration or replace the faulty transducer.

7.1.3 Packer Inflation Pressure

The packer must be inflated sufficiently to prevent the bypass flow of formation water from the areas of the formation not being tested to the tested interval.

GES' standard practice is to inflate the packers to ±30 psi above the greater of either the static water column above the top packer or the manufacturer's maximum prescribed injection pressure. Make sure that the packer is not inflated beyond its design capacity. To determine if water from the formation is bypassing the packers, water level measurements above the top packer can be obtained.

7.1.4 Pumping/Sampling of Groundwater

The pumping rate should be controlled as constant, steady flow.

The procedure for pumping water is as follows:

- Determine maximum allowable drawdown to prevent damage to pumping test pump (e.g., some pumps require a minimum depth of water above the pump intake to prevent pump damage).
- Start pumping the water slowly and increase to the pumping rate until either the maximum pumping rate of the equipment has been achieved (typically about □20 gpm) or the allowable drawdown has been achieved, whichever is the lesser.
- Once the pumping rate has stabilized, continue pumping for one hour, recording the data for each five minute interval on the field notebook. This provides backup in case the pressure transducer/data logger system fails.
- Perform a recovery test after deactivating the pump and collect data similar to that under pumping conditions.
- After the pumping/recovery test is complete, collect groundwater samples, as specified in the Work Plan, using the sample collection pump.
- Deflate the packer and remove the assembly.

- If specified in the site specific Work Plan, grout the borehole and wait the specified number of hours for the grout to set (typically overnight) before continuing to the next interval.
- Drill the next interval and repeat the above procedures until all bedrock intervals to be tested have been tested.

7.2 Injection Tests

Injection testing is generally performed in bedrock formations to select the appropriate interval to be monitored by estimating the hydraulic conductivity of the bedrock formation in preselected intervals (typically 15 feet) in an NX (3-inch diameter) borehole. The distance between the top of the bottom packer and the bottom of the top packer will be this preselected length. Each test interval should extend a small distance (±0.2 feet) into the previous interval to provide a small overlap, thereby insuring that no segments of the formation are missed. For ease of testing where multiple bedrock monitors are to be installed, the deepest bedrock well is cored in its entirety and then tested from the bottom up. The attached Injection Test Preparation Form identifies the calculations required prior to starting the test. These calculations need to be performed for each interval to be tested.

7.2.1 Maximum Allowable Injection Pressure Determination

Prior to performing the injection test, the maximum allowable pressure to prevent hydrofracturing of the formation must be determined. One method of calculating the maximum pressure is to make certain that it will not exceed 0.7 psi per foot of overlying overburden and bedrock as measured from the ground surface to the top of the interval to be tested. Another method is to use 1.0 psi for each foot of unsaturated formation plus 0.57 psi for each foot of saturated formation. If the groundwater table is close to ground surface and the borehole is relatively deep, the second method provides a more conservative (safer) value. Do not exceed the calculated hydrofracture pressure during the test.

7.2.2 Checking of Pressure Transducer Operation

The procedures for checking the pressure transducer operation are described in manufacturer's equipment manual and are applicable to injection testing.

7.2.3 Determining Injection Pressure/Flow Rate Steps

Typically, an injection test consists of injecting potable water into the formation in four to five steps, up to either the maximum allowable injection pressure or the maximum flow rate obtainable from the pump (typically ±20 gpm). The decision to use either the calculated pressure steps or the flow rate steps (e.g., 4, 8, 12, 16, and 20 gpm) will depend on the formation characteristics. Typically, the calculated pressure steps will be used for a low permeable formation (i.e., the formation cannot accept the specified injection rate for that test without exceeding the calculated hydrofracturing pressure for that step), while the specified injection rate will be used for a highly permeable formation (i.e., the formation can readily accept the injected water). The pressure steps are calculated using the following equation:

$$Pi = P_0 + I \times P_\Delta$$

Where:

P_0	= static borehole pressure with the packer(s) inflated (psi)
i	= the value of the step (i = 1, 2, 3, 4, or 5)
P_Δ	= Hydrofracturing Pressure ÷ 5 (for a 5 step test)

7.2.4 Packer Inflation Pressure

The procedures to determine packer inflation pressure are described in the manufacturer's manual and are applicable to injection testing with the following modifications:

- In addition to preventing the bypass of formation water from areas of the formation not being tested, the packers must also stop the bypass flow of injected water from the tested interval to the areas not being tested.
- To determine if water from the injection test is bypassing the packers, a pressure transducer below the bottom packer can be used and water level measurement above the top packer can be obtained.

7.2.5 Water Injection

The injection rate should be controlled by a gate valve in the injection line and measured using an in-line flow meter. For the first (bottom) interval, the bottom packer is not inflated to allow testing of that portion of the formation.

The procedure for water injection is as follows:

- Start injecting the water slowly up to either the prescribed pressure or flow rate value for the first step, whichever is achieved first.
- Once the pressure or flow rate has stabilized, continue water injection for 10 minutes, recording the data for each minute on the field note book. This provides backup if the pressure transducer/data logger system fails.

- Increase the flow rate until either the calculated pressure or flow rate for the second step is achieved.
- Repeat the above procedure until all five pressure/flow rate steps for the first interval have been completed.
- Deflate the packer(s), raise the packer/injection assembly by the selected test interval length for the next formation interval.

7.3 Pressure Drop Test

In low-permeable formations, in lieu of an injection test, a pressure drop test, sometimes called a pressure duration or pressure holding test, can be conducted. Preparation for and performance of the test are similar to an injection test (maximum pressure calculation, etc.) except for the following:

- In the pressure drop test, the test is usually done in one step by pressurizing the test section to a specified value that usually approaches the hydrofracture pressure
- Stopping the water supply
- Observing the rate of the pressure drop

8. Disposal of Contaminated Materials

All materials and equipment used for decontamination must be disposed of properly as outlined in the Sampling and Analysis Plan (SAP). Clothing (PPE), tools, buckets, brushes, and all other equipment that cannot be reused will be disposed of as discussed in the SAP.

9. Records

9.1 Field Notes

Record field notes in a standard bound survey-type field book issued for general note taking/field records and available from all GES equipment administrators. Make all field book entries black ink and make any changes/corrections with a single strikethrough line. Initial and date to indicate who made the change/ correction and when it was made.

10. Follow-Up Activities

Perform the following at the completion of packer testing field activities:

- If pumped groundwater is contained, collect appropriate samples to determine treatment/disposal option.
- Download all transducers and prepare data files. Check transducer recorded water levels with manual levels to confirm results.
- Clean and return the equipment to the equipment administrator and sign and date the appropriate form. Note any equipment which requires maintenance or service.
- Notify the contract laboratory of the test water samples.
- Complete purge water and cleaning fluid disposal requirements per the Work Plan.
- Complete the appropriate forms and data sheets. Send a copy to file, along with any field notes.
- Return site/well keys.

Attachments

Attachment A – Injection Test Preparation Form

Injection Test Preparation Form

Project Name:	______	Project Number:	______
Well Number:	______	Date:	______
Transducer Number:	______	Offset:	Sensitivity:
Interval to be Tested:	______ to ______ ft. bgs		
Depth to Transducer:	______ ft. bgs		
Initial Water Level (packers not inflated):	______ ft. bgs		

Initial Transducer Reading (packers not inflated): ______ psi (actual)

Water Column above Transducer: ____ft. x 0.433 = ______ psi (calc)

If psi (calc) • psi (actual), raid transducer 10 ft.

Observed change in transducer reading = psi

If observed change = 4.33 ± psi, continue test. If not, check transducer connections/calibration or replace transducer.

Initial Transducer Reading (packers inflated) = psi(P_o)

Hydrofracture Pressure Calculation (use minimum of a or b):

a) Top of Ground to Overburden or Bedrock Groundwater Table (whichever is higher)

= ______ ft. x 1.0 = ______ psi (P_a)

Groundwater Table to Bottom of Top Packer

= ______ ft. x 0.57 = ______ psi (P_b)

$P_a + P_b$ = ______ psi (P_T)

b) Top of Ground to Bottom of Top Packer

= ______ ft. x 0.7 = ______ psi (P_T)

$P\Delta = P_T \min \div 5$ = ______ psi

Calculated Pressure Steps

$P1 = P_0 + P_\Delta$ = ______ psi

$P2 = P_1 + P_\Delta$ = ______ psi

$P3 = P_2 + P_\Delta$ = ______ psi

$P4 = P_3 + P_\Delta$ = ______ psi

$P5 = P_4 + P_\Delta$ = ______ psi

GES Supervisor:	Time:

Standard Operating Procedure

SOP #:	FM-8.1 Rev. 004
Review Date:	06/03/2023
Origin Date:	03/01/2016

Title: Liquid Level Gauging

1. Purpose/Scope

This SOP describes procedures for collecting groundwater and Light and Dense Non-Aqueous Phase Liquid (LNAPL and DNAPL) level measurements in wells. Down-hole liquid level readings can be collected by using an oil/water interface probe, such as Solinst or Heron.

2. References

Solinst Model 122 Interface Meter Operating Instructions.

3. Equipment/Materials

The following equipment and materials are needed to comply with this SOP:

- Oil/water interface probe (e.g., Solinst) with the ability to detect light and dense non-aqueous phase liquids, LNAPL and DNAPL, respectively, and a minimum precision of +/-0.01 foot
- Clear bailer
- Field book, field form, or other approved method of water level documentation
- Records of previous water level readings and analytical data for site, if available
- Modified Level D personal protective Equipment (PPE) or as directed in task Job Loss Analysis (JLA)
- Decontamination materials

Refer to equipment manuals for general maintenance and/or troubleshooting.

4. Preparation

- Obtain a copy of previous water levels from the project manager and the appropriate field data collection form, as applicable, from the field work directive (FWD).
- Check the electronics and battery condition by pushing the 'Start' button. A brief tone and/or light indicate the meter is functional. Follow the equipment manual guidance for brand-specific tone and light indications.
- Inspect probe, probe connection to measuring tape, and optical tip.
- Transport the probe in manufacturer's bag or other suitable transport device to protect the equipment and to keep it clean.

5. Procedure

5.1 Water-Level Measurement Procedure

Liquid level measurements should follow a logical order from the least known or suspected level of contamination to the greatest. This will minimize the potential for cross-contamination between wells/monitoring locations.

1. Don the appropriate PPE per the JLA.
2. Confirm the well location on the Site Map.
3. Turn on the interface meter (e.g., pushing the “START” button) and make sure it indicates it is on through a light or tone.
4. Open the well cap.
5. If there is a potentially hazardous atmosphere, measure the breathing space above the well casing with a photoionization detector (PID) or other applicable meter to ensure safe conditions.
6. Inspect well casing for a measurement reference point (see Reference Point guidance below).
7. If being used in a potentially explosive environment, connect the grounding clip on the meter to the metal well casing or other suitable grounding point.
8. Insert the probe into the well casing.
9. Slowly lower the probe until the meter makes a steady beep with a flashing or solid indicator light. Slowly retrieve the probe until the unit stops beeping and the indicator light stops.
10. Slowly lower the probe again and immediately stop when the meter maintains a steady beep. When using an interface probe, a solid tone and light indicates product (LNAPL or DNAPL) and an alternating beep and blinking light indicates water.
    Note: For floating product (LNAPL), take the air/product interface measurement on the way into the liquid, and the water/product interface on the way up. For sinking product (DNAPL), take the water/product interface on the way down.
11. Read the tape measurement and document the readings in a field book and/or on the designated field form.
12. If depth to bottom readings are needed, continue to slowly lower the probe until the tape slackens, indicating it has reached the bottom. Slowly lift the probe up and down until the depth of impact with the bottom of the well can be determined. Record the depth in field book or on the designated form.
13. Retract the probe and decontaminate the probe (see Equipment Decontamination section below). Decontaminate the equipment after each measurement is complete.
14. Replace the well cap and lock it.
15. Repeat steps 1 through 14 at the remaining monitoring locations.
16. If NAPL is detected where it was not previously, or other unexpected or unusual findings are detected, lower a clear bailer into the well (do not fully submerge), remove the bailer, and conduct a visual inspection of the bailer and liquids for confirmation.

17. Call the Project Manager to report/discuss any unexpected findings.

5.2 Reference Point Determination

Use the reference point as imprinted on the top of the well casing as the measuring reference point. If a reference point is not present, the north side of the well casing will be used as the reference point and marked on the well casing in a manner that can be referred to during future monitoring events (e.g., notch piping with file or write with permanent marker). This will be the Point of Measure (POM) to be used when obtaining water-level measurements. Any deviation from this measuring point must be documented in the field notes and reported to the project lead.

5.3 Equipment decontamination

The water level indicator must be decontaminated after each measurement in accordance to the Work Plan requirements and manufacturers guidance. In general, wash the probe and any part of the measuring tape that came in contact with groundwater using warm water and a non-abrasive mild detergent. Rinse the probe with distilled water and wipe dry. Refer to FM SOP-14.1 for additional decontamination guidance.

After cleaning the probe, it should be placed back into the travel bag or transported to the next location in a way that will eliminate cross contamination.

Title: Passive Groundwater Sample Acquisition

1. Purpose/Scope

The objective of most groundwater quality monitoring programs is to obtain samples that are representative of existing groundwater conditions, or samples that retain the physical and chemical properties of the groundwater within an aquifer. Three common forms of passive (no purge) samplers are:

- Thief (grab) samplers (e.g., HydraSleeve™, Snap Sampler®)
- Discrete interval sampler, Pneumo-Bailer™, Kemmerer well sampler)
- Diffusion (equilibrium) samplers (e.g., passive diffusion bag sampler, dialysis sampler, rigid porous polyethylene sampler) and
- Integrating (kinetic) samplers (e.g., Enviroflux Passive Flux Meter, Chemcatcher®, Gore® Module, Semi-Permeable membrane device)

2. References

For additional information pertaining to groundwater sampling activities, the user of this manual may reference the following:

ASTM D2929-20: Guide for Selection of Passive Techniques for Sampling Groundwater Monitoring Wells, 2020

ASTM D5474-93: Guide for Selection of Data Elements for Groundwater Investigations, 2012

ASTM D5979-2019e1: Guide for Conceptualization and Characterization of Groundwater Systems, 2019

ASTM D5903-96: Guide for Planning and Preparing for a Groundwater Sampling Event, 2023

ASTM D4448-01: Standard Guide for Sampling Groundwater Wells, 2019

GES SOP FM 8.1: Liquid Level Gauging

GES SOP FM 13.2: Sample Preservation and Handling

GES SOP FM 13.3: Sample Identification and Labeling

GES SOP FM 13.4: Chain-of-Custody Procedures

GES SOP FM 13.5: Sample Management, Packaging, and Shipping

GES SOP FM 15.1: Containerization and Removal of Remedial Investigation Derived Waste

Passive (no purge) Samplers - CLU-IN June 4, 2020

USGS (2020: Passive Sampling of Groundwater Wells for Determination of Water Chemistry

Manufactures instructions for the selected passive sampler

2. Equipment/Materials

A number of devices exist to collect groundwater level data, and equipment will vary if "Passive" samplers are used. Equipment must be discussed with the Project Manager (PM) or detailed in the field work directive (FWD).

- Water interface probe
- Specific conductance/temperature/pH meter
- Decontamination materials
- Plastic sheeting/towels/garbage bags
- Transportable, purged water storage container
- Well construction details
- Photoionization detector (PID)
- Replacement passive sampler (if a sample is needed for the next periodic sampling event)
- Field book
- Indelible ink pen
- Proper personal protective equipment (PPE) per site-specific Health and Safety Plan (HASP)

3. Preparation

- Review the FWD, project documents, Job Loss Analyses (JLAs), and the health and safety requirements with the PM or Case Manager (CM). This procedure requires a two-step process, first deployment and then retrieval of the passive samplers at a later date. Once periodic sampling is established passive sampler retrieval and deployment can occur on the same day.
- Assemble required in-house equipment and supplies.

- Assemble site plan, well logs, and previous sampling data that will be required for the planned sample event.
- Determine the exact number and locations of the wells to be sampled.
- Contact the selected laboratory to arrange the following:
  - Glassware
  - Preservatives
  - Filtration information
  - Coolers
  - Shipping details
  - Starting date
  - Expected duration
- If several sampling events are planned, discuss the use of well-specific, dedicated equipment with the PM or CM to reduce the chances of cross-contamination and to minimize decontamination requirements.
- Verify with the PM/CM the regulator, client personnel, landowner, GES personnel, and laboratory have been notified of pending sample event.
- Arrange access to the site, assemble well keys and site keys, and consider site conditions (e.g., is snow removal required?).
- Evaluate groundwater and spent fluid disposal requirements before sampling activities start.
- Pre-plan sampling sequence to ensure that cleaner wells are sampled before contaminated wells to reduce potential cross-contamination.

4. Procedure

4.1 Field Procedures

- Make sure the well to be sampled is not impacted by vehicle or generator fumes. Place new plastic sheeting on the ground around the well casing to prevent contamination of the sampling equipment in case they need to be placed on the ground during purging/sampling.
- Confirm that the well to be sampled has been correctly located and identified.
- Determine proper well locations by comparing the well log details to measured well details (i.e., total well depth, casing diameter, casing stick-up or stick-down distances).

- Inspect the well and determine if it is suitable for sampling and record the results in the sampling field book.
- Record the results of the well inspection and note any repairs the well may require.
- Prior to opening the well cap, measure the breathing space above the well casing with a PID to establish baseline levels.
- Repeat breathing space measurement once the well cap is opened.
- Use appropriate PPE if either of these measurements exceed any of the air quality criteria established in the HASP.
- Open the well cap and obtain a PID measurement from inside the riser pipe.
- Prior to commencing the groundwater sampling tasks, measure the depth to water in the well from the mark off top of the casing.
- If deploying the selected passive sampling device (diffusion, grab or kinetic) follow the procedure as outlined below and in the manufacturer's instructions.
- If retrieving the passive sampling device follow the procedure below and the manufacturer's directions for device removal and sample retrieval.
- After removal of the device measure the depth to bottom of the well and note any significant differences to the original, logged depth of the well (this might indicate the presence of excess sediment or drill cuttings filling in the well). Compare the total depth measurements to the original total well depth. Notify the PM or CM of any monitor wells with significant differences.

Diffusion Samplers

- Diffusion sampler deployment
  - **Important:** Read the manufacturer's instructions in order to understand the operation of the diffusion sampler.
  - Working with the selected laboratory, determine the amount of sample volume needed based on the analytes being collected. Some diffusion samplers have limitations as to the analytes that can be collected (e.g., metals cannot permeate the membrane of some diffusion samplers).
  - Based on this volume determine the number of diffusion samplers deployed in each well. Multiple diffusion samplers can be placed in each well.
  - Determine the depth at which the diffusion sampler(s) will be deployed. In some cases, diffusion samplers can be placed at different well elevations.
  - Deploy the diffusion sampler
  - Determine the time that period of time that the diffusion samplers will remain in the well before retrieval. A minimum of 14 days is recommended. Typically, diffusion samplers

are left in a well for quarterly monitoring. However, diffusion samplers can remain in the well up to one year. If a well is prone to biofouling, the deployment duration may need to be minimized (e.g., 14 days versus deploying during the previous quarterly sampling event).

- Diffusion Sampler Retrieval
  - Following the determined monitoring schedule remove the diffusion sampler from the well.
  - Collect the sample by filling the laboratory-supplied bottleware by discharging the groundwater directly into the appropriate sample container.
  - Avoid handling the interior of the bottle or bottle cap.
  - Wear new gloves (e.g., disposable latex or latex-type) for each well sampled.
  - Do not place bottle caps on the ground or in a pocket.
  - Label, managed and package samples per FM-13.2, FM-13.3, FM-13.4, and FM-13.5.

Grab Samplers

- Grab sampler deployment
  - **Important:** Read the manufacturer's instructions in order to understand the operation of the grab sample device.
  - Working with the selected laboratory determine the amount of sample volume needed based on the analytes being collected. Grab samples are typically not restricted to certain analytes. Based on this volume determine the number of grab samplers deployed in each well. Multiple grab samplers can be placed in each well.
  - Determine the depth at which the grab sampler(s) will be deployed. In some cases, grab samplers can be placed at different well elevations.
  - Depending on the grab sampler determine the time that period of time that the grab samplers will remain in the well before retrieval. For some a minimum of 7-14 days is recommended before the well returns to equilibrium. Some grab samplers can be left in a well for a quarter, semi-annually or even annual sampling. If a well is prone to biofouling, the deployment duration may need to be minimized (e.g., 14 days versus deploying during the previous quarterly sampling event).
- Grab sampler retrieval
  - If required trigger the sampler to seal the sample bottles contained in the sampler. Remove the grab sampler from the well.
  - Label, managed and package samples per FM-13.2, FM-13.3, FM-13.4, and FM-13.5.

Integrating (Kinetic) Samplers

- Kinetic sampler deployment
  - **<u>Important</u>: Read** the manufacturer's instructions in order to understand the operation of the kinetic sampling device.
  - Working with the laboratory determine the contaminants of concern (hydrophobic organic compounds, organic or inorganic ions, etc.) by selecting appropriate sorbents or sampling device.
  - Determine the depth at which the will be deployed. In some cases, kinetic samplers can be placed at different well elevations.
  - Kinetic sampler retrieval
  - After a specified period of exposure to groundwater flow (usually one to four weeks), the kinetic sampler is removed from the well.
  - Label, managed and package samples per the laboratory's instructions and FM-13.2, FM-13.3, FM-13.4, and FM-13.5 as appropriate.

Sample Collection

If required per passive sampler instructions, collect and containerize in the following order of volatilization sensitivity as appropriate per passive sampler instructions

1. Volatile organic compounds (VOCs) – NO air bubbles in the bottle
2. Semi-volatile organic compounds (SVOCs)
3. Per- and polyfluoroalkyl substances (PFAS)
4. Total organic carbon
5. Total organic halogens
6. Extractable organics
7. Total metals
8. Dissolved metals
9. Phenols
10. Cyanide
11. Sulfate and chloride
12. Nitrate and ammonia
13. Radionuclide

4.2 Waste Fluid Disposal

Dispose of sampling wastes that were generated per FM-15.1.

4.3 Reinstall Passive Sampler

If periodic sampling is continuing reinstall a new passive sampler per manufactures and FWD instructions.

5. Records

Record field notes in a standard bound survey-type field book issued for general note taking/field records. Make all field book entries black ink and make any changes/corrections with a single strikethrough line. Initial and date to indicate who made the change/correction and when it was made.

The logbook should document the following for each well sampled:

- Well ID
- Well depth
- Static water level depth and measurement technique
- Sounded well depth
- Presence of immiscible layers and detection/collection method
- Measured field parameters
- Sampling device used
- Well sampling sequence
- Sample appearance
- Sample odors (if respiratory protection is not required)
- Sample volume
- Types of sample containers and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data and method(s)
- Sample distribution and transporter
- Laboratory performing analysis
- Chain-of-custody number
- Field observations on sampling event

- Name of collector(s)
- Climatic conditions including air temperature
- Problems encountered and any deviations made from the established sampling protocol.

6. Follow-Up Activities

Perform the following once field activities are complete.

- Review the FWD to ensure all samples have been collected and confirm this with PM or CM.
- Clean and return equipment to storage.
- Complete purge water and cleaning fluid disposal requirements per the FWD.
- Notify the contract laboratory as to when to expect the samples. Enclose the chain of custody and covering letter, indicating the parameters and number of samples, in the sample cooler.
- Complete the appropriate forms and data sheets. Send a copy to file, along with any field notes.

Standard Operating Procedure

SOP #: FM-9.1 Rev. 003
Review Date: 06/27/2023
Origin Date: 03/01/2016

Title: Soil Sampling for Analysis

1. Purpose/Scope

This standard operating procedure (SOP) describes procedures to obtain representative soil samples for analysis. Subsurface soil samples are usually “grab” samples, used to characterize the soil at a specific depth or depth interval (e.g., 2–4 feet). On occasion, composite samples are collected from a borehole or other locations such as stockpiled soils.

2. References

ASTM D1586/ D1586M-18e1: Standard Test Method for Standard Penetration Test (SPT) and Split Barrel Sampling of Soils, 2022.

ASTM D4220/D4220M-14: Standard Practices for Preserving and Transporting Soil Samples. 2023.

ASTM D4700-15: Standard Guide for Soil Sampling from the Vadose Zone. 2016.

ASTM D5434-12: Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock. 2021.

3. Equipment/Materials

- Stainless steel utensils (e.g., spatulas, spoons, bowl, self-retracting utility knives)
- Chain-of-custody form(s)
- Shipping cooler(s)
- Aluminum foil
- Ice
- Photoionization detector (PID) or flame ionization detector (FID)
- Glassware/sample jars/Ziplock bags/specialty sampling equipment (e.g., En core, Terra Core)
- Putty knife/trowel
- Personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Labels
- Indelible black ink pen

- Field notebook
- De-ionized water or distilled water and rinse water storage containers w/brushes
- Liquinox

4. Procedure

4.1 Collection of Soil Samples for Chemical Laboratory Analysis

1. Review sampling plan to determine the number and location of samples to be collected.
2. Wear PPE as required within the site-specific HASP.
3. Ensure a sufficient number of sample kits are available to collect the required number of samples and the kits are for the required analyses.
4. Collect soil samples immediately after scanning the core run with a PID or FID.
5. When collecting soil samples, remove rocks and biologic material from the sample interval.
6. Collect soil samples as stated within the field work directive (FWD) or as approved by the Project Manager (PM) when conditions dictate a variance from the FWD.
7. Label bottleware appropriately with date, analysis, time, sample ID (depth if applicable) and sampler, as well as any other necessary information. Reference SOP's FM-13.4 and 13.5.
8. Following collection of soil samples within laboratory supplied bottleware, place into a cooler on ice and maintain at 4°C.
9. After the sample has been placed into a cooler note a detailed description of the lithology of the sample as well as any other physical or sensory features such as the presence of non-aqueous phase liquids (NAPL) and PID readings.
10. If NAPL is present, describe the following:
    - Porosity of soil
    - Visual Description of NAPL
    - Volume of Soil Pore Space Containing NAPL
        - Saturated >0.5%
        - Some 0.5 - 0.25%
        - Trace <0.25%

A complete description of NAPL must include the following:

- Color
- Density (compared to water—e.g., light/floats or heavy/sinks)
- Odor (if observed)

- Viscosity (e.g., mobile/flowable, non-mobile/highly viscous-tar like)

The presence of an iridescent sheen by itself does not constitute NAPL presence, but may indicate NAPL presence in the vicinity.

Representative portions of the soil sample may need to be retained for geologic record following description. If required, place the soil portions into labeled, sealable clean sample containers (usually mason jars) without destroying any apparent stratification.

4.2 Chemical Sample Preparation and Packaging

The following describes the collection of grab samples for chemical analysis (all soil from one split spoon).

4.2.1 Clayey Soils

1. Discard upper and lower ends of sample core (±3 inches)
2. Use a pre-cleaned stainless steel putty knife or spatula
3. Cut the remaining core longitudinally
4. With a sample spoon remove soil from the center portion of the core and place in a pre-cleaned stainless steel bowl
5. Remove large stones and natural vegetation debris
6. For samples to be submitted for volatile organce compounds (VOC) analysis, collect soil from the length of the center portion of the core and place in the sample container until it is completed filled. For other analysis (e.g., metals), homogenize the soil and place directly into the sample jars

4.2.2 Sandy Soils

Since sandy soils have less cohesion than clayey soils, it is not easy to cut the core longitudinally to remove the center of the sample. Therefore, scrape away surface soils that have likely contacted the sampler with a stainless steel spoon, and then sample the center portion of the soil core. Immediately place all soil samples collected for chemical analysis in a cooler with ice.

All soil samples shall be recorded in the sample log book and labeled according to SOPs FM-13.4 and 13.5.

EPA adopted methods for sampling soils for VOC analysis. Method 5035 calls for collecting soil using a coring device (refer to SOP FM-9.3). For analysis of low level VOCs (typically 1 to 200 µg/kg), soil is sealed in a specially prepared vial with a solution of sodium bisulfate. For higher levels of VOCs, the soil is placed in a vial with a volume of methanol. This method increases the complexity of collecting soils and makes it imperative that the sampler and laboratory work closely together.

4.3 Geotechnical/Hydrogeologic Sample Preparation and Packaging

When a sample is collected for geotechnical or hydrogeologic properties, the sample needs to be prepared and packaged in a manner to maintain its physical properties. The following describes the collection of grab samples for geotechnical or hydrogeologic purposes for two common samplers, the split spoon and the thin wall samplers (Shelby Tube).

4.3.1 Split Spoon Sample

Following completion of PID screening, remove and dispose of soil at the top of the sample that is visibly sloughed material not representative of the soil at the sampled depth. Measure the length of the sample and record as the recovered length. If cohesive, perform pocket penetrometer reading. Carefully transfer sample onto a sheet of aluminum foil, taking care to maintain structure and bedding of the sample as much as possible. This may not be possible with non cohesive soils with low silt or clay contents. The sample may need to be packaged in three 6 to 8 inch segments. Roll the sample in the aluminum foil and fold over the ends to seal. Wrap in a second layer of foil. Identify the top, middle, and bottom segments with a T, M, and B using an indelible marker. For each segment, record the “up” direction with an arrow. Place the foil-wrapped sample in a plastic bag and write the sample identification on the bag using an indelible marker. Storing the sample in foil, as opposed to a jar, has the advantage of retaining the soil's in place structure and prevents loss of moisture. If the soils are sandy and it is not possible to retain the soils structure by rolling it in foil, packaging the sample in a jar is also acceptable, provided the jar is filled to eliminate air space, which could result in the soil drying out.

4.3.2 Shelby Tube Sample

Remove visibly sloughed material from the top of the sample using a putty knife, trowel, or similar long-bladed instrument. If it is not possible to distinguish sloughed soil from intact soil, do not remove. Following removal of sloughed material, measure the tube length and the air space in the tube above the sample and record the difference as the sample recovery. In the unusual circumstance that there is also air space at the bottom of the sample, subtract this as well and record this latter measurement as a separate entry.

Seal the top and bottom of the sample with wax (wax is normally provided and prepared by the driller). First, pour the liquefied wax into the top of the sample to a thickness of about 1 inch and let cool sufficiently. Next, remove approximately 1/2 inch of soil from bottom of sample (unless there is already a cavity at bottom of sample) and seal similarly.

Fill the remaining air space above the sample with loose soil to prevent the sample from shifting in the tube, and then close both ends of the sample with plastic caps. Tape the caps using duct tape, then write the sample identification number on the cap using an indelible marker.

Shelby tubes containing soft clays and wet silts need to be handled with care to avoid damage to the sample. Keep samples in an upright position at all times and transport in a specifically designed cushioned box or position in your vehicle with cushioning under and around the individual tubes.

5. Records

5.1 Field Notes

The field notes must document all the events, equipment used and measurements collected during the sampling activities. The field notes must be legible and concise so that the entire soil sampling event can be reconstructed later for reporting purposes.

Standard Operating Procedure

SOP #: FM-9.4 Rev. 003
Review Date: 06/27/2023
Origin Date: 03/01/2016

Title: Surficial Soil Sampling

1. Purpose/Scope

This standard operating procedure (SOP) describes procedures for sampling soil using surficial sampling techniques. The purpose is to obtain samples that are representative of existing physical and chemical conditions. Surficial soils are generally considered to be at depths ranging from the surface to approximately 2 feet below ground surface (bgs).

2. References

ASTM D4220/D4220M-14, Standard Practices for Preserving and Transporting Soil Samples. 2023.

ASTM D4547-20, Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds. 2020.

ASTM D6044-21, Standard Guide for Representative Sampling for Management of Waste and Contaminated Media. 2021.

ASTM D6051-15: Standard Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities. 2023.

3. Equipment/Materials

- Personal protective equipment (PPE) as outlined in the site-specific Health and Safety Plan (HASP)
- Appropriate sample collection tools (e.g., hand auger, hand trowel)
- Disposable nitrile gloves
- Sample containers with appropriate preservatives
- Cooler(s) with ice
- Chain-of-custody form(s)
- Decontamination supplies (including Liquinox)
- Polyethylene sheeting/cloth/paper towels/garbage bags
- Air monitoring equipment, including soil headspace scanning instrument (photoionization detection [PID] or flame ionization detector [FID]).

- Field book

4. Procedure

1. Surficial soil samples will be collected using a pre-cleaned stainless steel hand auger or other appropriate tool. Sampling in ditches will be done only when there is no water present. Remove rocks and biologic material from sample.
2. The surficial soil sample will be placed directly into laboratory supplied bottleware (sample kits).
3. A new pair of disposable gloves will be used at each sample location.
4. All sampling tools will be decontaminated in accordance with the Site Specific Work Plan prior to use at each sample location.
5. After samples have been placed in labeled bottleware immediately place on ice in laboratory-supplied coolers and maintain at 4ºC.

With the exception of VOC analyses, soil samples should be homogenized prior to filling sample containers. This step can be bypassed if only one sample container is required to be filled, as long as the laboratory will homogenize the sample upon receipt.

5. Records

5.1 Field Notes

The field notes must document all the events, equipment used, and measurements collected during the sampling activities. The field notes must be legible and concise so that the entire sampling event can be reconstructed later for future reporting purposes. Reference SOP FM – 1.6 Field Note Documentation for guidance.

All conditions at the time of sample collection should be properly documented in the field logbook. This should include a thorough description of the sample characteristics, including grain size, color, and general appearance, as well as date/time of sampling and labeling information. The location of the sampling point should be described in words and by three measurements taken from permanent structures so that the sample location can be readily identified in the field at a future date if necessary.

Title: Surface Water and Sediment Sampling

1. Purpose/Scope

This standard operating procedure (SOP) describes surface water and sediment sampling techniques. The purpose is to obtain samples that are representative of existing water or sediment conditions, or samples that retain the physical and chemical properties of the water or sediment from which the sample was collected. Improper sampling and transport procedures may cause constituents of concern (COC) to be inaccurately reported within the laboratory analysis report.

2. References

Feltz, H.R., 1980: Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments. Ann Arbor, Mich., Ann Arbor Science Publishers, Inc., v. 1. p. 271-287.

Kittrell, F.W., 1969: A Practical Guide to Water Quality Studies of Streams. U.S. Federal Water Pollution Control Administration, Washington, D.C., 135p.

USEPA, 1980: Standard Operating Procedures and Quality Assurance Manual. Water Surveillance Branch, USEPA Surveillance and Analytical Division, Athens, Ga.

USEPA, 2015: Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological Risk Assessments. Ecological Risk Assessment Support Center, National Center for Environmental Assessment, Office of Research and Development, Cincinnatti, Oh.

US Geological Survey, 1977: National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, USGS, Reston, Va.

3. Equipment/Materials

- Field Work Directive (FWD)
- Site-specific Health and Safety Plan (HASP)
- Personal protective equipment (PPE) as outlined in the HASP
- The appropriate sampling device(s) specified in the site specific work plan
- Labeled sample containers with appropriate preservatives
- Cooler(s) with ice
- Chain-of-custody forms
- Custody seals for cooler(s)

- Decontamination supplies
- Polyethylene sheeting/cloth/paper towels/garbage bags
- Field book

4. Procedure

4.1 Defining the Sampling Program

Many factors must be considered in developing a sampling program for surface water or sediments, including study objectives, best practices or Federal/State guidance documents, contaminant or COC, accessibility, site topography, flow, mixing and other physical characteristics of the water body, point and diffuse sources of contamination, personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on the bottom current or flow characteristics, sediment characteristics (density, size), and geochemical properties (which affect adsorption/desorption). The hydrologist developing the sampling plan must, therefore, know not only the mixing characteristics of streams and lakes, but also must understand the role of fluvial-sediment transport, deposition and chemical sorption.

The first steps in selecting sampling locations, therefore, are to review site history, to define the hydrologic boundaries and features of the site, and to identify the sources, pathways and potential distribution of the contamination. Based on these considerations, the numbers, types, and general locations of required samples up gradient (for background measurements), on-site and down gradient can be identified. Considerations for selection of sampling stations are further described in Reference 4.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Stream flow data, in association with contaminant concentration data, are essential for estimating the total contaminant loads carried by the stream. If a gauging station is not conveniently located on a selected stream, the project hydrologist should explore the possibility of obtaining stream flow data by direct or indirect methods.

Many methods exist for the collection of surface water samples with the driving force being the desired sample location and the COC. A couple of examples are listed below:

- Bridges and piers (streams, rivers or lake crossings)
- Boats for larger bodies of water
- Wading to collect samples from smaller streams or install Passive Diffusion Bags (PDBs)

4.2 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of COC to or in a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., spills). The major pathways for surface water contamination are overland runoff, leachate influx to the water body, direct waste disposal (solid or liquid) into the water body, and groundwater flow influx from up gradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) that encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as man-made cover (e.g. asphalt or concrete), berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., should not be overlooked.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. Dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. However, such dispersion does not always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation include: (1) moving the collection site far enough downstream to allow for adequate mixing; or (2) collecting integrated samples in a cross section. Also, non-homogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates with a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to be adsorbed by particulate matter. Nitrogen, phosphorus, and heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device should include transferring a proportionate amount of the suspended material.

4.3 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and description of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler should be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician should wait for the sediments to settle before collecting a sample.

When a boat or pontoon is used, ensure that the access point(s) is/are identified during the planning stage. A permit, approvals, or similar may be required before launching, and in many cases, must be obtained in advance of the event. When a subcontractor is used, obtain a copy of the permit or approval prior to mobilization. When launching in the off-season (fall, winter, early spring depending on location), verify that the launch/access point is open; some close in the colder months and are not available for use.

Sampling in marshes or tidal areas may require the use of an all-terrain-vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance will apply.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed in order to ensure, as nearly as possible, that samples are collected where uniform flow or deposition and good mixing conditions exist.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Stream flow data, in association with contaminant concentration data, are essential for estimating the total contaminant loads carried by the stream. If a gauging station is not conveniently located on a selected stream, the project hydrologist should explore the possibility of obtaining stream flow data by direct or indirect methods.

4.4 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the site-specific work plan. For single-event site or area-characterization sampling, both bottom material and overlying water samples should be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes—consisting of repetitive measurements to define variations and trends at a given location—water samples should be collected at a pre-established and constant interval as specified in the site specific work plan (often monthly or quarterly) and during droughts and floods. Samples of bottom material should be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons. It is important to mark sample locations accurately in the field so data can be compared between sampling events. Use stakes, flags, or buoys to mark sample locations as well as marking the location on a site map. Identifying sample locations using a GPS location device should also be considered. This will assist in the accurate reporting of the data collected.

4.5 Surface Water Sample Collection

4.5.1 Streams, Rivers, Outfalls and Drainage Features, Ditches and Culverts

Methods for sampling streams, rivers, outfalls and drainage features at a single point vary from the simplest of hand sampling procedures to the more sophisticated multipoint sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods described below.

Samples from different depths or cross-sectional locations in the water course taken during the same sampling episode should be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore should not be composited.

In small streams, less than about 20 feet wide, a sampling location can generally be found where the water is well mixed. In such cases, a single grab sample collected at mid-depth in the center of the channel is adequate to represent the entire cross-section. For larger streams, at least one vertical composite should be collected with one sample each from just below the surface, at mid-depth, and just above the bottom. Measurements of dissolved oxygen (DO), pH, temperature, conductivity, etc., may be made on each sample and on the composite itself, if specified in the site-specific work plan. For rivers, several vertical composites should be collected.

4.5.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires the collection of more samples.

In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, and temperature, may be conducted on each aliquot of the vertical composite. In naturally formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites should be composited to form a single sample. These vertical composites are often taken along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the upper, warmer and less dense layer of lake water (above the thermocline) which is exposed to the atmosphere. The hypolimnion is the lower, confined layer, which is only mixed with the epilimnion and vented to the atmosphere during seasonal overturn (when density stratification disappears). These two zones may thus have different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epiliminion but not the hypolimnion), or if only the epilimnion is involved in short-term flushing (i.e., inflow from or outflow to shallow streams).

Similarly, additional samples should be collected where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in-situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

4.5.3 Estuaries

Estuarine areas are by definition zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types dependent upon freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations:

- **Mixed estuary** – characterized by the absence of a vertical halocline and a gradual increase in salinity seaward. Typically, this type of estuary is shallow and is found in major freshwater sheet flow areas. Being well mixed, the sampling location is not critical in this type of estuary.
- **Salt wedge estuary** – characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.
- **Oceanic estuary** – characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh-saline water mixing occurring near, or at, the shoreline.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs should include vertical salinity measurements at 1- to 5-foot increments coupled with vertical dissolved oxygen and temperature profiles. A variety of water sampling devices are used.

4.6 Sampling Equipment and Techniques

The selection of sampling equipment depends on the site conditions and sample type required. In addition, the site-specific work plan will call out any specific sampling equipment requirements or restrictions (inclusion or exclusion of certain sampling equipment and/or materials) based on the COC. The most frequently used samplers are:

- Open tube
- Dip sampler
- Weighted bottle sampler
- Hand or mechanical pump
- Kemmerer or Van Dorn Sampler
- Depth-Integrating Sampler
- PDBs

Measure each sample (grab or each aliquot collected for compositing) for the following as soon as it is recovered if specified in the site-specific work plan:

- Specific conductance
- Temperature
- pH (optional)
- dissolved oxygen (optional)

4.6.1 Dip Sampling

Water is often sampled by filling a container—either attached to a pole or held directly—from just beneath the surface of the water (a dip or grab sample). Often the use of a sampling device constructed of a nonreactive material such as glass, stainless glass, or Teflon is best. The sampler should have a capacity of at least 500 mL in order to minimize the number of times the liquid must be disturbed. Preservatives cannot be present in the container when it is lowered into the water. This method is impractical for hazardous samples, since the external surface of each container would then need to be decontaminated.

Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and cross-section. Therefore, whenever possible one should augment dip sampling with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

4.6.2 Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects samples throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of a glass or plastic bottle with a stopper, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The procedure for sampling is:

1. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
2. Pull out the stopper with a sharp jerk of the sampler line.
3. Allow the bottle to fill completely (when air bubbles stop).
4. Raise the sampler and cap the bottle.
5. Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as original bottle is an approved container).

4.6.3 Hand Pumps

Hand pumps may operate by peristaltic, bellows, diaphragm, or siphon action. Pumps which operate by a bellow, diaphragm, or siphon action should not be used to collect samples that will be analyzed for volatile organics because the slight vacuum applied may cause loss of these contaminants. It is also not recommended for pH-sensitive samples. To avoid contamination of the pump, a liquid trap consisting of a vacuum flask or other vessel to collect the sample should be inserted between the sample inlet hose and the pump. Tubing used for the inlet hose should be nonreactive (preferably Teflon). The tubing and liquid trap must be thoroughly decontaminated between uses (or disposed after one use).

When sampling, the tubing is weighted and lowered to the desired depth. The sample is then obtained by operation of the pump, transferring water from the trap to the sample container.

4.6.4 Kemmer/Van Dorn Samples

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon-coated sampler, a standard Kemmerer or Van Dorn sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leaves the ends open while being lowered in a vertical position to allow free passage of water through the cylinder. Kemmerer samplers can be adapted for sample collection for organic analysis by substituting Teflon for the rubber or plastic stoppers, or by ordering it with stainless steel metallic parts. The Van Dorn sampler is plastic and is lowered in a horizontal position. In each case a “messenger” is sent down the line when the sampler is at the designated depth to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles.

4.6.5 Depth-Integrated Sampling

Depth integration is used to collect a water and suspended material sample in direct proportion to relative velocity at each increment of depth. This means that a volume of water and suspended material must enter the sample bottle at a rate proportional to the velocity of the flow passing the intake of the sampler. If a depth-integrating sampler is lowered from the surface to the bed and back at the same rate—presuming that the sampler is not overfilled during the course of the sampling operation—each increment of flow in that vertical column is sampled proportionate to the velocity it was made to travel.

Another method of collecting depth-integrated samples is the equal-width-increment (EWI) technique. Samples are collected at several equally-spaced vertical columns across the stream, with the transit rate of the sampler—that is, the velocity at which the sampler is passed through the water column—the same in all verticals. The samples collected in each vertical are then composited into a single sample representative of the entire flow in the cross-section. Since the volume collected in each vertical sample will be directly proportional to the depth and velocity at the vertical location, the composite sample of the water-sediment mixture flowing in the cross-section will be discharge-weighted.

In the equal-discharge-increment (EDI) technique, the positions of sampling verticals across the stream are based on incremental discharges rather than width (i.e., deeper or higher-velocity areas of stream cross-section are sampled at a closer spacing). This method provides the most accurate measurement of total discharge of the contaminant for streams that are not well mixed; however, it requires knowledge of the cross-sectional stream flow distribution.

4.7 Sediment Sampling

4.7.1 General

Sediment samples are usually collected at the same verticals at which water samples were collected. The water sample should be collected first. If only one sediment sample is to be collected, the sample location should be approximately at the center of the water body. This is particularly true for reservoirs that are formed by the impoundment of rivers or streams. The shape, flow pattern, bathymetry (depth distribution), and water circulation patterns must all be considered when selecting sediment sampling locations. In streams, areas likely to have sediment accumulation—bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas—should be sampled while the main flow path or areas likely to show net erosion (high-velocity, turbulent areas) and suspension of fine solid materials should be avoided. The depth of the water at the sampling location should be taken into consideration as it will affect the equipment needed to collect the sample.

The depth of sediment sample collection is a project-specific determination and may be based on the thickness of sediment present. For ecological evaluations, samples are collected from the biologically active zone, which typically varies from 4 to 14 inches depending on the type of environment (e.g., lotic systems typically have a deeper biologically active zone than lentic environments).

4.7.2 Sampling Equipment and Techniques

A bottom-material sampler may consist of a single scoop or core or may be a composite of several individual samples in the cross-section. Sediment samples may be obtained using on- or off-shore techniques.

The following samplers may be used to collect undisturbed bottom sediment:

- Scoop sampler
- Core sampler
- Hand-operated gravity corers
- Dredge samplers

Sediment samples collected for all analyses except Volatile Organic Analysis (VOA) and Total Organic Halogens (TOX) should be thoroughly mixed before being placed in appropriate sample containers. Rocks, twigs, and other debris should be removed from the sample prior to homogenization. VOA and TOX samples are to be collected first as individual grab samples, never homogenized. Rinse blanks are required on the pans used for homogenization. The site-specific work plan will call out any specific sampling equipment requirements or restrictions (inclusion or exclusion of certain sampling equipment and/or materials) based on the COC.

4.7.3 Scoop Sampler

If the water body can be sampled from the shore or if it can be waded, a scoop sampler is the easiest and “cleanest” way to collect a sediment sample. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping the sample along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

4.7.4 Core Samples

Core samples are used to sample vertical columns of sediment. They are useful when a historical record of sediment deposition is desired, for they preserve the sequential layering of the deposit. Coring devices are particularly useful for sediments because the “shock wave” created by descent is minimal, thus the fines of the sediment-water interface are not disturbed.

4.7.5 Hand Operated / Gravity Corers

Hand corers are generally constructed of an outer rigid-metal tube into which a 2-inch inside diameter, plastic or Teflon core sleeve fits with minimal clearance. The cutting edge of the corer has a recessed lip on which the core sleeve rests and that accommodates a plastic core catcher. The core catcher is composed of intermeshing fingers that point upward into the core sleeve so that when the sampler is pressed into the sediment, the core is free to move past the catcher, but cannot fall through the catcher upon removal of the sampler from the sediment.

Use of hand corers or liners involves pushing the device into the substrate until only 4 inches or less is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the corer while it is pushed will facilitate greater penetration and cut down on core compaction. The orientation of the core should be marked on the sleeve.

Gravity corers are used to collect sediment samples in water bodies deeper than 3 to 5 feet. These types of samplers can be used for collecting 1 to 2 foot cores (with a 2 inch Inside Diameter [ID]), of surface sediments at depth of up to several hundred feet beneath the water surface. Because of the small diameter, gravity corers are not suitable for obtaining coarse-grained samples, but they are excellent for obtaining fine-grained materials.

The gravity core sampler operates in a manner similar to the hand-operated corer. A plastic or Teflon liner (2-inch ID) fits within a metal core housing fitted with a cutting edge. Core-catchers are used to retain the core within the liner. An opening above the liner allows free flow of water through the corer as it moves vertically through the water and into the sediment. The sampler has a messenger-activated valve assembly, which seals the opening above the liner following sediment penetration and creates a partial vacuum to assist in sample retention during retrieval.

Samples are collected by allowing the sampler, which is attached to a sufficient length of stainless steel cable, to drop to the bottom. The weight of the sampler drives the core into the sediment to varying depths depending on the sediment characteristics. The messenger is then dropped and the sampler carefully retrieved.

4.7.6 Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (e.g., coarse-grained or partially-cemented materials) or when large quantities of materials are required. Dredges generally consist of a clamshell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger. Most dredges are heavy (several hundred pounds) and require use of a winch and crane assembly for sample retrieval. Peterson, Eckman and Ponar are the three major types of dredges.

The Peterson dredge is used when the bottom is rocky, the water is very deep, or when the flow velocity is high. The dredge should be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in high flow velocity streams.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends, thus reducing the “shock wave” and permitting direct access to the secured sample without opening the jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing metal contamination from the frame of the device.

5. Records

5.1 Field Notes

The field notes must document all the events, equipment used and measurements collected during the sampling activities. The field notes must be legible and concise so that the entire sampling event can be reconstructed later for reporting purposes. Field notes should detail all specific information that would be useful to understanding the nature and location of sample collection. For accurate sample location reporting, identify sample locations on a map. Using global position system (GPS) data (latitude and longitude) provides highly accurate sample locations. Field notes should be attached to the FWD and scanned in accordance with to the Project Implementation Process (PIP).

Title: Sample Preservation and Handling

1. Purpose/Scope

The purpose of this Standard Operating Procedure (SOP) is to describe the appropriate steps to properly preserve and handle environmental samples (primarily aqueous samples), including field preservation if necessary, based on the laboratory analyses to be performed. Environmental samples are subject to chemical, physical, and biological change due to exposure to ambient conditions during and following sample collection. Physical and chemical preservation of samples minimizes further changes in sample chemistry that can occur from the moment of collection to initiation of analysis at the laboratory.

Preservation techniques generally include pH adjustment, chemical additions (stabilizers) and/or refrigeration (cooling). Different types of chemicals react differently with sample containers made of various materials. It is critical to select the appropriate container and preservative and perform the appropriate preservation technique(s) to maintain the quality of the sample before laboratory analysis. This will ensure representative, usable and supportable laboratory data are obtained.

This SOP shall be used in conjunction with an approved Health and Safety Plan (HASP) for information on the selection and use of Personal Protective Equipment (PPE).

This SOP shall be used in conjunction with a project-specific Sampling and Analysis Plan (SAP).

2. References

ASTM D6517-18 - Standard Guide for Field Preservation of Groundwater Samples, 2018

GES SOP FM 13.5 Sample Management, Packaging, and Shipping

3. Equipment/Materials

- HASP and proper PPE
- Site-specific SAP and Field Work Directive (FWD)
- Certified-clean sample containers that include the appropriate acid/base preservative required for the planned sample analytical method(s)
- Cooler
- Ice

- Chain-of-custody
- Field book

4. Procedure

1. Review the FWD and project-specific SAP for the number, location, and type of samples to be collected.
2. Verify and validate with the Project Manager and laboratory the appropriate sample containers, volumes, preservatives and maximum hold times required for the planned analyses. Obtain appropriate number and type of sample containers from the laboratory performing the analyses, including pre-preserved containers where appropriate. Site/job-specific sample container orders are highly recommended, particularly when multiple analytical methodologies and sample preservation protocols are required.
3. Upon receipt from the laboratory, verify that the appropriate number and type of sample containers are included. Confirm an appropriate number of temperature blanks, trip blanks, and water for field blanks, as necessary. Prior to sampling, ensure all sample and Quality Assurance/Quality Control (QA/QC) sample containers are stored properly to avoid cross-contamination.
4. Ensure that an appropriate number and type of certified-clean field filtration devices are obtained if field filtering is required (e.g., dissolved metals analyses). Filter samples, as appropriate, in the field. Have samples filtered and preserved at the laboratory if a filtration device is not available in the field. The chain-of-custody form should clearly describe any filtration the laboratory must perform prior to analysis.
5. If pre-preserved sample containers cannot be obtained from the laboratory prior to sampling, add preservative to the sample containers in the field by determining the approximate volume of acid (or base) required. Refer to the FWD and/or site-specific SAP, and use the appropriate PPE to avoid contact with low/high pH preservatives.
6. Collect samples as described in the FWD and/or SAP. During sample collection, ensure that sample preservative is not flushed out of the containers due to over-filling.
7. Preservation of all samples should occur immediately upon collection, including immediate placement of samples in an iced cooler to maintain the required temperature for preservation.
8. Complete chain-of-custody documentation including details regarding number and type of containers being submitted for each sample and type of preservative.

    Note: All collected samples that have been recorded on the chain-of-custody are sent to the laboratory. Under no circumstances should a sample delivery arrive at the laboratory without all samples noted on the chain of custody. If it is determined after sampling and prior to shipping that data for a specific sample and/or method recorded on the chain-of-custody form is not required for project completion, the chain-of-custody should clearly state "hold for laboratory analysis" for the sample/method in question. The laboratory will *not analyze that sample/method without specific direction from GES. GES does not dispose of samples that have been recorded on a chain-of-custody.*

9. Once samples are properly collected and preserved, refer to SOP FM13.5 for proper sample management, packaging, and shipping procedures to ensure the required sample preservation is maintained until receipt at the laboratory.

Note: Refer to GES SOP FM 22.0 (Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling) for required sample handling procedures specific to these substances.

5. General

5.1 Sample Containers

The following general rules apply to sample containers:

- The laboratory performing the analyses should provide certified-clean and pre-preserved (as appropriate) containers per USEPA procedures. Some laboratories may not provide containers; therefore, it will need to be purchased from an approved vendor.
- If the analyte to be determined is organic in nature, use glass containers.
- If the analyte to be determined is inorganic in nature, use plastic (polyethylene) containers.
- Separate sample containers should be used when collecting samples for analysis of both organic and inorganic compounds.
- Once opened, a container must be used immediately to store the sample. Opened, unused containers must be considered contaminated and must be discarded. Opened containers are not to be closed and saved for later use. Likewise, any unused containers that appear contaminated upon receipt or that have loose caps or missing Teflon liners (if required) should be discarded.
- Sample containers should be sealed and stored as far as possible from potential sources of cross-contamination when not in use.

5.2 Sample Holding Times

Holding times are the maximum amount of time that a sample may be held—from the moment of sampling until analysis—without compromising the validity of the analytical results. In general, the following shipping protocols should be used:

- Samples requiring organic analysis shall be shipped the same day that they are collected, or no later than the following day.

- Samples for inorganic analysis may be held until the shipping container is full, up to three days maximum before shipment.

5.3 Preservation Techniques

Sample preservation techniques are grouped into two general categories: (1) chemical preservation and (2) physical preservation. Preservation techniques and procedures should address the following details on a parameter-specific basis: sample container design and construction, protection from ultraviolet light, temperature control, chemical addition, and pH control measures.

It is preferred that the laboratory performing the analyses provide sample containers pre-filled (and labeled) with the necessary preservative(s). Verify the correct preservatives are provided, and avoid addition of chemical preservatives during sampling whenever possible.

5.4 Field Filtration

When sampling for dissolved inorganic constituents in an aqueous sample, use the following filtration technique:

- Filter the sample through a certified-clean, dedicated (per sample location) non-metallic 0.45-micron membrane filter immediately after collection.
- Discard the first 20 to 50 ml of filtrate from each sample used to rinse the filter and filtration apparatus (to minimize the risk of altering the composition of the samples by filtering).
- For analysis of dissolved metals, collect the filtrate in a laboratory-supplied sample bottle and immediately acidify to pH 2.0 or less with analytical reagent-grade nitric acid. (Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified.)

5.4.1 Precautions

- Do not filter samples used for determining temperature, dissolved oxygen, oxidation/reduction potential (ORP), and pH.
- Do not use vacuum filtering prior to determining carbonate and bicarbonate concentrations because it removes dissolved carbon dioxide and exposes the sample to the atmosphere. (Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.)
- Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in an appropriate container.

- Because most organic samples require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended filtrate can be sealed in a glass container and analyzed separately as soon as practical. Total recoverable inorganic constituents may be determined using a second, unfiltered sample for dissolved constituents.

6. Disposal of Contaminated Materials

All materials and equipment used for decontamination must be disposed of properly. Clothing (PPE), tools, buckets, brushes, and all other equipment that cannot be reused will be disposed of in accordance with the site-specific SAP.

7. Records

7.1 Field Notes

Record field notes in a standard bound survey-type field book issued for general note taking/field records or other field form as provided by the PM. Maintain chain-of-custody from the time of sampling (i.e., fill out chain-of-custody as samples are being collected, not at the end of the event) to the time that the samples are relinquished to the laboratory.

Standard Operating Procedure

SOP #: FM-13.3 Rev 004
Review Date: 06/03/2023
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Title: Sample Identification and Labeling

1. Purpose/Scope

The purpose is to provide general guidance regarding the identification and labeling of environmental samples.

Samples, other than in-situ measurements, are removed from the sample collection location and transported to a laboratory. Following collection, samples are placed in laboratory supplied sample containers containing the appropriate preservatives, as necessary. Each sample container is identified by a unique identification number that is written on a sample tag or label that is affixed to the sample container.

2. References

GES SOP FM-13.2: Sample Preservation and Handling

GES SOP FM-13.4: Chain-of-Custody Procedures

GES SOP FM-13.5: Sample Management, Packaging, and Shipping

ASTM D4840-99e1: Standard Guide for Sampling Chain-of-Custody Procedures, 2018

3. Equipment/Materials

- Waterproof, adhesive labels and/or sample tags
- Waterproof and/or indelible pen (suggest an ultra-fine tipped Sharpie)
- Custody seals, if required by project
- Sample containers

4. Procedure

1. Collect samples as described in the project-specific Sampling and Analysis Plan (SAP). Precisely record the sample location and sample identification on the label to ensure that the sample identification on the sample label exactly matches the sample log sheet and chain-of-custody records.
2. Neatly fill out the label/tag with a waterproof pen just before sample collection. Filling out the label/tag after sample collection may make it difficult to write on the label if it becomes wet or covered with debris. At a minimum, labels should contain the following information:

- Sample identifier
- Name or initials of collector
- Date and time of collection (suggested military time)
- Site name
- Required analyses
- Sample preservation

Note: Additional information for inclusion on the label will be specified in the site-specific SAP.

3. If the sample is to be split, divide the sample equally between two similar sample containers. Fill out the labels with identical information. Collect samples as described in the project-specific SAP. Precisely record the sample location and sample identification on the label to ensure that the sample identification on the sample label exactly matches the sample identification on the sample log sheet and chain-of-custody record. Each label is also marked as “split”.
4. If required, affix the sample custody seal to the container in such a way that the seal must be broken to open the sample bottle. Seals must be affixed before the sample leaves the sampler’s custody.

5. Records

5.1 Field Notes

Record all information pertinent to field sampling on the chain-of-custody record and in the project field notes.

Title: Chain-of-Custody Procedures

1. Purpose/Scope

The purpose of this Standard Operating Procedure (SOP) is to provide accountability for, and tracking of, sample integrity from the time samples are collected until sample disposal, to ensure the legal defensibility of the resulting analytical data.

This SOP is to be used in completing sample chain-of-custody forms for environmental samples. A chain-of-custody form is required, without exception, for the tracking and recording of all samples collected for off-site analysis. All environmental samples collected shall be accompanied by a chain-of-custody form, ideally provided by the laboratory performing the requested analyses.

This SOP does not take precedence over site-specific requirements for chain-of-custody.

2. References

ASTM D4840-99(2018)e1: Standard Guide for Sampling Chain-of-Custody Procedures, 2018

USEPA QA Handbook Vol II, Section 8.0 Revision No. 1, Sample Handling and Custody, December 2008

3. Equipment/Materials

A basic checklist of suggested equipment and supplies needed to implement this SOP includes, but is not limited to:

- Chain-of-custody form provided by the designated laboratory
- Watch/phone for recording sample collection time
- Waterproof and/or indelible ink pen

4. Procedure

Collect samples as described in the project-specific Sampling and Analysis Plan (SAP). Precisely record the sample location and sample identification on the label immediately after sample collection to ensure that the sample identification on the sample label exactly matches the sample log sheet and chain-of-custody record.

A chain-of-custody form should be utilized for tracking documentation. Field information related to sample collection may be included on the chain-of-custody form, as appropriate.

Chain-of-custody Forms may vary, depending upon the selected analytical laboratory, but the following information should always be provided:

- Sample identifying name
- Sample location identification (ID), sampling point ID, date, and sampling time interval as listed on sample container
- Signatures of sampling personnel and signatures of all personnel handling and receiving the samples
- Project identification code
- Project contact and phone number
- Number of containers per sample
- Sample type: grab, composite, etc.
- Sample matrix: soil, water, sediment, air or vapor
- Analysis desired with Method designation
- Preservative type (if applicable)
- Additional comments as needed, including a request for expedited sample analysis, if desired

Note: All collected samples that have been recorded on the chain-of-custody are sent to the laboratory. Under no circumstances should a sample delivery arrive at the laboratory without all samples noted on the chain of custody. If it is determined after sampling and prior to shipping that data for a specific sample and/or method recorded on the chain-of-custody form is not required for project completion, the chain-of-custody should clearly state "hold for laboratory analysis" for the sample/method in question. The laboratory will not analyze that sample/method without specific direction from GES. GES does not dispose of samples that have been recorded on a chain-of-custody.

The completed chain-of-custody form accompanies the samples from initial transfer/shipment through receipt at the laboratory. Copies of the form are typically distributed as follows: The sampler/shipper will maintain a copy while the other two copies will be enclosed in a waterproof envelope and placed within the sample cooler or shipping container (SUMMA Canisters). The cooler or shipping container will then be sealed properly for shipment. Upon receiving the samples, the laboratory will complete the two remaining copies. The laboratory will maintain one copy for their records, and one copy of a fully completed chain-of-custody will be returned with the analytical results package. Note: This is a general process; internal laboratory procedure may vary from laboratory to laboratory.

When transferring possession of samples, the individual relinquishing the sample and the person receiving the sample will sign (waterproof/indelible ink), date and log the time on the chain-of-custody. Any corrections are made by drawing a line through the correction, initialing and dating the change, and entering the correct information. Do not erase.

Chain-of-custody records are legal documents. They must be complete and handled accordingly to ensure the defensibility of the collected data.

A chain-of-custody is completed for every shipping container or cooler within a shipment from the field to the laboratory. When more than one chain-of-custody form is used for a single shipment, each form must be consecutively numbered using the “Page ___ of ___” format.

> *Note: Common carriers will usually not accept responsibility for handling chain-of-custody records. That is why the chain-of-custody is to be enclosed in a zip-lock bag and packaged in the sample container.*

The laboratory representative who accepts the incoming sample shipment signs and dates the chain-of-custody record, completing the sample transfer process.

Whenever samples are split with a private-party or government agency, a separate Receipt for Samples Record Form should be completed in its entirety. The person relinquishing the samples to the party or government agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable, or refuses to sign, this is noted in the “Received by” space. When appropriate, as in the case where the representative is unavailable, the custody record should contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator or agent-in-charge.

5. Records

5.1 Field Notes

Copies of the completed chains-of-custody must be maintained in the project file.

Title: Sample Management, Packaging, and Shipping

1. Purpose/Scope

The purpose is to provide general guidance regarding sample management, packing and shipping.

Improper sample management can result in sample integrity, chain-of-custody and sample holding time issues, which can have a direct effect on the legal defensibility of the collected data. This Standard Operating Procedure (SOP) provides requirements for the proper field management of the most commonly collected types of environmental samples (i.e., soil and groundwater, vapor and free product samples) including proper packaging and shipping procedures.

2. References

- ASTM D6911-15: Packaging and Shipping of Environmental Samples for Laboratory Analysis, 2016

3. Equipment/Materials

A basic checklist of suggested equipment and supplies needed to implement this SOP include, but is not limited to:

- Chain-of-custody forms
- Waterproof and/or indelible ink pens
- Labels
- Shipping information (laboratory address, shipper info, etc.)
- Coolers and ice
- Additional packing material (ice will melt, making it inadequate for packing)
- Packing tape
- Resealable bags
- Custody seals
- Field book
- Large plastic bags, for overnight shipments

4. Preparation

Contact the laboratory that will analyze the samples to arrange for necessary supplies and the delivery date and time. Arrange for transportation of the samples to the laboratory (see Shipment under the Procedure section below). Also, alert the laboratory if expedited analysis or non-standard analysis is required, and confirm that the laboratory will be able to satisfy the required timeframe and/or analytical requirements.

5. Procedure

5.1 Field Sample Management

Field sample management is the continuous care given to each sample from the point of collection to delivery to the analytical laboratory. Good sample management ensures that samples are properly collected, recorded, and labeled; and not lost, broken, or exposed to conditions, which may affect the sample's integrity.

Often, due to weather or time constraints, the entry of sample data into the sample log or labeling of the sample containers does not occur immediately following sample collection. Additionally, the secure sample storage location on site may be distant from the actual area where sampling is being conducted. These are only a few of the many undesirable situations, which may be encountered. Field personnel must adjust to field conditions and manage the pace of each sampling job to ensure that proper sample management practices are maintained. All sample submissions must be accompanied with a chain-of-custody document to record sample collection and submission. SOP FM-13.4 Chain-of-Custody Procedures describes the chain-of-custody requirements in detail.

5.2 Field Handling

Prior to entering the field area where sampling is to be conducted, especially at sites with defined exclusion zones, the sampler should ensure that all materials necessary to complete the sampling are on hand.

If samples must be maintained at a specified temperature after collection, proper coolers and ice or cool packs must be brought to the field. Consideration should be given to keeping reserve cooling material on hand if sampling events will take a long time in warm ambient air conditions. Conversely, when sampling in extremely cold weather where freezing may occur, proper protection of water samples, trip blanks, and field blanks must be considered.

Personnel performing groundwater sampling tasks must check the sample preparation and preservation requirements to ensure compliance with the quality standards or the project-specific Sampling and Analysis Plan (SAP). Typical sample preparation may involve pH adjustment, sample filtration and preservation, or simply cooling to less than 4 degrees Celsius (°C) ± 2 °C. Sample preparation requirements vary from site to site and vary depending upon the selected analytical method(s).

The sampling personnel must also confirm the number and type of containers for each sample, as well as the filling required for the respective sample containers before the sampling event. Volatile Organic Compound (VOC) samples must not have any headspace within the sample collection vial. Sample collectors must also take care when handling containers prepared with a preservative. Overfilling a container may result in a loss of preservative, whereas careless handling may result in skin contact with the preservative.

5.2.1 Sample Labeling

Depending upon the analytical laboratory, sample bottle ware may be pre-labeled prior to collection. If not, samples must be properly labeled as soon as practical after collection.

No one sample number format is adequate for every type of sampling activity. Prior to the start of every sampling event, project managers and field personnel should discuss and confirm the acceptable sample number format. Sample number formats should be as simple and short as possible. Simple number formats will reduce transcription errors by both GES and lab personnel. The sample number format should also be comprehensive enough to allow for easy location of detailed sample data within the GES logbooks. Prior sample identification numbers should also be reviewed for sites with prior investigation activities, to assure that historic sample numbers are not duplicated.

All samples must be labeled with, at a minimum:

- A unique sample number (e.g., MW-1)
- The date and time
- The parameters to be analyzed
- Sample preservation method
- The job number
- The sampler's initials

The unique sample identification number may be specified in the project-specific SAP or Field Work Directive (FWD). A format should be selected to maximize the information content of the sample number. The decision of how to assign sample numbers should be made at the beginning of a job or phase, and should be consistent throughout the job.

Often the analytical laboratory supplying the containers will provide blank sample labels. If these are adequate and convenient, they can be used.

Note: Under certain field conditions it is sometimes impractical to complete and attach sample labels to the container at the point of sample collection. In those instances, to ensure that samples are not confused, a clear notation should be made on the container with a permanent marker indicating the last three digits of the sample number, and any other required information. If the containers are too soiled or small for marking, the container can be put into a resealable plastic bag, which can then be labeled.

The project-specific SAP and/or FWD should always be reviewed to determine any additional requirements.

5.3 Storage

On completion of sampling activities, water samples shall be stored in an iced cooler while on-site to cool the samples to a temperature of less than 4 °C ± 2 °C. Samples may be stored in the iced cooler and packaged as directed in Section 5.4, for sample shipment direct to the laboratory.

Upon arriving at a GES office, water and soil samples may be removed from the cooler and stored in a dedicated sample refrigerator. Samples stored in this method awaiting laboratory courier shall be stored away from the rear of the refrigerator to prevent sample freezing and stored in a method to prevent the samples from being accidentally dropped from the refrigerator, such as in a box. Verify that the refrigerator temperature setting (typically a numeric dial) is at the pre-determined setting to achieve a temperature of 4 °C ± 2 °C. Temperature monitoring of such refrigerators is recommended (e.g., thermometer/thermocouple inside with externally-visible dial or digital read-out).

All samples (water, soil, or gas/vapor) awaiting courier pick-up must be stored in a secure area to prevent unauthorized access (e.g., in a refrigerator or iced cooler within a secure GES office; in a locked refrigerator if at an unsecure location; in an iced cooler within a locked room or vehicle if at an unsecure location). When storing samples for courier pick-up, the chain-of-custody must be signed and relinquished to “secure storage area” or similar nomenclature. Ensure a courier pick-up is scheduled within the hold time of the stored samples.

5.4 Packaging

Complete sample container preparation and packing for shipment in a well-organized and clean area, free of any potential cross contaminants.

While there is no one “best” way to pack samples for shipment, the following packing guidelines should be followed. Additional information (job aid) is provided as **Attachment A**.

- Plan time to pack your samples (and make delivery to shipper if applicable). Proper packing and manifesting takes time. A day’s worth of sampling can be easily wasted due to a few minutes of neglect when packing the samples.

- Select the "right-sized" cooler to accommodate the samples and ice.
- Check cooler integrity and for open or inoperable drain spouts that could inadvertently leak melted ice during shipping. Use a plastic cooler liner to guard against leakage. Tape drain spouts closed.
- Always opt for more coolers and more padding, rather than crowd samples. Crowding samples leads to breakage during transport.
- Do not bulk pack—each sample must be individually padded.
- Large glass containers (1-liter and up) require much more space between containers.
- In most cases Summa canisters can be shipped back to the laboratory in the same boxes they were delivered in. Tedlar bags can also be shipped in boxes back to the laboratory.
- Check sample container labels against the FWD and chain of custody when placing into the cooler.
- During shipping preparation, glass sample containers should be individually secured in bubble wrap or similar protective material or separated by cardboard or plastic sample containers. Small glass sample vials (e.g., 40 ml VOAs) may be placed two or three per bubble wrap package/sleeve or foam pack. Packing glass sample containers to avoid breakage without over-insulating and inhibiting cooling to the range of 4 °C ± 2 °C is important.
- Care should be taken to prevent ice from directly contacting sample containers. This can degrade labels as the ice melts. Ice should be double-bagged and should not be used as the primary packing media to secure bottles in the cooler as shifting and breakage may result as the ice melts.
- Double check to ensure trip and temperature blanks have been included for all shipments containing VOCs, or where otherwise specified in the Quality Assurance/Quality Control plan.
- Enclose the chain of custody form in a sealed plastic bag.
- Ensure at least one custody seal is placed on each cooler. Coolers with hinged lids should have the placed on the opening edge of the lid. Coolers with hinge-less lids should have the seal placed on a corner of the lid. Some laboratories or clients may require additional custody seals on coolers (e.g., two). Place clear tape over custody seals.
- For overnight shipping, place "fragile" stickers on the cooler, ensure that any hazardous material stickers/markings have been removed from coolers, which previously contained such materials, or that hazardous material stickers/markings are on containers which do contain hazardous materials. Secure packed coolers with clear sealing tape. Seal the lid to the cooler both horizontally and vertically.

Note: Never store sterile sample containers in enclosures containing equipment which use any form of fuel or volatile petroleum-based product. An alternate means of secure storage must be planned for.

5.5 Shipment

Whenever possible, collected samples should be transferred directly to the analytical laboratory's courier; either by arranging for pick up at the sample location, or at the GES office. In some cases, shipment by overnight carrier may be necessary. However, this is the least preferred option. Many problems can be avoided by proper advance planning. Additional information (job aid) is provided as **Attachment B**.

- Ensure that sample hold times will be met with the shipping method (e.g., 24- and 48-hour hold time samples).
- Confirm the shipping address is correct. Verify against the FWD.
- Avoid using third party carriers (e.g., FedEx, UPS) when possible. Use laboratory couriers or direct drop off at the laboratory when possible.
- For multi-day sampling projects, ship samples daily.
- Avoid shipping samples on Fridays when possible. If samples must be shipped on a Friday, ensure the laboratory is open on Saturday to receive samples and use appropriate labels (e.g., Saturday delivery) on cooler(s).
- When pre-planning for sample shipment or laboratory courier pickup, ensure that samples will arrive at the analytical laboratory at an appropriate time to allow for immediate log-in and processing. Do not leave samples unattended over weekends or holidays prior to shipment or courier transport to the laboratory.
- If pickup is desired at the sample locations, the carrier should be contacted prior to the start of sampling to confirm that the pickup can be made. If so, the time deadline must be determined for having the shipment ready.
- If no pickup is available at the site or at the GES office, the nearest commercial shipping drop off location should be determined and hours of operation confirmed.
- Sufficient time must be allowed not only for packaging but also for delivery of samples if this becomes necessary.
- Sample shipments must not be left at unsecured or questionable drop locations (e.g., if the cooler will not fit in a remote drop box do not leave the cooler unattended next to the drop box).
- Some overnight carriers do not provide actual overnight shipment to/from some locations. Do not assume—call the carrier before the start of field work.
- When samples are shipped via commercial carrier, a copy of the tracking form must be retained and entered into the project or office filing system. Track movement of the samples once relinquished.

6. Records

6.1 Field Notes

The field notes must document all the events, equipment used, and measurements collected during the sampling activities. The field notes and chain-of-custody forms must be legible and concise so that the entire sampling event can be reconstructed later for future reference.

6.2 Field Deliverable Packages

Field deliverable packages with all appropriate task documentation, including sample preparation/management and packing must be uploaded within 24 hours of the event and subsequently reviewed by the project manager or designee within one business day for task and chain-of-custody accuracy.

Attachments

Attachment A – Cooler Packing Best Practices Job Aid

Attachment B – Cooler Shipping Best Practices Job Aid

Attachment A – Cooler Packing Best Practices Job Aid

Best Practice

Packing a Sample Cooler

Five tips for better sample cooler packing

Take ownership and accountability for this priority GES field task by following these steps:

1 Prep the Cooler

Start by using the “right-sized” cooler to accommodate the samples and necessary ice. Line the bottom of the cooler with sorbent padding and bubble wrap. Consider lining the sides of the cooler with bubble wrap for additional protection. Insert the appropriate sized cooler liner to enclose the samples and ice.

2 Add the Samples

Check bottleware labels against the Field Work Directive and chain of custody (e.g., sample locations, sample IDs, bottleware and preservative, analytical requirements). Group like samples together (e.g., all bottles for MW1 together in a resealable bag). Protect glass bottles by wrapping in bubble wrap or separating the glassware with cardboard or samples contained in plastic bottles. Plastic bottles do not need to be wrapped.

3 Ice

Cool the samples to 4 °C ± 2 °C — this is critical. Put samples on ice as soon as they are collected. Pack the cooler with loose ice — on the bottom and between bottles/bags of bottles. Add a generous amount of ice on top of the samples (10-25 lbs., depending on cooler size). Seal the cooler liner with a tie wrap or tape and place bubble wrap on top. Do not overpack the cooler.

Best Practice
Packing a Sample Cooler

(Continued)

4 Verify Documentation

Review and sign the chain of custody, enclose in a sealed bag, and place in the cooler or tape to inside lid. Double-check that the shipping information is correct. Is the lab and lab address correct? Is overnight delivery marked? Is Saturday or holiday delivery required?

5 Seal and Ship

Place custody seal(s) along the cooler lid and side. Cover custody seal(s) and shipping label with clear packing tape. Seal the cooler with clear packing tape along the lid and at least two locations around the entire cooler. Add appropriate external labeling as needed (wet ice, fragile, short hold time, etc.).

Contact:

Rich Evans, PE
SVP, Technical Functions

E. revans@GESonline.com
T. 800.220.3606 ext. 3014

Attachment B – Cooler Shipping Best Practices Job Aid

Best Practice

Shipping Sample Coolers

Tips for getting your samples to the lab safely.

Take ownership and be accountable for this priority GES field task by following these steps:

Double-check the destination — Confirm you are shipping to the correct laboratory and location per the field work directive (FWD) and check that the provided information is identical on all shipping paperwork.

Plan to meet holding times — Confirm sample holding times with laboratory for the bottleware and preservative being used as holding times can vary between 24 hours and 2 weeks.

Avoid using 3rd party carriers when possible — Instead of FedEx, UPS, or DHL, use a lab courier, or deliver the samples directly to the lab.

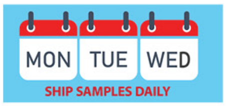
Don't miss your shipping cutoff — Plan your work day to leave enough time to responsibly pack and ship samples. If you miss the shipping cut-off time, the samples may sit at the carrier's warehouse for the entire next day.

Keep cool — During warm weather, ship fewer samples per cooler to help maintain sample temperatures. Use the largest cooler available (or multiple coolers), lined with a large clean plastic bag. Protect glassware with bubblewrap and fill with ice. Wait, then add more ice.

Avoid delayed shipments — If the cooler leaks during shipment, it will likely be pulled and delivery delayed. Make sure to double-contain ice in sealed bags, tightly seal the cooler lid, and add initialed Custody Seals.

Best Practice Shipping Sample Coolers (Continued)

If you must ship samples using a third party shipper:

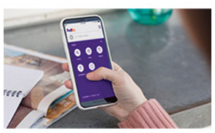


Ship samples daily — Call for a scheduled pick up or drop off at a manned 3rd party logistics office.

Do not use FedEx First Overnight (8:00 AM) Service — If the lab is closed or no one is immediately available at the destination to receive package, the next delivery attempt won't happen until the next business day.

Avoid shipping on a Friday — If you do, use appropriate labels (Saturday delivery) and confirm delivery date/time.

Never relinquish samples to an unattended shipping location — Confirm delivery date and time with the shipping attendant when dropping off coolers.



Track movement of all shipments — Even if using preprinted shipping labels, sign up for the carrier's shipment delivery exception notifications by text message.

Confirm delivery with RECIPIENT — Once notified, contact the lab to ensure the cooler was delivered to the right building, suite, etc. and that the contents were intact.

If you are cutting it close or miss the shipping cut-off:


https://local.fedex.com/en-us

Drop samples off at the carrier's main airport facility — (typically open the latest) if shipping late in the day. Search carrier's website to find closest open location.

If you miss the shipping cutoff — Keep the samples in your possession, add fresh ice and ship them the next day. **ALWAYS REPLACE ICE PRIOR TO SHIPPING.**

Still have questions? Contact your Project Manager for further instructions.

Title: Decontamination of Non-Dedicated Sampling Equipment

1. Purpose/Scope

This Standard Operating Procedure (SOP) describes procedures for the initial decontamination of non-dedicated sampling equipment or for field decontamination of non-dedicated equipment that comes into contact with environmental media.

2. References

ASTM D5088-15a: Standard Practice for Decontamination of Field Equipment Used at Waste Sites

ASTM D5088-90: Standard Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites

3. General

Check the sampling plan to determine if equipment blank rinsate (samples) are required. See QA-1.1 “Collection of Field QA/QC Samples.”

4. Equipment/Materials

- Personal Protective Equipment (PPE) as detailed in the site-specific Health and Safety Plan (HASP)
- Rinse and wash water containment (clean 5-gallon plastic pail) or larger containment depending on site-specific circumstances
- Wash and rinse brush constructed out of an inert material
- Detergent, non-phosphate detergent solution (Alconox, Liquinox, etc.)
- Distilled or deionized rinse water
- Plastic sheeting

5. Procedure

1. The below procedure is for the decontamination of sampling equipment at non-radioactive sites. Refer to the site-specific HASP and work plan as decontamination procedures and materials used will vary from site to site. Equipment that would require decontamination would

include, but is not limited to: well pumps, re-usable bailers, hand augers, split-spoons, hollow stem augers for drilling and certain PPE.

2. If unsure of cleanliness of equipment, decontaminate prior to use
3. Decontaminate equipment between each use
4. Wash with non-phosphate detergent (Alconox, Liquinox, etc.) and distilled or deionized water
5. Use brush to scrub the exterior of the equipment and if decontaminating a pump, run the detergent through the pump to clean the interior
6. Rinse with distilled or deionized water and if decontaminating a pump run the rinse through the pump to clean the interior
7. Inspect cleaned item thoroughly before using
8. Wrap with inert material if the equipment will not be used immediately
9. If required by regulation, client, or other requirements, containerize water for characterization and disposal. Where allowed, discharge decontamination water into a grass/landscaped area; treating through granular activated carbon (GAC) prior to discharge is a best practice.

6. Records

6.1 Field Notes

The field notes must document all the events, equipment used, and measurements collected during the sampling activities. The field notes must be legible and concise so that the entire sampling event can be reconstructed later for reporting purposes. Reference SOP FM – 1.6 Field Note Documentation for guidance.

Title: Decontamination of Heavy Equipment

1. Purpose/Scope

This standard operating procedure (SOP) describes procedures for the proper decontamination of drilling and excavation equipment used to conduct field investigations. To ensure that chemical analysis results reflect representative concentrations, heavy equipment involved in sampling activities must be properly decontaminated. This will minimize the potential for cross-contamination between sampling locations, and the transfer of contamination off-site.

2. References

GES SOP FM-14.3: Field Personnel Decontamination

GES SOP FM-14.1: Decontamination of Non-Dedicated Sampling Equipment

GES SOP FM-15.1: Containerization and Removal of Remedial Investigation Waste

3. Procedure

All heavy equipment involved in excavation, soil borings, and well installation activities will be decontaminated prior to and after drilling, excavation or sampling. Such equipment includes drilling rigs, backhoes, excavators, down-hole tools, rods, augers, well casings and screens.

3.1.1 Decontamination Procedures

Prior to use and before leaving the site, large equipment, not directly utilized for sampling, will be decontaminated by steam cleaning or pressure washing at a designated area (decontamination pad). This area will be designed to contain decontamination wastes and waste waters. Equipment decontamination pad construction specifics should be discussed with the job subcontractor and GES field leads prior to dispatching to the field.

At certain sites, due to the type of contaminants or proximity to residences, concerns may exist about air emissions from steam cleaning or pressure washing operations. These concerns can be alleviated by utilizing one or more of the following practices:

- Locate the steam cleaning or pressure washing area on-site to minimize potential impacts.
- Enclose steam cleaning or pressure washing operations. For example, augers and rods can be steam cleaned or pressure washed in drums that have been modified. Tarps can also be placed around the cleaning area to control emissions.

The location of the steam cleaning or pressure washing area will be identified in the site-specific work plan. This is a general procedure for decontaminating heavy equipment, which should not supersede the decontamination plan included within the site-specific Health and Safety Plan (HASP). Decontamination requirements vary from site to site depending on circumstances and should be detailed in the site-specific work plan and discussed before conducting the work. Waste produced during decontamination activities should be containerized and classified for proper disposal.

Transport vehicles shall be cleaned as appropriate to prevent tracking of contaminated soil from the site.

Standard Operating Procedure

SOP #: FM-14.3 Rev. 004
Review Date: 06/03/2023
Origin Date: 03/01/2016

Title: Field Personnel Decontamination

1. Purpose/Scope

This Standard Operating Procedure (SOP) establishes the materials and procedures necessary to decontaminate personnel who contact environmental media containing residual contaminants, chemical preservatives, and equipment decontamination solutions.

2. References

NIOSH Pocket Guide to Chemical Hazards, September 2007

3. General

During site activities, personnel could contact soil and/or groundwater that contains site-related contaminants. The site-specific Health and Safety Plan (HASP) should be referenced to review all contaminants including decontamination solutions that may be encountered at a site.

Direct contact with site-related contaminants is not expected due to the controls incorporated in the various SOPs. However, contact could occur if personnel fail to wear the specified Personal Protective Equipment (PPE) as detailed in the HASP.

4. Equipment/Materials

- PPE as specified in the HASP
- Eye wash and rinse, which is required to be included within all GES vehicles
- Minimum 2 gallons potable water
- Mild soap and water solution (0.5 L)
- Cloth diapers, paper towels or equivalent
- Materials including plastic tarp or similar, to construct a decontamination zone and collect decontamination waste
- Coveralls (2 pair)—large enough to fit the largest person who may handle chemicals
- Disposable over boot/boot covers

5. Preparation

1. The personnel decontamination equipment must be staged, ready for use, and close to the area where contact with chemical preservatives and decontamination solutions occur.
2. For non-hazardous waste sites, collection of the personnel decontamination waste water (and soap/water) is not necessary. Cloth diapers or equivalent may be disposed of as nonhazardous solid waste. Waste Management Plans are to be followed for the collection of and disposal of personnel decontamination waste water and related solid waste from Areas of Concern (AOCs) containing RCRA hazardous waste.
3. A minimum of 2 gallons of flush water and 0.20 gallons of a mild soap solution shall be initially established for decontamination. While working in cold climates, precautions should be taken to be sure decontamination water does not freeze. Any used water shall be immediately discarded and replaced prior to proceeding with work subsequent to decontamination. Replenish soap prior to being depleted by 50%.
4. An eye wash station shall also be established with its self-contained water source. In most cases this can be the eye wash materials provided within a GES vehicle. If a more permanent station is needed on-site, a clean area away from site activities shall be set up. Consult the Regional Health and Safety Officer (RHSO) for details on a fixed eye wash station needs.

6. Procedure

6.1 Eye Contact

- Only water shall be used to flush the eyes, unless administered by emergency personnel.
- If any environmental medium as stated in the HASP, equipment decontamination solution, or other material contacts the eye(s), immediately wash the eye(s) with large amounts of water, occasionally lifting the lower and upper lids. Subsequently, report the situation to the GES project manager and the assigned Health and Safety Officer (HSO). If necessary, contact emergency personnel for first aid followed by immediately contacting the GES RHSO to report the occurrence.

6.2 Skin Contact

- The HASP shall be reviewed prior to conducting site activities so that skin hazards can be identified and planned for in the event that cleaning of the skin is required. Skin contact with environmental media such as soil or groundwater outside of the areas of concern does not require immediate attention. In the event skin contact is made with a constituent outlined in the HASP, the affected area shall be immediately cleaned as outlined in the HASP.
- Notify the GES RHSO of all instances of skin contact with a constituent of concern as listed in the HASP.

6.3 Clothing Contact

- Personal clothing contacted by the constituents outlined in the HASP should be decontaminated immediately or removed and the skin under the wetted portion of the clothes shall be washed as specified in the HASP. The clothes must be washed prior to reuse.
- Notify the GES RHSO of all instances of personal clothing contamination.

6.4 Ingestion

- Ingestion is not considered a very likely mode of contact. However, should ingestion of environmental media occur, rinse the mouth with water (DO NOT SWALLOW) and immediately report the incident to the GES RHSO.
- Critique any ingestion. Do not resume work until the cause is determined and corrected.

6.5 Inhalation

- Inhalation, other than an occasional, brief whiff of vapors is not likely. However, should inhalation occur other than an occasional, brief whiff, move away from the source to fresh air. If breathing has stopped, perform artificial respiration and get medical attention.
- Notify the GES Health and Safety Officer of all events which require movement to fresh air. The Health and Safety Officer shall evaluate the cause and institute appropriate corrective actions.

7. Disposal of Contaminated Materials

All materials and equipment used for decontamination must be disposed of properly as outlined in the Sampling and Analysis Plan (SAP). Clothing (PPE), tools, buckets, brushes, and all other equipment that cannot be reused will be disposed of as discussed in the SAP and waste management plan.

8. Records

8.1 Field Notes

The field notes should document all the events, equipment used and measurements collected during the activities. The field notes should be legible and concise so that the field event can be reconstructed later for future reporting purposes.

9. Follow-Up Activities

Perform the following once field activities are complete.

- Clean and return equipment to the equipment administrator and sign and date the appropriate form.
- Complete purge water and cleaning fluid disposal requirements per the Work Plan.
- Complete the appropriate forms and data sheets. Send a copy to file, along with any field notes.

Standard Operating Procedure

SOP #: FM-15.1 Rev. 004a
Review Date: 06/03/2023
Origin Date: 03/01/2023

Title: Containerization and Removal of Remedial Investigation Derived Waste

1. Purpose/Scope

The objective of this standard operating procedure (SOP) is to establish consistent methods of handling and managing investigation-derived waste (IDW) where not specified in a site-specific work plan. The waste streams are comprised of:

- Solid waste, both hazardous and non-hazardous (e.g., soil cuttings or contaminated debris)
- Liquid waste, both hazardous and non-hazardous (e.g., purged water, rinse water from decontamination processes, product removal)
- Personal protective equipment (PPE) (e.g., gloves, coveralls, boot covers)

Note: GES is not authorized to take ownership of any derived waste unless permitted in writing by the client. This includes signing hazardous waste manifests or non-hazardous bills of lading on behalf of the client.

2. References

Code of Federal Regulations. Title 40: Protection of Environment. Chapter 1 – Environmental Protection Agency, Subchapter I – Solid Wastes, Part 261 – Identification and Listing of Hazardous Waste. Electronic Code of Federal Regulations: https://www.ecfr.gov

Code of Federal Regulations. Title 40: Protection of Environment. Chapter 1 – Environmental Protection Agency, Subchapter I – Solid Wastes, Part 262 – Standards Applicable to Generators of Hazardous Waste. Electronic Code of Federal Regulations: https://www.ecfr.gov

Code of Federal Regulations. Title 40: Protection of Environment. Chapter 1 – Environmental Protection Agency, Subchapter I – Solid Wastes, Part 268 – Land Disposal Restrictions. Electronic Code of Federal Regulations: https://www.ecfr.gov

Code of Federal Regulations. Title 40: Protection of Environment. Chapter 1 – Environmental Protection Agency, Subchapter R – Toxic Substances Control Act, Part 761 – Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions. Electronic Code of Federal Regulations: https://www.ecfr.gov

Code of Federal Regulations. Title 49: Transportation. Subtitle B – Other Regulations Relating to Transportation, Chapter I – Pipeline and Hazardous Materials Safety Administration, Subchapter C – Hazardous Materials Regulations, Part 172 – Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements, and Security Plans, Subpart E – Labeling. Electronic Code of Federal Regulations: https://www.ecfr.gov

3. Scope

This guideline applies to methods and procedures applicable to the containerization and removal of IDW. This guideline **does not apply to radiological waste**.

4. Definitions

Term	Definition
DOT	Department of Transportation
EPA	Environmental Protection Agency
Hazardous Waste	Soil, liquid, or other wastes generated from site investigations that exhibit toxic (human or ecological effects), ignitable, corrosive, or reactive characteristics (D waste), or is derived from a listed (F, K, P or U) waste as defined by applicable federal regulations (at 40 CFR 261) or state regulations.
LDR	Land Disposal Restrictions
Non-hazardous waste	A waste that does not exhibit characteristics of hazardous waste and which is not derived from a listed hazardous waste.
RCRA	Resource Conservation and Recovery Act
TSCA	Toxic Substance Control Act - While TSCA regulates a variety of hazardous chemicals, this SOP will limit its focus to Poly Chlorinated Biphenyls (PCBs). While PCBs are not RCRA hazardous wastes, they must be transported under a uniform hazardous waste manifest. For the purpose of this SOP, PCBs will meet the same management requirements as hazardous wastes.

5. Guidelines

Solid waste should be segregated from the liquid waste and miscellaneous IDW. Solid waste includes excess soil from test pits/excavations, soil cuttings from soil borings, monitoring wells; drilling mud that has been recirculated in a monitoring well; protective clothing (Tyvek, gloves, boots, etc.); sampling equipment (syringes, filters, used bottles, etc.); or other miscellaneous solid material.

Hazardous waste determinations are the responsibility of the waste generator (typically the responsible party/client), and may be based upon knowledge of the process through which the waste is generated or on laboratory analysis. The GES project lead will classify a given waste stream as hazardous or non-hazardous prior to its removal from the site for off-site disposal. The GES Project Manager will inform the client of the waste classification and will coordinate proper containerization, labeling and procurement of an off-site disposal facility.

5.1 Waste Separation

Liquid waste should be containerized separately from solid waste. For this guideline, liquid waste includes purge/well development water and decontamination fluids, and sample preservatives only, while solid waste includes soil, drilling mud, and sampling debris. The drum log sheet must be completed and must document the waste type in each drum (see **Attachment A**).

5.1.1 Solids

Solid waste needing to be containerized must be placed in DOT-specified, 17H 55-gallon drums or other DOT-approved waste transport containers. For the collection of solid waste in drums, allow at least 12-18 inches of empty space in each drum. This will facilitate the addition of absorbent, if necessary, as well as reduce the weight for ease of handling. The following solid material should be handled as described:

Soil Cuttings

Drums of soil cuttings should be identified with a particular boring, well, or pit. However, to minimize the number of drums generated during an investigation, it may be necessary to mix soils from several sources, provided those sources are from the same general location, and contain similar (compatible) contaminants. Documentation must be maintained to identify the source of the soils (including depths) containerized in a particular drum. The documentation shall specify which samples sent for laboratory analysis correspond to the drum contents. The description of the waste/soil, boring location, and general observations should also be noted in the field logbook. The logbook control number and page where the drum waste is described should be noted in the drum log sheet (see **Attachment A**).

Drilling Mud

Drilling muds are defined as those materials/additives required during the reaming of boreholes to maintain the integrity of the borehole wall and/or to expedite the drilling of the borehole. Though generally fluid in nature, these muds will be referred to as solids in this document. Drilling mud should preferably be isolated from soil cuttings. However, it is acceptable to combine drilling mud with soil cuttings to reduce the number of drums. In either case, careful documentation shall be made in the field logbook and the drum log sheet indicating which wells the drilling mud came from. If samples of the mud were collected and sent for analysis, then the documentation should indicate which samples correspond to the contents of the drum and adequate information included in the drum log sheet. (See **Attachment A**).

Other Drilling Materials

Drilling materials such as filter pack sand or bentonite grout/seals that have not been in contact with site soils or water should not be handled in a manner similar to hazardous waste. If these materials are containerized for the purpose of tidiness, then they should be clearly marked as non-hazardous, and stored in a separate area from the other drums. These drums should be removed from the site by the drilling subcontractor.

Protective Clothing and Sampling Equipment

Certain client programs may require drumming of PPE. If this is applicable, after proper decontamination, protective clothing and used disposable sampling equipment should be drummed together and separated from other solid and liquid wastes. Protective clothing and sampling equipment is typically collected on a daily basis in plastic garbage bags and disposed of at the end of daily activities in a drum dedicated for this type of waste. With the exception of footwear, PPE worn by observers or other site personnel who do not come in contact with contaminated media can be disposed of with domestic waste, which may include lunch wrappers, papers, etc. Disposable footwear should always be containerized in drums for proper disposal.

5.1.2 Liquids

For this guideline, liquid waste refers to monitoring well purge/development water and decontamination fluids. If containerization is necessary to facilitate off-site transport, then the preferred methods are to use 55-gallon drums or welded tanks.

Well Purge/Development Water

Well purge and development water should be containerized separately from soil cuttings, drilling mud, protective clothing, or other solid waste. Documentation shall be maintained to track drum samples sent for analysis with waste contained in a particular drum. It is acceptable to mix water from different wells, provided that proper documentation is maintained, that non-hazardous materials are not mixed with hazardous materials, and that contaminants are similar and compatible. However, the disposal of the mixed water will depend on the quality of the most contaminated well. Groundwater from upgradient wells or other wells expected to show groundwater concentrations at or below current detection levels may be discharged on-site, if so authorized, or, if site conditions warrant drumming, this groundwater should be containerized separately from known or suspected contaminated water.

Decontamination Water and Sample Preservatives

Decontamination water, including decontamination fluids such as acetone or nitric acid, if utilized, can be containerized with well purge/development water. Excess sample preservatives can be included with these decontamination fluids. Notations on preservative type should be made in the logbook and drum log sheet (See **Attachment A**). Waste characterization sampling should be completed in accordance with was disposal facility requirements.

Steam cleaning rinsate should be containerized separately from other liquids, such as well purge/development water, unless it is documented that the rinsate is non-hazardous.

5.2 On-Site Handling

All filled or partially filled drums must be properly closed, sealed, labeled, and staged before demobilization of the remedial investigation operations. If storage is anticipated in excess of two weeks, the drums should be covered with a wind/rain resistant cover such as a plastic or polyethylene tarp. See checklist in **Attachment B** for preparation of drums for shipment.

If drums contain a hazardous waste or PCBs, labelling should be in accordance with 40 CFR 262.31 and 49 CFR part 172 subpart E (labeling).

5.2.1 Staging

All drums shall be staged in a location that is approved in advance by the client or facility manager. Depending upon the accessibility of the site to unauthorized individuals, the staging area might need to be fenced in or located inside a larger fenced area. All drums shall be stored on pallets or other firm, suitable surfaces in an area where they will stay dry in the case of heavy rain or ponding of water. The drums should be grouped by waste type, arranged in rows of two pallets with adequate space between rows, and with labels in clear view. This will allow access to each drum and minimize the need to move or rearrange drums. Drums are not to be stacked on top of each other. Equipment must be available to move filled drums, including backhoes, front-end loaders, or drum grapplers. Caution should be exercised to prevent damaging drums. Any drums found to be damaged or leaking upon inspection must be overpacked (drum numbers should be marked on the overpack drums).

The number and types (e.g., soil cutting, purge water) must be accurately reported in field notes on a daily basis with a total provided at completion of the work. The project manager is responsible for tracking staged waste and complying with onsite storage time limits as they pertain to state and federal regulations.

5.2.2 Sealing

Proper sealing involves securing and fastening the bungs. It should be noted that rings are delivered fastened with the bolt on the upper side of the drum lid, which is a universal convention indicating an empty drum. When the drums are filled, rings should be fastened with the bolt on the lower side of the ring and fastened over the drum lip. Depending on the access of the site to unauthorized individuals, it is appropriate to notch the drum and ring to assist in determining whether stored, unsecured drums have been opened. If a drum needs to be opened after sealing, Level C or B PPE shall be required, unless the drum is known to contain non-hazardous material.

5.2.3 Labeling

Initial labeling of all drums shall be performed through the use of indelible marking on both the top and side of the drum (about 6 inches below the bolt). The label should be at least 6 inches in height and consist of a number that will allow the drum to be cross-referenced with the field logbook and the drum log sheet (see **Attachment A**).

Upon receipt of the sample characterization analyses, final labeling of the drums will occur and should consist of a purchased factory label that will prevent easy removal by erasure, washing, or dissolving, and will provide space for the following information:

- Site Name and Drum Log Number
- Material Description (soil, sludge, etc.)
- Waste Code (RCRA, TSCA, State)
- Generator's Name and Address
- Date Generated
- DOT Shipping Name (if known)
- Generator's Temporary ID Number (if known)
- Manifest Number (if known)

Drums should be labeled and the accumulation date noted on the label. The waste removal subcontractor may perform additional labeling for transport.

5.2.4 Sampling

When sampling of the drums is required to characterize the waste, an effort should be made to distinguish drum lots. In order to reduce the total number of samples analyzed, composite samples may be collected from drums with similar characteristics, so long as they contain waste from the same source area (i.e. monitoring well or excavation). The procedure for drum opening and sampling is described in SOP FM-20.1 (Waste Sampling) and is summarized briefly in the following:

- Inspect the drums to determine their conditions and whether they contain potentially explosive substances.
- Move one drum at a time to a staging and sampling area with adequate ventilation.
- Open drums by remote means (except as noted in **Attachment A**, and SOP FM-20.1) using one of three types of equipment: the bung spinner, the remote controlled drill, and the drum piercer.
- Use special handling techniques leaking or deteriorated drums, bulging drums, etc. (SOP FM-20.1 Waste Sampling).
- Follow sampling procedures described in SOP FM-20.1, Section 5.

5.3 Waste Classification

Analytical data specifically relating to the drum contents is used to determine the waste classification. The analytical results of the samples of a particular medium can be used as an indication of the contents of a drum. Careful separation of wastes and proper documentation will prevent the need for drum sampling. In the case that drum sampling is performed, the results of one drum sample cannot be used to infer the contents of an unsampled drum. Therefore, to minimize the expense of sampling, careful documentation and labeling should be completed.

RCRA defines a hazardous waste as a solid waste (which may include solids, liquids, semi-solids or gaseous material) that, because of its identity or characteristics, may pose a hazard when improperly treated, stored, disposed of, or otherwise mismanaged. To be considered hazardous, a waste must either be listed, must demonstrate one of the four characteristics of a hazardous waste (ignitability, corrosivity, reactivity or toxicity—i.e., fails TCLP tests), or must be a mixture of or derived from a listed waste (see 40 CFR 261).

A determination must be made by the project lead to determine if the waste is a RCRA hazardous waste and if the land disposal restrictions (LDR) are applicable requirements. For listed hazardous waste, this determination will require either specific information about the waste (e.g., source, prior use, process type) or actual sampling results. Compare against Subpart D of 40 CFR 261 to determine if the waste falls under one of the following categories:

- F Waste Codes (Part 261.31)
- K Waste Codes (Part 261.32)
- P Waste Codes (Part 261.33(e))
- U Waste Codes (Part 261.33(f))

For characteristic wastes, the project lead may rely on the results of the tests described in 40 CFR 261.21 – 261.24 for each characteristic or on the knowledge of the properties of the substance. The project lead should work with the client, as appropriate, in making these determinations.

If a drum contains a mixture of a listed hazardous waste (as defined by RCRA) and non-hazardous waste, then the entire contents of the drum must be considered hazardous and subject to RCRA regulations. If a characteristic waste is mixed with a non-hazardous waste or other material, analysis must be performed to determine whether the mixture still exhibits the characteristic. In the case of a boring or well with distinct zones of contamination, proper documentation is necessary to determine which drums contain contaminated portions of soil cuttings and/or drilling mud. If the depths of particular cuttings or drilling mud cannot be accurately identified, then all drums which contain cuttings or mud from a contaminated boring or well must also be considered hazardous.

Dilution of a known volume of characteristically hazardous water may result in that volume becoming non-hazardous if chemical analyses exist to support that claim. If there is not sufficient analytical data to show that the aqueous solution is non-hazardous, the material should be classified as hazardous waste. Mixing a volume of listed hazardous water with non-hazardous water will not remove the listing, and will increase the volume of listed hazardous waste. If the pH of a liquid is less than 2 or greater than 9, metal drums should be lined with polyethylene (or other suitable liner) prior to filling, or fiberglass containers should be used.

If rinsate has been used to decontaminate sampling material which has come into contact with a listed hazardous waste, that rinsate must be managed as listed hazardous waste.

If wastes contain PCBs, it is important to consider whether the waste is regulated under TSCA (see 40 CFR 761). Material containing total PCBs at concentrations greater than or equal to 50 parts per million (ppm) are considered TSCA-regulated waste and must be handled and disposed according to 40 CFR 761. If the waste is considered a RCRA hazardous waste and contains PCBs, it may be regulated under the LDR (40 CFR 268). If RCRA waste (liquid or non-liquid) contains total halogenated organic compounds (as listed in the LDR and including PCBs) at concentrations greater than 1,000 ppm, it is subject to the LDR under 40 CFR 268. The LDR also restricts land disposal of a liquid RCRA hazardous waste containing PCBs at 50 ppm or greater.

If proper decontamination steps are followed, protective equipment, clothing, and/or miscellaneous sampling equipment solid wastes may be considered non-hazardous.

5.4 Drum Disposal

Drummed wastes determined to be non-hazardous must be removed. For example, the emptying of a large number of drums or tanks of water on a hazardous waste site in a residential area could attract unwanted attention. On-site disposal of large volumes of non-hazardous soil cuttings may be completed by backfilling an excavated area or by spreading evenly over a wide, unused area, if available. The final decision regarding on-site disposal should be made by the client, and must be made on a site-specific basis. Non-hazardous wastes that cannot be disposed of on-site must be removed as residual wastes.

Non-regulated solid waste and hazardous solids that are not subject to LDR can be sent to an approved Subtitle D licensed landfill, or depending upon state regulations, to a permitted recycling facility for beneficial reuse. Hazardous solids subject to LDR must receive treatment (to meet specified treatment standards) prior to disposal in a Subtitle C landfill. Treatment can be performed on-site during a remedial action; however, in many cases the need to remove the drums precedes the site remediation, and off-site treatment is necessary.

Drummed hazardous liquid waste may also be treated. This treatment may also be performed on-site during a remedial action, but this material may require removal prior to site remediation. On-site disposal options for non-hazardous liquids include disposal on the ground in relatively remote areas, into the sewer system in residential or populated areas, or into a nearby stream. Any applicable discharge permits must first be obtained and regulatory suspended solids criteria met. If on-site disposal is not practical, or if discharge permits cannot be obtained, then the non-hazardous liquids should be treated as non-regulated waste by an appropriate facility.

5.5 Drum Removal

Removal of drums from a site should be performed only by subcontractors holding licenses/permits approved by federal and state authorities to transport hazardous materials. In most cases, the various categories of wastes will be transported to one of several destinations. It is the responsibility of GES personnel to assure that these wastes are properly categorized and to know their final destination. Furthermore, the PM or project lead must coordinate with the client regarding the wastes' final destination. In many cases, the client will have a list of pre-approved disposal facilities. Although it is not required, subcontractors may be used to classify the waste, complete the waste profile sheets, perform confirmatory drum sampling, inspect/overpack (if necessary), and complete shipping manifest forms. The manifests should be signed by the client unless a waste agent agreement is in place and in writing allowing GES to sign "on behalf of" the client. This agreement must be in place prior to any GES signature.

For removal of drums off-site, the following procedures must be followed:

1. A completed waste profile sheet for each waste stream must be completed. For example, if there were 60 drums on-site, and 15 contain wastewater, 25 contain soils and 20 contain debris, then waste profile sheets should be provided for each batch (i.e., there are three waste streams here).
2. The actual or potential destination(s) and type of disposal (incineration, aqueous treatment) of each of the waste streams should be identified.
3. Backup data:

- Copies of the applicable laboratory analysis. (In the case of RI-derived wastes this may be the result of direct drum sampling or the results of field sampling of materials representative of the contents of the drums.)
- If the material to be disposed was not directly sampled, the backup file must identify the process used to characterize the composition of the waste (e.g., the characterization may be an estimate based on the highest concentrations of contaminants in soils/sludge/liquid samples taken from the locations where the waste originated).

4. Copies of Profiles, Manifest or Land Ban Records which are proposed for signature.
5. An analysis memo of how LDR may or may not apply to the waste or subsets of the waste must be attached to the backup file. (See 40 CFR Part 268.7 (a)(1) through (a)(6).) The analysis memo must include:

- How LDR applies to each waste stream. This should take into account case-by-case compliance extensions under 40 CFR 268.5, and exemptions under 40 CFR 268 Subpart C. The analysis memo must cite under which of the sections—such as 40 CFR 268.7(a)(1),(2),(3),or (4) LDR—the records will be prepared.
- If LDR applies, the information specified in the regulations must be provided in a Land Ban Notification. For example, complying with 40 CFR 268.7(a)(1) would require providing:
    - EPA Hazardous Waste Number
    - Corresponding treatment standards and all applicable prohibitions set forth in 40 CFR 268.32 or RCRA Section 3004 (d)

- Manifest number associated with the shipment of waste
- Waste analysis data, where available

- If signature of the Certification at 40 CFR 268.7(a)(2)(ii) is anticipated, the analysis memo must show specifically how it was determined that the waste complies with the treatment standards specified in 40 CFR 268 Subpart D and all applicable prohibitions set forth in 40 CFR 268.32 or RCRA Section 3004 (d).

6. Health and Safety

Appropriate PPE is needed for each situation. PPE for drums of known contents are not the same as PPE requirement for drums of unknown contents. Refer to the site-specific Health and Safety Plan (HASP) and task scope for PPE details. If unsure, do not proceed until you have confirmed PPE needs with the PM and regional health and safety officer (RHSO). The RHSO should be informed that these activities will be performed. Approval to perform these operations in any health and safety level other than Level B protection must be authorized by the company Health and Safety Director. The approval will depend upon the documentation of the contents of the drums, the availability of analytical results of the drums, and the affirmation by the project lead that the drums have not been opened or tampered with by unauthorized individuals.

Attachments

Attachment A – Drum Log Sheet

Attachment B – Checklist for the Preparation of Drums for Shipment

Attachment A – Drum Log Sheet

Project Number:________________________ Site Name:____________________________ Site Location:__________________________

Drum Number	**-Waste Description** (Solid, Liquid) **- General Characterization** **- Field Logbook Number / Page**	**Absorbent Added** (Type & Depth)	**Sample Info** (Sample Number, Analyses)	**Comment or Other Descriptive Information** (Well, Boring, Pit Number, Depths, Date Sampled/Drummed)

____

FS Signature

Attachment B – Checklist for Preparation of Drums For Shipment

	Checklist for Preparation of Drums for Shipment
☐	Number of Drums Liquid Solid (soil or sludge) Debris
☐	Collect a grab or composite sample from each drum or group of drums, if other comparable analyses are not available
☐	Initiate the transportation/disposal subcontract
☐	Add absorbent to sludge-containing drums, if necessary
☐	Secure the ring top with screw down
☐	Apply seal over ring or notch ring/drum to prevent unaccountable entry
☐	Complete drum inventory log sheet (**Attachment A**)
☐	Label each drum/cross-reference with log sheet
☐	Cover the drums with plastic or tarp
☐	Tie down drum cover

Title: Waste Sampling

1. Purpose/Scope

The purpose of this SOP is to describe equipment and procedures that can safely be used to collect waste samples.

2. References

ASTM D6232-21: Standard Guide for Selection of Sampling Equipment for Wastes and Contaminated Media Data Collection Activities, 2021.

ASTM D6009-19: Standard Guide for Sampling Waste Piles, 2019.

ASTM D6051-15: Standard Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities, 2015.

ASTM D4547-15: Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds, 2105.

3. General

RCRA Hazardous wastes are regulated by US EPA under 40 CFR Parts 260-265. As a result, many of the methods used to manage, store, treat, and dispose hazardous wastes and potential hazardous wastes are of concern to both the regulators and the regulated community. The generator of a solid waste is required to determine whether that waste is RCRA hazardous, either by knowledge of the waste's origin, via sampling and analysis, or through a combination of the two. Consequently, Sample collection is often required. While it is understood that each facility and waste stream may present its own unique sampling and analytical challenges, this section will list equipment and procedures that have been used to safely and successfully sample specific waste units.

4. Equipment/Materials

Waste streams may vary depending on how, when, and under what conditions a waste was generated and stored. Also, the physical location of the wastes or the storage/collection unit configuration may prevent the use of conventional sampling equipment. Any deviations from the sampling plan or difficulties encountered in the field concerning sample collection should be documented in a log book, reviewed with the analytical data, and presented in the report.

4.1 Sampling Equipment

Waste sampling equipment should be made of non-reactive materials that will neither add to nor alter the chemical or physical properties of the material that is being sampled. **Table 1**, provided as an attachment to this SOP, lists some conventional equipment for sampling waste units/phases and some potential limitations of the equipment.

4.2 Ancillary Equipment for Waste Sampling

In addition to the equipment listed in **Table 1**, ancillary equipment may be required during the sampling for safety and/or analytical reasons. Some examples include glass mixing pans, particle size reducers, remote drum opening devices, and spark resistant tools. Any influences that these types of ancillary equipment may have on the data should be evaluated and reported as necessary.

The collection of auxiliary information and data is particularly important when collecting waste samples. Any field analyses or field screening results should be recorded in a logbook. Sketches of waste units, sampling locations, containers, tanks and ancillary equipment, markings/labels, etc., should be fully documented in logbooks. Photographs are extremely useful for recording this information and may be used during waste sampling operations. A photographic log should also be maintained.

5. Procedure

5.1 Waste Unit Types

Waste management units can be generally categorized into two types: open and closed. In practice, open units are larger than closed units. Open units include waste piles and surface impoundments whereas closed units include containers and tanks as well as ancillary tank equipment. Besides containers and tanks, sumps may also be considered closed units because they are designed to collect the spillage of liquid wastes and are sometimes configured as a confined space. Sampling of closed units is considered a higher hazard risk because of the potential of exposure to toxic gases and flammable/explosive atmospheres. Because closed units prevent the dilution of the wastes by environmental influences, they are more likely to contain materials that have concentrated levels of hazardous constituents.

Note: While opening closed units for sampling purposes, investigators shall use Level B personal protective equipment (PPE), along with air monitoring instruments to ensure that the working environment does not contain hazardous levels of flammable/explosive gasses or toxic vapors, and follow the appropriate safety requirements stipulated in the site-specific Health and Safety Plan (HASP).

Buried waste materials should be located and excavated with extreme caution. Once the buried waste is uncovered, the appropriate safety and sampling procedures utilized will depend on the type of waste unit.

5.1.1 Open Units

While open units may contain many types of wastes and come in a variety of shapes and sizes, they can be generally regarded as either waste piles or surface impoundments. Definitions of these two types of open units from 40 CFR Part 260.10 are:

- Waste pile- any non-containerized accumulation of solid, non-flowing hazardous waste that is used for treatment or storage and that is not a containment building.
- Surface impoundment- a facility or part of a facility which is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), which is designed to hold the accumulation of liquid wastes or wastes containing free liquids, and which is not an injection well. Examples of surface impoundments are holding, storage, settling and aeration pits, ponds, and lagoons.

The nature of the waste will also determine the mode of delivering the waste to the unit. Wastes are commonly pumped or gravity fed into impoundments while heavy equipment or trucks may be used to dump wastes in piles. Once the waste has been placed in an open unit, the state of the waste may be altered by environmental factors (e.g., temperature, precipitation). Surface impoundments may contain several phases, such as floating solids, liquid phase(s), and sludges. Waste piles are usually restricted to solids and semi-solids. All of the potential phases contained in a waste unit should be considered in developing the sampling plan.

5.1.2 Closed Units

There are a variety of designs, shapes, sizes, and functions of closed units. In addition to the challenges of the various designs and the safety requirements for sampling them, closed units are difficult to sample because they may contain liquid, solid, semi-solid/sludge, or any combination of phases. Based on the sampling plan, it may be necessary to obtain a cross sectional profile of the closed unit in an attempt to characterize the contents. The following are definitions of various closed waste units.

- Container - any portable device in which a material is stored, transported, treated, disposed, or otherwise handled. Examples of containers are drums, overpacks, pails, totes, and roll-offs.
- Tank - a stationary device designed to contain hazardous waste, and usually constructed of metal, fiberglass, or plastic. Portable tanks, tank trucks, and tank cars vary in size and

may range from simple to extremely complex designs. Depending on the unit's design, it may be convenient to consider some of these storage units as tanks for sampling purposes even though they meet the definition of a container.

- Ancillary equipment (tank) - any device including, but not limited to, such devices as piping, fittings, flanges, valves, and pumps that is used to distribute, meter, or control the flow of hazardous waste from its point of generation to a storage or treatment tank(s), between hazardous waste storage and treatment tanks to a point of disposal on-site, or to a point of shipment for disposal off-site.
- Sump - any pit or reservoir that meets the definition of a tank and those troughs/trenches connected to it that collect hazardous wastes (some outdoor sumps may be considered open units).

Although any of the closed units may not be completely sealed and may be partially open to the environment, the unit needs to be treated as a closed unit for sampling purposes until a determination can be made. Once a closed unit is opened, a review of the proposed sampling procedures and level of protection can be performed to determine if the PPE is suitable for the site conditions.

Note: Samples collected from different waste units should not be composited into one sample container without additional analytical and/or field screening data to determine if the materials are compatible and will not cause an inadvertent chemical reaction.

5.2 Waste Sampling Procedures

In most cases, a preliminary characterization of the constituents in and hazards associated with a waste stream may performed, based upon the type of facility/process which has generated the waste stream. This preliminary characterization should be taken into account when developing a sampling plan.

5.2.1 Waste Piles

Waste piles vary in size, shape, composition, and compactness, and may vary in distribution of hazardous constituents and characteristics (strata). These variables will affect safety and access considerations. The number, type, and location of samples should be based on the sampling plan. Commonly used equipment for waste pile sampling is listed in **Table 1**. All equipment must be compatible with the waste and cleaned to prevent any cross contamination of the sample.

5.2.2 Surface Impoundments

Surface impoundments vary in size, shape, and waste content, and may vary in distribution of hazardous constituents and characteristics (strata). The number, type, and location of samples should be based on the sampling plan. Commonly used equipment for surface impoundment sampling is listed in **Table 1**. All equipment must be compatible with the waste and cleaned to prevent any cross contamination of the sample.

Note: Because of the potential danger of sampling waste units suspected of containing elevated levels of hazardous constituents, personnel should never attempt to sample surface impoundments used to manage potentially hazardous wastes from a boat. All sampling should be conducted from the banks or piers of surface impoundments. Any exception must be approved by the Regional Health and Safety Office (RHSO) and the Vice President of HSSE.

5.2.3 Drums

Drums are the most frequent type of containers sampled by field investigators for chemical analyses and/or physical testing. Caution must be exercised by the field investigators when sampling drums because of the potential presence of explosive/flammable gases and/or toxic vapors. Therefore, the following procedures should be used when collecting samples from drums of unknown material.

1. Visually inspect all drums being considered for sampling for the following:

- Pressurization (bulging/dimples)
- Crystals formed around the drum opening
- Leaks, holes, stains
- Labels, markings
- Composition and type (steel/poly and open/bung)
- Condition, age, rust
- Sampling accessibility

Drums showing evidence of pressurization and crystals should be furthered assessed to determine if remote drum opening is necessary. If drums cannot be accessed for sampling, heavy equipment is frequently used to stage drums for the sampling activities. Adequate time should be allowed for the drum contents to stabilize after a drum is handled.

2. Identify each drum that will be opened (e.g., paint sticks, spray paint, cones).

   Note: LEVEL B protection is required for the following procedures.

3. Before opening, ground each metal drum that is not in direct contact with the earth using grounding wires, alligator clips, and a grounding rod or metal structure. If a metal drum is in an overpack drum, the metal drum inside should be grounded.

4. Touch the drum opening equipment to the bung or lid and allow an electrical conductive path to form. Slowly remove the bung or drum ring and/or lid with spark resistant tools (brass/beryllium).
5. Screen drums for explosive gases and toxic vapor with air monitoring instruments as the bung or drum lid is removed. Depending on site conditions, screen for one or more of the following:

- Radioactivity
- CYANIDE fumes
- halogen vapors
- pH
- Flash point (requires small volume of sample for testing)

Note the state, quantity, phases, and color of the drum contents. Record all relevant results, observations, and information in a logbook, Drum Data Form or Drum Data Table. **Figure 1**, provided as an attachment to this SOP, is an example of a Drum Data Form. Review the screening results with any pre-existing data to determine which drums will be sampled.

6. Select the appropriate sampling equipment based on the state of the material and the type of container. Sampling equipment should be made of non-reactive materials.
7. Place oil wipe (as necessary), sampling equipment, and sample containers near drum(s) to be sampled.

   Note: Air monitoring for toxic vapors, explosive gases and oxygen deficient atmospheres should be conducted under the guidance of a site-specific HASP during drum sampling.

- For Liquids - Slowly lower the composite liquid waste sampler (COLIWASA) or drum thief to the bottom of the container. Close the COLIWASA with the inner rod or create a vacuum with the sampler's gloved thumb on the end of the thief and slowly remove the sampling device from the drum. Release the sample from the device into the sample container for analysis. Repeat the procedure until a sufficient sample volume is obtained.
- For Solids/Semi-Solids - Use a push tube, bucket auger, screw auger, or, if conditions permit, a pneumatic hammer/drill to obtain the sample. Carefully use a clean stainless steel spoon to place the sample into the sample container for analysis.

8. Close the drums when sampling is complete. Segregate contaminated sampling equipment and investigative derived wastes containing incompatible materials as determined by the drum screening procedure (Step #5). At a minimum, contaminated equipment should be cleaned with laboratory detergent and rinsed with tap water prior to returning it from the field. Wastes should be managed according to SOP FM 15.1.

5.2.4 Tanks

Sampling tanks is considered hazardous due to the potential for large volumes of hazardous materials-appropriate safety protocols must be followed. Unlike drums, tanks may be compartmentalized or have complex designs. Preliminary information about the tank's contents and configuration should be reviewed prior to sampling to ensure the safety of personnel and the success of the sampling plan. In addition to having discharge valves near the bottom of tanks and bulk storage units, most tanks have hatches at the top. It is desirable to collect samples from the top hatch because of the potential for waste stratification. Additionally, discharge valves can get stuck or broken, causing an uncontrolled release. Investigators should not utilize valves on tanks or bulk storage devices unless they are operated by the owner or operator of the facility, or a containment plan is in place should the valve stick or break. If the investigator must sample from a tank discharge valve, the valve arrangement of the particular tank must be clearly understood to insure that the compartment(s) of interest is sampled. Because of the many different types of designs and materials that may be encountered, only general sampling procedures that outline sampling a tank from the top hatch are listed below.

1. All relevant information concerning the tank such as the type of tank, the tank capacity, markings, condition, and suspected contents should be documented in a logbook.
2. The samplers should inspect the ladder, stairs, and catwalk that will be used to access the top hatch to ensure that they will support the samplers and their equipment.

   Note: LEVEL B protection is required for the following procedures.

3. Before opening, ground each metal tank using grounding wires, alligator clips, and a grounding rod or metal structure.
4. Any vents or pressure release valves should be slowly opened to allow the unit to vent to atmospheric pressure. Air monitoring for explosive/flammable gases and toxic vapors should be conducted during the venting and the results recorded in a log book. If dangerous concentrations of gases escape from the vent or the pressure is too great, leave the area immediately.
5. Touch tank opening equipment to the bolts in the hatch lid and to allow electrical conductive path to form. Slowly remove bolts and/or hatch with spark resistant tools (brass/beryllium). If a pressure buildup is encountered or detected, cease opening activities and leave the area.
6. Screen tanks for explosive/flammable gases and toxic vapors with air monitoring instruments. Depending on the sampling plan and site conditions, conduct characteristic screening (e.g., pH, halogen) as necessary. Collect a small volume of sample for flash point testing, if warranted. Note the state, quantity, number of phases, and color of the tank contents. Record all relevant results, observations, and information in a logbook.

Compare the screening results with any pre-existing data to determine if the tank should be sampled.

7. Select the appropriate sampling equipment based on the state of the material and the type of tank. Sampling equipment should be constructed of non-reactive materials.
8. Place oil wipe (as necessary), sampling equipment, and sample containers near tanks(s) to be sampled.

Note: Air monitoring for toxic vapors, explosive gases and oxygen deficient atmospheres should be conducted during drum sampling.

- For Liquids - Slowly lower the bailer, bacon bomb, Dipstick, COLIWASA, or Teflon tubing to the desired sampling depth. (NOTE: In work areas where explosive/flammable atmospheres could occur, peristaltic pumps powered by 12V batteries should not be used.) Close the sampling device or create a vacuum and slowly remove it from the tank. Release the sample from the device into the sample container. Repeat the procedure until a sufficient sample volume is obtained.
- For Solids/Semi-Solids - Use a push tube, bucket auger, screw auger, Mucksucker, or, if conditions permit, a pneumatic hammer/drill to obtain the sample. Carefully extrude the sample from the sampling device or use a clean stainless steel spoon to place the sample into sample containers for analysis.

9. Close the tank when sampling is complete. Segregate contaminated sampling equipment and investigative derived wastes containing incompatible materials as determined by the screening procedure (Step #6). At a minimum, contaminated equipment should be cleaned with laboratory detergent and rinsed with tap water prior to returning it from the field. Wastes should be managed according to SOP FM-15.1.

5.2.5 Miscellaneous Contaminated Materials

Sampling may be required of materials or equipment (e.g., documents, building materials, equipment) to determine whether or not various surfaces are contaminated by hazardous constituents, or to evaluate the effectiveness of decontamination procedures. Wipe or swab samples may be taken on nonabsorbent, smooth surfaces such as metal, glass, plastic, etc.

The wipe materials must be compatible with the solvent used and the analyses to be performed, and should not come apart during use. The wipes are saturated with a solvent; methylene chloride, hexane, isopropanol or analyte-free water depending on the parameters to be analyzed. The laboratory performing the analyses can provide the appropriate solvent. Wipe samples should not be collected for VOC analysis. Sampling personnel should be aware of hazards associated with the selected solvent and should take appropriate precautions to prevent skin contact or inhalation of these solvents. All surfaces and areas selected for sampling should be based on the sampling plan. Typically, 10 cm by 10 cm templates are prepared from aluminum foil and secured to the surface of interest. The prepared (saturated with solvent) wipes are removed from their container with tongs or gloves and used to wipe the entire area with firm strokes using only one side of the wipe. The goal is to systematically wipe the whole area. The wipe is then folded with the sample side inward and placed into the sample container.

This procedure is repeated until the area is free of visible contamination or no more wipes remain. Care should be taken to keep the sample container tightly sealed to prevent evaporation of the solvent. Samplers must also take care to not touch the used side of the wipe.

Note: If gloves are used to collect the wipe samples, control samples should be collected to determine if the gloves could potentially contribute constituents to the parameters of interest.

For items with porous surfaces such as documents (usually business records), insulation, wood, etc., actual samples of the materials are required. It is therefore important that evidentiary material is not destroyed. Use scissors or other particle reduction device that have been cleaned as specified in Appendix B to cut/shred the sample. Mix in a glass pan. The shredded, homogenized material is then placed in sample containers.

5.3 Waste Sample Handling Procedures

When collecting samples of concentrated wastes for laboratory analysis, field personnel are required to screen the waste materials to ensure safe handling and transportation of the samples. Safety procedures, sampling and screening methods used to collect the samples must comply with those procedures/methods described in this SOP.

It should be noted that waste samples should not be preserved because of the potential for an inadvertent chemical reaction with the preservative. Additionally, concentrated waste samples are not required to be cooled to 4°C. After samples have been collected and containerized, the outside of the sample containers should be cleaned with water, paper towels and/or oil wipes to remove any spilled material from the exterior of the container. Each sample container should be tagged and sealed, placed in a plastic bag, and the bag securely closed.

Samples collected from materials that did not demonstrate any hazardous characteristics during the screening process may be placed in coolers and handled as non-hazardous samples.

Field investigators will use knowledge gained of site practices and processes, labels and marking on waste containers, field screening results, and personal observations made during their investigation to determine the hazard potential of a sample. Samples considered to be hazardous by the field investigators will be placed in secondary containment for transport to the laboratory and for subsequent handling upon arrival. The tagged, sealed and bagged samples will be placed in a 6-quart plastic pail, packed with vermiculite, and sealed with a tight fitting lid.

The project number for the sampling investigation and the specific sample station number will be marked on the secondary container in indelible ink. A standard hazard communication label will be affixed to the side of the secondary container. The appropriate hazard(s) for the sample (Health, Flammability, and/or Reactivity) will be indicated with an “X”. Additionally, an “X” will be placed in the Protective Equipment section. In addition, each pail should indicate when protective equipment is recommended to handle the actual waste/sample material.

5.4 Particle Size Reduction

Particle size reduction of waste samples is periodically required in order to complete an analytical scan or the Toxicity Characteristic Leaching Procedure (TCLP). Samples that may require particle size reduction include slag, bricks, glass/mirror cullet, wire, etc. Method 1311 (TCLP) states “Particle size reduction is required, unless the solid has a surface area per gram of material equal to or greater than 3.1 cm^2, or is smaller than 1 cm in its narrowest dimension (i.e., capable of passing through a 9.5 mm standard sieve). If the surface area is smaller or the particle size larger than described above, prepare the solid portion of the waste for extraction by crushing, cutting, or grinding the waste to a surface area or particle size as described above” (55 FR 26990).

The method also states that the surface criteria are meant for filamentous (paper, cloth, etc.) waste materials, and that “Actual measurement of the surface area is not required, nor is it recommended”. Also, the loss of VOCs could be significant during particle size reduction. Waste samples that require particle size reduction are often too large for standard sample containers. If this is the case, the sample should be secured in a clean plastic bag and processed using normal chain-of-custody procedures. Note that the tags that will be required for the various containers should be prepared in the field and either inserted into or attached to the sample bag. The bag should then be sealed with a custody seal. The following procedure may be used for crushing and/or grinding a solid sample.

1. Remove the entire sample, including any fines that are contained in the plastic bag and place them on the standard-cleaned stainless steel pan.
2. Using a clean hammer, carefully crush or grind the solid material (safety glasses are required), attempting to minimize the loss of any material from the pan. Some materials may require vigorous striking by the hammer, followed by crushing or grinding. The material may be subject to crushing/grinding rather than striking.

3. Continue crushing/grinding the solid material until the sample size approximates 0.375 inch. Attempt to minimize the creation of fines that are significantly smaller than 0.375 inch in diameter.
4. Pass the material through a clean 0.375-inch sieve into a glass pan.
5. Continue this process until sufficient sample is obtained. Thoroughly mix the sample. Transfer the contents of the glass pan into the appropriate containers.
6. Attach the previously prepared tags and submit for analysis.

Attachments

Attachment A – Drum Data Form

Attachment B – Sampling Equipment for Various Waste Units

Attachment A- Drum Data Form

Date ____________________ Page ______________

Sample Collected: ☐ Yes ☐ No Time ______________

Project No. ________________________ Site Name ______________
City ________________________ State ______________

EPA Drum ID# ____________________ Other Drum ID# ________________________

DRUM OBSERVATIONS

1 Overpack ☐ Yes ☐ No ☐ Metal ☐ Plastic ☐ Other ______________
Size ☐ 85 ☐ 55 ☐ ______

2 Drum ☐ Metal ☐ Plastic ☐ Other ______________
Size ☐ 85 ☐ 55 ☐ ______ Condition ☐ Good ☐ Fair ☐ Poor
Markings / Labels
____
____
____

3 Drum Opening Team ____

4 Estimated Volume ☐ Full ☐ ¾ ☐ ½ ☐ ¼ ☐ Empty

5 Physical Appearance of Drum Contents
Color ____________________ Viscosity ☐ Low ☐ Medium ☐ High
Phased ☐ Yes ☐ No Description ________________________
Other ____

6 Air Monitoring Results
PID ______________ ppm Explosion $\%O_2$ __________ %LEL __________
FID ______________ ppm Halogen ☐ Yes ☐ No
CN ______________ ppm pH ________________________
RAD Mrem

7 Flash Point Sample Collected ☐ Yes ☐ Flash Results At 140°F
No ______________
Hot Wire Test For Halogen ☐ Positive ☐ Negative

8 If Sample was Collected, Name of Collectors ________________________
____

Attachment B - Sampling Equipment for Various Waste Units

Equipment	Waste Units/Phases	Limitations
Scoop with bracket/conduit	Impoundments, piles, containers, tanks/liquids, solids, sludges	Can be difficult to collect deeper phases in multiphase wastes. Depth constraints.
Spoon	Impoundments, piles, containers/solids, sludges	Similar limitations as the scoop. Generally not effective in sampling liquids.
Push tube	Piles, containers/cohesive solids, sludges	Should not be used to sample solids with dimensions >½ the diameter of the tube. Depth constraints.
Auger	Impoundments, piles, containers/solids	Can be difficult to use in an impoundment or a container, or for solidified wastes.
Sediment	Sampler impoundments, piles/solids, sludges	Should not be used to sample solids with dimensions >½ the diameter of the tube.
Ponar dredge	Impoundments/solids, sludges	Must have means to position equipment to desired sampling location. Difficult to decon.
COLIWASA or drum thief	Impoundments, containers, tanks/liquids	Not good with viscous wastes. Devices ≥7' require two samplers to use effectively.
Dipstick/Mucksucker	Impoundments, containers, tanks/liquids, sludges	Not recommended for tanks >11 feet deep. Devices ≥7' require two samplers to use effectively.
Bacon bomb	Impoundments, tanks/liquids	Not good with viscous wastes.
Bailer	Impoundments, tanks/liquids	Only if waste is homogeneous. Not good with viscous wastes.
Peristaltic pump with vacuum jug assembly	Impoundments, tanks/liquids	Cannot be used in flammable atmospheres. Not good with viscous wastes.
Back-hoe bucket	Piles/solids, sludges	May be difficult to access desired sampling location. Difficult to decon. Can lose volatiles.
Split-spoon	Piles/solids	Requires drill rig or direct push equipment.
Roto-hammer	Piles, containers/solids	Physically breaks up sample. May release volatiles. Not for flammable atmospheres.

Standard Operating Procedure

Title: Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling

1. Purpose/Scope

The objective of this standard operating procedure (SOP) is to provide specific direction and guidance for collection of environmental samples for per- and polyfluoroalkyl substances (PFAS) analysis. This SOP includes information applicable for sampling various media for PFAS. Additional procedures and guidance for sampling specific media are included in supplemental companion SOPs. To avoid redundancy, the information presented in this SOP is not repeated in the media-specific SOPs and vice versa. This SOP (FM 22.0) must be used in conjunction with the media-specific SOPs referenced below.

Drinking water (FM 22.1)	Soil (FM 22.7)
Groundwater (FM 22.2)	Sediment and pore water (FM 22.8)
Groundwater treatment systems (FM 22.3)	Sludge and biosolids (FM 22.9)
Surface water and surface water foam (FM 22.4)	Aqueous film forming foam (AFFF) (FM 22.10)
Wastewater (FM 22.5)	Air (FM 22.11)
Leachate (FM 22.6)	Fish and Fish Tissue (FM 22.12)

1.1 PFAS Introduction

PFAS are a group of man-made chemicals that have been manufactured and used in many industries globally since the 1940s. They have been widely used for water, oil/grease, and stain resistance for clothing, carpeting, upholstery, and food packaging; non-stick cookware; firefighting foams used at airports, military facilities, and petroleum refineries and terminals; personal care products and cosmetics; cleaning products; paints, varnishes, sealants, and elastomers; mist suppression (metals plating); and many other industrial uses. PFAS are persistent, bioaccumulative, and mobile in the environment. There are thousands of PFAS chemicals, and only a small percentage of them can currently be analyzed by a laboratory (about 30 individual compounds). PFAS analysis requires extremely low detection limits (parts per trillion), and there are many potential sources of cross-contamination from common equipment, materials, and consumer products.

Following specific PFAS sampling procedures is critical due to the high probability of false positives or elevated results from the large number of cross-contamination sources and low laboratory detection limits. PFAS-containing materials are commonly present during traditional environmental sampling events from personal protective equipment (PPE) to equipment and equipment components to consumable materials to personal care products worn by and food consumed by samplers to the water used during decontamination.

Therefore, PFAS-specific sampling procedures are necessary to produce representative, accurate, and defensible data.

2. References

For additional information pertaining to sampling activities, the user of this manual may reference the following:

- Bartlett, Samuel A and Davis, Katherine L. Evaluating PFAS Cross Contamination Issues. Wiley Periodicals, Remediation. 2018;28:53-57
- BIOEX Laboratory: Foam Sample Analysis. https://www.bio-ex.com/en/our-services/foam-quality-analysis-and-testing/ (March 21, 2021)
- Buckeye Fire Equipment (2019): Sampling and Testing Procedures for Fire Fighting Foam Concentrates
- Department of Defense (DoD) Environment, Safety and Occupational Health Network and Information Exchange (DENIX) (2017): Bottle Selection and other Sampling Considerations When Sampling for Per- and Poly-Fluoroalkyl Substances (PFAS)
- Florida Department of Environmental Protection (FDEP) (2019): PFAS SOP Draft
- Government of Western Australia Department of Environmental Regulation (2016): Interim Guideline of the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)
- Interstate Technology & Regulatory Council (ITRC) (2020): Per- and Polyfluoroalkyl Substances (PFAS)
- Massachusetts Department of Environmental Protection (MassDEP) (2017): Draft Fact Sheet Guidance on Sampling and Analysis for PFAS at Disposal Sites Regulated Under the Massachusetts Contingency Plan
- Michigan Department of Environment, Great Lakes, and Energy (EGLE) (2018): General PFAS Sampling Guidance, Residential Well Sampling, Groundwater PFAS Sampling, Soil PFAS Sampling, Wastewater PFAS Sampling, and Surface Water PFAS Sampling
- Michigan EGLE (2019): Sediment PFAS Sampling, Surface Water Foam PFAS Sampling, Biosolids & Sludge PFAS Sampling, Fish Tissue
- Michigan EGLE (2020): Leachate PFAS Sampling
- Minnesota Pollution Control Agency (MPCA) Petroleum Remediation Program (2017): Groundwater Sample Collection and Analysis Procedures

- Minnesota Pollution Control Agency (MPCA): PFAS Monitoring of Fish, Water, and Sediment. https://www.pca.state.mn.us/waste/pfas-monitoring-fish-water-and-sediment (March 19, 2021)
- National Foam (2020): Sampling Procedure for Foam Concentrates and Proportioning Testing
- New Hampshire Department of Environmental Services (NHDES) (2016): Sampling for Per- and Polyfluoroalkyl Substances/Perfluorinated Chemicals (PFASs/PFCs) at Contaminated Sites
- New York Department of Environmental Conservation (NYSDEC) (2021) Sampling, Analysis, and Assessment of Per- and Polyfluorinated Alkyl Substances (PFAS)
- Ohio Environmental Protection Agency Division of Drinking and Ground Waters (EPA DDAGW) (2020): Standard Operating Procedure for Per- and Polyfluorinated Alkyl Substances Sampling at Public Water Systems, Revision 1.1
- Oklahoma Department of Environmental Quality (DEQ) (2022): Protocols for PFAS Sampling, Standard Operating Procedures, Air Sampling SOP
- Pennsylvania Department of Environmental Protection (PADEP) (2009): Fish Tissue Sampling and Assessment Protocol
- United States Environmental Protection Agency (US EPA) Region 4 Laboratory Service & Applied Science Division (2020): Fish Field Sampling
- United States Environmental Protection Agency (US EPA) Region 4 Science and Ecosystem Support Division (2013): Pore Water Sampling

3. General Practices Applicable for PFAS Sampling

Field sampling for PFAS will follow GES SOPs specific to the task (Section 2 References). PFAS sampling methods may deviate from these SOPs in the selection of field equipment, consumable materials, sample containers, and PPE. If there are discrepancies between this SOP and the referenced SOPs, this SOP shall take precedence. Additionally, if there is a project specific Quality Assurance Project Plan (QAPP) or sampling and analysis plan (SAP), the QAPP and/or SAP shall take precedence over the procedures presented in this SOP should there be discrepancy between them.

While sampling for PFAS does not require use of unique or non-standard equipment, the high potential for cross-contamination during sampling and the low parts per trillion detection limits for PFAS compounds requires specific equipment, materials, sample containers, PPE, and practices to reduce the potential for cross-contamination.

3.1 Equipment/Materials

For PFAS sampling, it is critical that sampling equipment and materials do not contain materials that may themselves be manufactured in processes using PFAS (e.g., Teflon) or when PFAS may adsorb to the material (e.g., LDPE, glass). The table below identifies prohibited and acceptable materials for sampling when one or more PFAS are analyzed. However, the health and safety of personnel are paramount and should not be compromised to prevent cross-contamination. Accordingly, PPE that contains PFAS may be used when site conditions warrant use of such PPE when no other materials that provide the level of protection needed are available; use of such PPE must be recorded in field notes.

Material limitations for sampling equipment, consumable materials, and PPE should focus on those that could potentially directly contact the sample media. Equipment with PFAS-containing or coated parts can be used if the parts are internal to the equipment and are not in direct contact with the external environment or the sample.

☒ Prohibited	☑ Acceptable
Field Equipment	
Teflon-containing materials (tubing, bailers, plumbing tape and paste)	HDPE-containing materials, plumbing tape and paste confirmed to be PFAS-free
LDPE materials including tubing	Acetate liners (direct push)
Waterproof field books	Silicone tubing
Plastic clipboards, binders, spiral hard-cover notebooks	Aluminum or Masonite clipboards
Chemical (blue) ice packs	Ice
Decontamination	
DECON 90	Alconox, Liquinox, Citranox, and/or geotech Field Equipment Cleaner (FEC)
Sample Containers	
LDPE or glass containers	HDPE and polypropylene
Teflon-lined caps	Unlined polypropylene caps
PPE and Field Clothing	
New cotton clothing or synthetic water-resistant, waterproof, or stain-treated clothing	Well-laundered clothing made of natural fibers (cotton preferred)
Tyvek and clothing containing Gore-Tex	Cotton clothing
Clothing laundered using fabric softener	No fabric softener
Boots containing Gore-Tex	Boots made with polyurethane and polyvinyl chloride (PVC)

Standard Operating Procedure

☒ Prohibited	☑ Acceptable
Waterproof or resistant rain gear	Polyurethane or wax-coated materials
Personal Hygiene	
Cosmetics, moisturizers, hand cream, or other related products on the morning of sampling	Sunscreens: Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, Baby sunscreens that are “free” or “natural” Insect Repellents: Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, Off! Deep Woods, Sawyer Permethrin Insect Repellent Treatment for Clothing, Gear, and Tents Sunscreen/insect repellants: Avon Skin-So-Soft Bug Guard Plus – SPF 30 Lotion Clothing: InsectShield Pretreated Clothing
Paper towels	Mechanical hand dryer (after washing hands), instant/waterless hand sanitizer (Purell is fluorinated chemical free)
Other Sampling Considerations	
Water from an on-site well	Potable water from municipal drinking water supply
Food and drink	Bottled water and hydration fluids only; deliver and consume in staging areas only
Post-It Notes, Sharpie and other regular and thick markers	Ball point pens; fine and ultra-fine Sharpie markers can be used to label the empty sample container outside of the sample area provided the lid is on the sample container and gloves are changed after sample container labeling
Aluminum foil	Stainless steel

3.2 Quality Analysis/Quality Control Samples

Use of Quality Assurance/Quality Control (QA/QC) samples is recommended for PFAS sampling projects to support the defensibility of the data. Recommended QA/QC samples should be detailed in the project QAPP and/or SAP. General recommendations are presented in Table 1 and described in this section.

Table 1
Summary of QA/QC Samples

QA/QC Sample Type	Recommended Frequency
Trip Blanks	One per chain-of-custody, per cooler
Field Blanks	One per field sampler (or sampling team if working together to sample the same locations), per day
Equipment (Rinsate) blanks	One per non-dedicated type of sampling equipment
Field (Blind) Duplicates	One duplicate per ten field samples (10%) with a minimum of one per sampling event
Temperature Blanks	One per cooler

The collection of QA/QC samples and decontamination activities require the use of "PFAS-free water." This is water that has been verified to be PFAS-free through laboratory analysis. For small projects, PFAS-free water is typically provided by the laboratory on request. For larger projects, where higher volumes of PFAS-free water are required than would be reasonably provided by a laboratory, and another source of PFAS-free water must be used, such as verified PFAS-free drinking water.

3.2.1 Trip Blanks

Trip blanks are sample containers filled with PFAS-free water provided by the laboratory that remain with the PFAS sample containers throughout the entire sample collection process, including transportation from and to the laboratory. They are used to assess cross-contamination introduced from the laboratory and during shipping and transport.

3.2.2 Field Blanks

Field blanks are used for aqueous analyses (e.g., drinking water, groundwater, surface water). They are collected by pouring PFAS-free water, which is typically provided by the laboratory, into an empty clean sample container at the sampling site. Field blanks should be collected first to most accurately represent potential PFAS introduction to samples. Leaving the lid off a PFAS-free water sample container and submitting that sample container as a field blank is not acceptable. Field blanks are used to verify that the sampling environment does not introduce PFAS during the sampling event.

3.2.3 Equipment (Rinsate) Blanks

Equipment (rinsate) blanks are collected by passing PFAS-free water, which is typically provided by the laboratory, over or through decontaminated field sampling equipment into an empty clean sample container. Equipment blanks are typically collected before the collection of field samples and are used to assess the potential for contamination from equipment used during field sampling and/or the adequacy of the decontamination process at the sampling site.

3.2.4 Field (Blind) Duplicates

Field (blind) duplicates are collected at the same time and under identical circumstances as the labeled/identified field samples. They are used to verify the precision and consistency of field and laboratory procedures.

3.2.5 Temperature Blanks

Temperature blanks are laboratory-provided sample containers filled with water that accompany each sample cooler from the laboratory to the field and back to the laboratory. They are used to determine the temperature of the samples in each cooler, which should be 4°C ± 2°C.

3.3 General PFAS Sampling Practices

This section presents PFAS sampling practices that are applicable for media listed in Section 1 of this SOP.

Where practical, the sampling site should include 1) an eating area, 2) a staging area where equipment is set up and PPE is donned and doffed, and 3) the sampling area where samples are collected. These areas may be changed during the sampling event (e.g., when there are sample locations that are widely separated warranting additional staging and eating areas).

If samples are being collected at a site where the presence of PFAS has been documented or suspected, sampling should be in "best-to-worst" order. Sampling should begin areas upgradient of the known or suspected source area(s), followed by sampling locations furthest downgradient. Sampling should then proceed progressively back toward the areas closest to and within the known or suspected source area(s). If no information is available, water samples should be collected in this order – 1) drinking water, 2) surface water, and 3) groundwater.

- Two-person sampling teams are recommended. This allows one person to perform sample collection duties while the second person can perform documentation tasks log book, chain-of-custody) and perform other tasks not directly related to sampling and sample handling.
- If visitors are present on-site, request that they remain outside of the sampling area. If necessary, stop work until the visitor has departed.
- Field vehicle seats may be treated with PFAS and are a possible source of cross-contamination. It is recommended that vehicle seats are covered with well-laundered cotton sheets or blankets, provided fabric softeners were not used.

- Confirm materials of construction of sampling equipment (e.g., sample pump o-rings/elastomers and bladders, tubing). Verify rather than assume materials of construction.
- Obtain sample containers from the laboratory in a dedicated cooler containing only PFAS sampling containers if possible.
- Keep the PFAS sampling containers (before and after collecting samples) separate (e.g., separate coolers) from other samples/analytes.
- Samplers should wear well-laundered clothing, which is clothing that which has been washed at least three times and preferably six times prior to wearing for PFAS sampling.
- New untreated leather boots may be worn with polypropylene, polyethane, or PVC boot covers. Well-worn leather boots may be worn.
- When sampling during precipitation events, field samplers should wear appropriate clothing that does not pose a risk for cross-contamination.
- Consider using a gazebo-style tent that is only touched prior to and at the completion of sampling for sun and precipitation protection. Change gloves after set up and prior to collecting samples.
- Wear disposable nitrile gloves throughout the sampling process. Don new disposable nitrile gloves prior to the following activities at each sample location.
  - Contact with sample containers or PFAS-free water containers
  - Collecting samples and handling sample containers
  - Collecting QA/QC samples and handling QA/QC sample containers
  - Decontamination of re-usable equipment
  - After handling non-dedicated sampling equipment, contact with non-decontaminated surfaces, and when judged necessary by field personnel
- Collect PFAS samples from each location prior to other analytes to minimize contact with other sample containers and packing materials. After PFAS samples are collected and capped, place the sample container(s) for each location in an individual resealable plastic bag and place in a dedicated PFAS cooler with ice.
- Sample containers must be kept sealed and only opened during sample collection. This prevents potential sources of cross-contamination (e.g., particulates, dust, fibers) from entering the sample container. Do not place container caps on any surface during sampling collection and avoid contact with the inside of the container and cap. Never insert anything into the sample container (e.g., tubing). Immediately replace cap after collecting the sample.

- When it is necessary to use a collection container and then transfer the sampled media into laboratory-provided sample containers, collection of a field blank is recommended to evaluate the potential for ambient conditions to affect laboratory analytical results.
- The preferred sample container labeling method is to use pre-printed labels or ball point pen to write on the labels adhered to the sample container after caps have been placed on sample containers. Fine and ultra-fine Sharpie markers can be used if ball point pens do not work to label the empty sample container provided the lid is on the sample container and gloves are changed after sample container labeling but must be used outside of the designated sample area. Change gloves after applying self-adhesive labels to sample containers before collecting samples.
- Single-use (disposable) or dedicated sampling equipment is preferred to reuse of sampling equipment across multiple sampling locations.
- Sample equipment can be scrubbed using a PE or PVC brush to remove particulates.
- Store PFAS-free water in containers labeled “PFAS-free” and use only PFAS-free water for decontamination. This includes sampling equipment and large equipment (e.g., drill rigs).
- If prescreening for the presence of PFAS is desired (e.g., recent AFFF release), an aqueous sample (e.g., 10-25 milliliters [mL]) can be collected in an unpreserved vial and gently shaken to monitor for foaming, which may be an indication of the presence of PFAS. Similarly, deionized water (e.g., 10-25 mL) can be added to solid samples (e.g., 5 grams) and gently shaken for foaming observation. However, the presence of foam does not guarantee the presence of PFAS nor does the lack of foam guarantee the absence of PFAS. Specific to recent AFFF releases, ethylene glycol is a common ingredient in AFFF. Ethylene glycol field test kits (e.g., CHEMetrics glycol test kit K-4815) can be used to prescreen for the presence of AFFF/PFAS using small aqueous samples or soil samples with deionized water (as described above).
- If 1,4-Dioxane is also an analyte, do not use Liquinox during decontamination.

4. Unknown Materials of Construction

A sampling program must result in defensible data, and avoiding the use of PFAS-containing or questionable materials during sampling is critical. Therefore, it is necessary to obtain SDS or sample data for the materials being used rather than assuming a material or piece of equipment is PFAS-free. The use of equipment blanks as QA/QC measures for PFAS sampling programs provides supporting document for data defensibility.

Materials that will come in direct contact with the media being sampled must be evaluated in detail if the materials of construction have not been evaluated for PFAS or are unknown.

To be "known," the materials of construction/ingredients must be indicated as acceptable in this SOP or documented to be PFAS-free by the manufacturer.

Materials that will not come in direct contact with the media being sampled but could reasonably be expected to contain PFAS and may come in contact with sample containers, packing material, and sampling personnel must also be evaluated. These materials can be evaluated using the safety data sheet (SDS) for the material. No PFAS-containing materials are permissible. Typical indicators of PFAS are "fluoro," "PTFE," "FEP," "TPE," "ETFE," and "PFA." If the SDS does not indicate PFAS, confirm acceptability (e.g., with the project chemist). If the SDS does not specifically state PFAS, that does not mean PFAS is not present. Additionally, PFAS can be used in the manufacturing process (e.g., mold coating) and not explicitly an ingredient or material of construction.

Some equipment manufacturers and vendors may have studies available that demonstrate equipment and materials are PFAS-free. Confirm that such studies are acceptable to the regulatory agency and client prior to selecting such equipment or materials. While these studies are useful, they can be misleading as they may not be representative of the specific piece of equipment or material being used in the sampling program (e.g., a different manufacturing batch or from a different manufacturing location).

The health and safety of personnel are paramount and should not be compromised to prevent cross-contamination. Accordingly, PPE that contains PFAS may be used when site conditions warrant use of such PPE when no other materials that provide the level of protection needed are available; use of such PPE must be recorded in field notes.

5. Records

In addition to standard record keeping using the materials described herein, complete the Daily PFAS Sampling Procedure Checklist (Attachment A) to document compliance with this SOP.

6. Related GES Standard Operating Procedures

The following GES SOPs apply to sampling of different media (e.g., groundwater, soil) and contain general practices and information necessary to perform sampling activities in accordance with GES standards.

- GES SOP FM 4.1: Soil Boring Advancement
- GES SOP FM 4.5: Gas Probe Installation for Landfills
- GES SOP FM 5.6: Monitor Well Development

- GES SOP FM 8.3: Groundwater Sampling Acquisition
- GES SOP FM 8.5: Low-Flow Groundwater Sampling
- GES SOP FM 8.7: Well Purging Prior to Sample Collection
- GES SOP FM 8.12: Residential Well Sampling
- GES SOP FM 9.1: Soil Sampling for Analysis
- GES SOP FM 9.2: Standard Penetration Test (SPT) for Collecting Soil Samples Using a Split Spoon Sampler (SSS)
- GES SOP FM 9.4: Surficial Soil Sampling
- GES SOP FM 9.6: Soil Sampling in Test Pits and Trenches
- GES SOP FM 10.1: Surface Water and Sediment Sampling
- GES SOP FM 11.3: Soil Gas Sampling for Preliminary Site Characterization
- GES SOP FM 13.2: Sample Preservation and Handling
- GES SOP FM 13.3: Sample Identification and Labeling
- GES SOP FM 13.5: Sample Management, Packing, and Shipping
- GES SOP FM 14.1: Decontamination of Non-dedicated Sampling Equipment
- GES SOP FM 14.3: Field Personnel Decontamination
- GES SOP FM 20.1: Waste Sampling
- GES SOP QA 1.1: Collection of Field QA/QC Samples

Attachments

Attachment A – Daily PFAS Sampling Checklist

DAILY PFAS SAMPLING CHECKLIST

Client Name: ______________________________

Site Name: ______________________________

Address: ______________________________

GES PM: ______________________________

Completed By: ______________________________ **Date:** ____________

THIS FORM IS TO BE COMPLETED DAILY DURING PFAS SAMPLING FOR ANY MEDIA

Field Equipment

- ☐ No Teflon-containing materials on-site
- ☐ No chemical blue ice on-site
- ☐ No waterproof field books, plastic clipboards, binders, or spiral hard cover notebooks on-site
- ☐ Sample materials made from stainless steel, HDPE, acetate, silicone, or polypropylene

Decontamination

- ☐ Alconox, Liquinox, or Citranox to be used
- ☐ PFAS-free water to be used

Sample Containers

- ☐ All sample containers made of HDPE or polypropylene
- ☐ Caps are unlined and made of HDPE or polypropylene

PPE and Field Clothing

- ☐ No waterproof or resistant rain gear or clothing or boots containing Gore-Tex or Tyvek
- ☐ Field crew has not used fabric softener on clothing

Personal Hygiene

- ☐ Field crew has not used cosmetics, moisturizers, hand cream, or other related product this morning
- ☐ Field crew has not applied prohibited sunscreen or insect repellent

Other Sampling Considerations

- ☐ No food or drink on-site exception for bottled water and hydration drinks in staging area
- ☐ No Post-It Notes on-site
- ☐ No aluminum foil on-site
- ☐ Using ball point pens; no markers

IF ANY APPLICABLE BOXES CANNOT BE CHECKED, THE FIELD LEAD SHALL DESCRIBE THE NONCOMPLIANCE ISSUES BELOW AND WORK WITH FIELD PERSONNEL TO ADDRESS NONCOMPLIANCE ISSUES PRIOR TO COMMENCEMENT OF THAT DAY'S WORK. CORRECTIVE ACTION SHALL INCLUDE REMOVAL OF NONCOMPLIANCE ITEMS FROM THE SITE OR REMOVAL OF WORKER OFFSITE UNTIL IN COMPLIANCE.

Describe the noncompliance issues (include personnel not in compliance) and action/outcome of noncompliance: ______________________________

Field Lead Name: ______________________________

Field Lead Signature: ______________________________ **Time**: ____________

Standard Operating Procedure

Title: Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling – Groundwater

1. Purpose/Scope

This standard operating procedure (SOP) is intended to be used as a supplemental companion to FM 22.0 Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling. The objective of this SOP is to provide specific direction and guidance for collection of groundwater samples for PFAS analysis.

2. Groundwater Specific Procedures

This section presents PFAS sampling practices that are applicable for collecting groundwater samples, typically from groundwater monitoring wells, piezometers, or temporary sampling points.

- Standard monitoring well construction techniques use materials that may contain PFAS such as Teflon or Viton o-rings (well casing and screen coupling) and bentonite. PFAS can also be introduced through PPE and installation practices (e.g., standard decontamination water and cleaning agents). When new monitoring wells that will be used for PFAS sampling are being constructed, the following practices should be used.
  - Decontaminate drilling equipment between sample locations using the PFAS-free water and a PE or PVC brush to remove particulates. Detergents noted as approved in this SOP may be used if necessary.
  - Use PFAS-free drilling fluids, lubricants, and materials during drilling (e.g., RectorSeal No. 5, LOCTITE No More Leaks Plastic Pipe Sealant [PTFE Free], Gasoila Blue NT pipe thread sealant).
  - Collecting a sample of the PFAS-free water used during drilling is recommended unless the laboratory data demonstrating that the water is PFAS-free is available from the supplier.
  - If development agents are used, they must be PFAS-free.
  - Pumps, surge blocks, and other development equipment must be PFAS-free.
- If monitoring wells have dedicated tubing for sampling, that tubing should be removed if it is known or suspected to contain PFAS. It should be replaced with HDPE or silicone tubing and purged to remove potential PFAS from the previously installed tubing.
- Low-flow sampling techniques are preferred to reduce turbidity in samples as PFAS sorbs to particulate that can cause biased high laboratory analytical results.

- Acceptable sampling equipment for collection of samples from monitoring wells includes:
  - Stainless steel submersible pumps verified to be PFAS-free or otherwise approved by the regulatory agency and client, including fittings (e.g., stainless steel or HDPE) and joining materials (e.g., LOCTITE No More Leaks Plastic Pipe Sealant [PTFE Free] Gasoila Blue NT pipe thread sealant)
  - Peristaltic pumps with HDPE and/or silicone tubing
  - Bladder pumps with polyethylene bladders and HDPE tubing
  - Stainless steel inertia pump with HDPE tubing
  - Passive diffusion bags (PDBs) known to be PFAS-free
  - HDPE and stainless steel bailers with non-coated twine or verified to be PFAS-free
- Ensure tubing is HDPE (e.g., “poly” tubing may be HDPE or LDPE). Many types of tubing appear similar. Preferably, purchase/use tubing labeled by the manufacturer on the tubing. If new HDPE tubing is not labeled by the manufacturer, label the tubing and/or reel with “HDPE,” the manufacturer name, vendor name, and part number.
- If bailers are used for purging, sampling, or both, collect downwell geochemistry before the bailer is deployed. Also, allow the groundwater collected in the bailer to settle for at least 5 minutes prior to decanting into sample containers.
- When using PDBs, collect downwell geochemistry prior to retrieving the PDB if the monitoring well diameter is large enough to allow both the geochemistry meter sonde and the PDB to be deployed simultaneously without becoming entangled.
- Confirm that sample equipment does not contain PFAS, such as Teflon.
- Don new disposable nitrile gloves prior to the following additional activities at each sample location.
  - Insertion of anything into the well (e.g., HDPE tubing, HydraSleeve bailer)
  - Insertion of silicone tubing into a peristaltic pump
  - Completion of well purging prior to sampling
- When collecting water level measurements, the best practice is to allow only the stainless steel probe to come in contact with groundwater, and avoid immersing the plastic tape in the groundwater by slowing lowering the probe into the monitoring well.
- A maximum turbidity of 10 Nephelometric Turbidity Units (NTUs) is recommended for collection of representative samples as turbid samples may be biased high for PFAS.
- Do not field filter samples as this may introduce PFAS from the filter or PFAS may be adsorbed to the filter. Collect samples with low turbidity and no sediment where practical. The presence of turbidity and sediment may result in laboratory issues such as elevated

reporting limits and elevated reported dissolved-phase concentrations as PFAS tend to sorb to sediment particles. Laboratories handle the presence of turbidity and sediment differently that can result in inconsistent results between laboratories. If sample filtration is necessary, it should be performed in the laboratory using a verified method such as centrifuging.

SOP #:	FM-22.4 Rev. 001
Review Date:	7/30/2021
Origin Date:	4/21/2021

Standard Operating Procedure

Title: Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling – Surface Water and Surface Water Foam

1. Purpose/Scope

This standard operating procedure (SOP) is intended to be used as a supplemental companion to FM 22.0 Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling. The objective of this SOP is to provide specific direction and guidance for collection of surface water and surface water foam samples for PFAS analysis.

2. Surface Water and Surface Water Foam Specific Procedures

This section presents PFAS sampling practices that are applicable to surface water (including stormwater) and surface water foam.

- Acceptable materials for field sampling equipment include stainless steel, HDPE, PVC, silicone, acetate, and polypropylene.
- PFAS stratify in solution and accumulate at the air to water interface. Consider this stratification in selecting the sample depth of surface water bodies. In general, the best practice is to sample still water bodies (e.g., lakes and ponds) from approximately 1 to 2 feet below the water surface and to sample shallow flowing water bodies (e.g., streams, stormwater outfalls) at approximately 6 inches below the surface.
- If PPE such as waders and personal floatation devices are necessary during sampling, select PFAS-free PPE without waterproof coatings.
- When collecting surface water samples, triple rinse the capped sample container(s) with PFAS-free water or the surface water to be sampled.
- Submerge the capped sample container into the water with the opening pointed down. Remove the cap under water with the opening pointing upstream. Recap the bottle while still submerged.
- If transfer containers are necessary for sample collection, they must be PFAS-free and ideally made of the same material as the sample containers.
- Field sampling equipment, including dippers and extension rods/handles, must be PFAS-free material and similarly triple-rinsed.
- Avoid contact with foam when collecting surface water samples (i.e., do not submerge sampling devices through foam to sample the underlying water). PFAS and other organic compounds can partition and concentrate in foam naturally present on surface

water. As such, unintentional contact with foam during surface water sampling can cause uncertainty in the analytical results.

- When sampling surface water, select appropriate locations based on the characteristics of the water body.
  - Do not sample from stagnant water.
  - If a stream can be safely traversed, sample from the center of stream.
  - Where it is safe to enter a water body, the sampler must always enter the waterway from downstream and stand downstream of the sample location to avoid cross-contamination from the sampler.
  - When sampling directly with the sample container in flowing water, dip the container with the opening facing upstream.
  - Avoid sampling immediately downstream from structures such as bridges or stormwater culverts/pipes associated with roadways as runoff from the roadway may affect sample results and not be indicative of the PFAS source being investigated.
  - When sampling at depths greater than 5 feet, Kemmerer Bottles or Van Dorn Samplers (with PFAS-free stoppers) can be used.
- Avoid contact with the bottom of streams, ponds, lakes, channels, or pipes to prevent disturbance of sediments/particles.
- Do not field filter samples as this may introduce PFAS from the filter or PFAS may be adsorbed to the filter. Collect samples with low turbidity and no sediment where practical. The presence of turbidity and sediment may result in laboratory issues such as elevated reporting limits and elevated reported dissolved-phase concentrations as PFAS tend to sorb to sediment particles. Laboratories handle the presence of turbidity and sediment differently that can result in inconsistent results between laboratories. If sample filtration is necessary, it should be performed in the laboratory using a verified method such as centrifuging.
- When sampling surface water foam, consider that foam present proximal to an AFFF release may be different from foam present further downstream, which can be created by dissolved PFAS chemicals and water turbulence/agitation. The most common source of foam in surface water bodies is natural and caused by algae and plant decomposition.
- When collecting surface water foam samples, avoid collecting plants, insects, debris, etc. that may be present in the foam. They may need to be removed manually.
- Surface water foam samples can be collected in resealable plastic bags and allowed to condense to a liquid in a prior to transfer to the laboratory-provided sample container. Cheesecloth may also be used to collect surface water foam samples and then

transferred to a resealable plastic bag and allowed to condense to a liquid. Do not reuse cheesecloth. During condensing, the foam should be double-bagged and placed in a cooler to condense to a liquid. In this application, low density polyethylene (LDPE) resealable bags are acceptable for use.

- When sampling surface water foam, don new disposable nitrile gloves prior to the additional following activities at each sample location.
  - Each time sampling equipment is in contact with and removed from foam
  - Placing sampling equipment into foam

Standard Operating Procedure

Title: Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling – Soil

1. Purpose/Scope

This standard operating procedure (SOP) is intended to be used as a supplemental companion to FM 22.0 Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling. The objective of this SOP is to provide specific direction and guidance for collection of soil samples for PFAS analysis.

2. Soil Specific Procedures

This section presents PFAS sampling practices that are applicable for soil.

- Acceptable materials for field sampling equipment include stainless steel, HDPE, PVC, silicone, acetate, and polypropylene.
- Shallow soils may be collected with stainless steel augers, trowels, or other PFAS-free hand tools. If compositing or homogenization is necessary, stainless steel spoons and bowls can be used for sample mixing.
- When sampling during drilling, avoid reusing liners. Single use liners should be used.
- Decontaminate drilling equipment between sample locations using the PFAS-free water and a PE or PVC brush to remove particulates. Detergents noted as approved in this SOP may be used if necessary.
- Use PFAS-free drilling fluids, lubricants, and materials during drilling (e.g., RectorSeal No. 5, LOCTITE No More Leaks Plastic Pipe Sealant [PTFE Free], Gasoila Blue NT pipe thread sealant).
- Collecting a sample of the PFAS-free water used during drilling is recommended unless the drilling contractor provides laboratory data demonstrating that the water is PFAS-free.

Standard Operating Procedure

SOP #:	QA-1.1 Rev 003
Review Date:	6/3/2023
Origin Date:	03/01/2016

Title: Collection of Field QA/QC Samples (Trip Blanks, Equipment Blanks, Duplicate Samples, Matrix Spike Samples)

1. Purpose/Scope

This Standard Operating Procedure (SOP) provides requirements to prepare or collect equipment blanks, trip blanks, duplicate samples, and matrix spike samples. It also specifies the criteria to determine the number of these samples plus equipment blanks that must be prepared for a given batch of field samples.

Generally, all project sampling tasks are outlined within the project-specific Quality Assurance and/or Sampling Plan that identifies the Quality Assurance / Quality Control (QA/QC) sampling requirements.

2. References

SW 846 (Update V, Rev. 2, 2014) Chapter 1, Quality Control

3. Equipment/Materials

A basic checklist of suggested equipment and supplies needed to implement this SOP include, but is not limited to the equipment outlined in the appropriate sampling media and decontamination SOPs, which may include FM-8.1, 8.3, 8.5, 8.7, 9.1, 9.3, 9.4, 9.6, 10.1, 11.3, 14.1, 14.2, and 20.1.

4. Preparation

Have on hand and review the appropriate sampling media SOP, and Job Loss Analyses (JLAs). Pre-plan the schedule of sampling activities so that sample collection progresses from “clean” to “dirty” areas to minimize the potential for cross contamination.

Gas powered equipment at sampling sites require special care to ensure that GES staff handling these units do not contaminate down-hole equipment. Frequent disposable glove changes are required, as well as strict separation of sampling crew tasks (e.g., those handling pumps and hoses do not conduct fueling activities).

5. Procedure

5.1 Field QA/QC

The following is a brief discussion defining the common types of field-derived quality control samples which may be required for a groundwater sampling program. It should be noted that specific project quality and/or sampling plans may include all or only some of the following quality control procedures.

5.1.1 Equipment Blanks

Equipment field blanks are defined as QA/QC samples used to determine if cleaning procedures are effective and adequate. Equipment field blanks are prepared by collecting distilled deionized organic-free water that has been "run through" or "poured over" the cleaned sample collection equipment. Equipment blanks are typically collected at the sample preparation area of the project site and submitted to the lab "blind" by providing a false identification number.

Preservation or filtration (if required) is completed on the respective blank aliquots to ensure that each step of the sampling procedure is evaluated.

Note: Samplers must be aware of the various qualities of distilled deionized water and the impact the use of non-ultra-pure distilled water may have on the program analysis results. Sampling staff are urged to check with the Project Manager to verify the distilled deionized water needs; in most instances only ultra-pure distilled deionized water is acceptable for preparation of analytical blanks.

5.1.2 Field Blanks

Similar to equipment blanks, a field blank is collected to evaluate the influence of field ambient conditions on the sampling process. These could include trip, rinsates, equipment blanks, etc. Field blanks are collected using distilled deionized organic-free water poured directly into the sample container. Field blank collection is performed at a typical sampling site (e.g., well location) to evaluate if ambient site conditions influence sample results.

One field blank is typically collected for each batch of samples submitted or at a prescribed frequency (i.e., one field blank for every 20 samples).

Field blanks are submitted to the lab "blind". The frequency of field blank submission will be determined by the project quality and/or sampling plan.

5.1.3 Trip Blanks

Trip blanks are prepared before the sampling event and sent to the site in the shipping container(s) designated for the project. These samples are intended to be kept with investigative samples, then submitted for analysis with the project samples. The samples should not be opened, and are intended to determine if the sample shipping or storage procedures influence the analytical results.

Trip blanks are usually submitted for VOCs, only. The frequency of trip blank submission is generally one per day of sampling, unless otherwise specified in the quality and/or sampling plan.

5.1.4 Field Duplicates

Field duplicates are collected and submitted to assess the potential for laboratory data inconsistency and the adequacy of the sampling and handling procedures. A duplicate sample is collected from the same source utilizing identical collection procedures.

During groundwater sample aliquot collection, the original and duplicate sample are collected simultaneously by partially filling the original and then the duplicate and alternating back and forth until both samples have been fully collected. This will provide two representative samples for analyses. Transferring the sample aliquot from a bulk container to the respective sample containers is typically not permissible.

Field duplicates are typically submitted “blind.” The sampling key to ensure proper sample identification must be submitted to the appropriate personnel to enable completion of the QA/QC review process.

The frequency of field duplicate submission will be determined by the project quality and/or sampling plan.

5.2 Laboratory QA/QC Sample Volumes

MS/MSD sample volumes are additional sample aliquots provided to the laboratory to evaluate the accuracy and precision of the sample preparation and analysis technique.

Typically, three times the normal sample aliquot is required to conduct MS/MSD procedures. Sample collection is identical to the technique described for collection of field duplicates. Sample labeling identifies the respective sample location and each additional container which is labeled as the MS/MSD volume.

5.3 Laboratory QA/QC Samples

Laboratories analyze a variety of QA/QC samples internally to monitor the analytical procedure with regard to accuracy, precision, and contamination. A description of some QA/QC samples follows.

5.3.1 Matrix Spikes

Matrix spikes consist of an aliquot of the sample which is spiked with a known concentration of the target analyte prior to sample preparation and analysis. The recovery of the spike is calculated using the equation:

$$\frac{100 \times (\text{Spiked Sample Result} - \text{Unspiked Sample Result})}{\text{Spike Amount Added}}$$

The recovery of the spike is used to measure the accuracy of the test performed. The spike is sometimes performed in duplicate in order to measure the precision of the test as well by comparing the resulting spike recoveries.

5.3.2 Laboratory Duplicates

A laboratory duplicate consists of an intra-laboratory split of an investigative sample prior to preparation and analysis. The split results in the sample being analyzed as two samples to measure the precision of the analysis. The relative percent difference of the duplicate analysis is measured as:

$$\frac{100 \times |\text{Original Samples Result- Duplicate Sample Result}|}{\frac{1}{2} (\text{Original Sample Result + Duplicate Sample Result})}$$

5.3.3 Surrogate Spikes

Surrogate spikes are organic compounds similar to the target analytes of interest in both chemical composition and behavior, but which are not normally found in environmental samples. They are added to the samples to monitor the accuracy of the analytical procedure for organic testing.

5.3.4 Laboratory Control Samples

Laboratory control samples are analyzed with the investigative samples in order to monitor analytical performance. They consist of a known matrix which is free of interferences (i.e., water, sand), which is subsequently spiked with the analytes of interest.

5.3.5 Method Blanks

Method blanks are prepared and analyzed with the investigative samples to assess the potential level of contamination introduced to the analytical process by the laboratory. They consist of a matrix demonstrated to be analyte free (i.e., sand, water) which is processed with each sample batch. Method blank results are used to evaluate the possible impact of laboratory contamination on the results reported for investigative samples. A method blank is included with the analysis of every analytical batch of 20 samples or less or as stated in the site-specific quality and/or sampling plan.

5.3.6 Lower Limit of Quantitation (LLOQ)

The lowest point of quantitation which, in most cases, is the lowest concentration in the calibration curve. The LLOQ is initially verified by spiking a clean control material (e.g., reagent water, method blanks, Ottawa sand, diatomaceous earth, etc.) at the LLOQ and processing through all the preparation and determinative steps of the method. LLOQs are specific to laboratory procedures and should be determined at a frequency established by the method, laboratory's quality system (most common), or project.

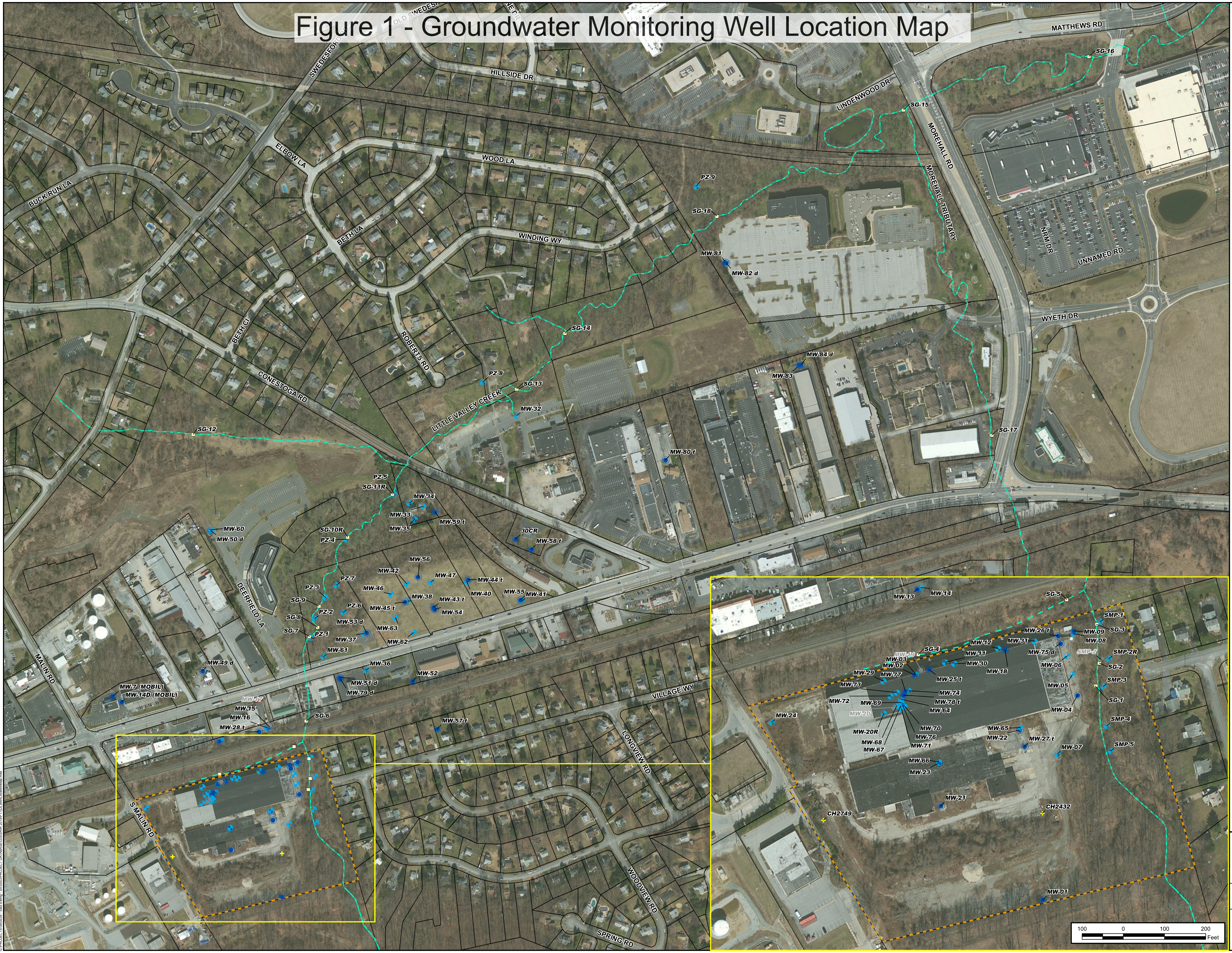
6. Records

6.1 Field Notes

The field notes should document all the events, weather, equipment used, procedures used, and measurements collected during the sampling activities such as sample identifier, sample location, depth, time collected and number and type of quality control samples that were collected each day. The field notes should be concise so that the entire sample event can be reconstructed later for future reference.

Appendix B – Laboratory Method Detection and Reporting Limits, Certification and Scope of Accreditation

Appendix C – Figures



Legend

- Overburden Monitoring Well Location and Identification
- Damaged/Abandoned Overburden Monitoring Well Location and Identification
- Bedrock Monitoring Well Location and Identification
- Abandoned Bedrock Monitoring Well Location and Identification
- Production Well Location and Identification
- Staff Gauge Location and Identification
- Stream
- Drainage Swale
- Property Boundary

N

Note:

1. Service Layer Credits: ESRI, DigitalGlobe, GeoEye, Earthstar Geopgraphics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Layer Access Date: 6/3/2019.
2. ^{t} indicates nested bedrock monitoring well location (3 wells at each location).
3. ^{d} indicated nested bedrock monitoring well location (2 wells at each location)

200 0 200 400 Feet

Title:

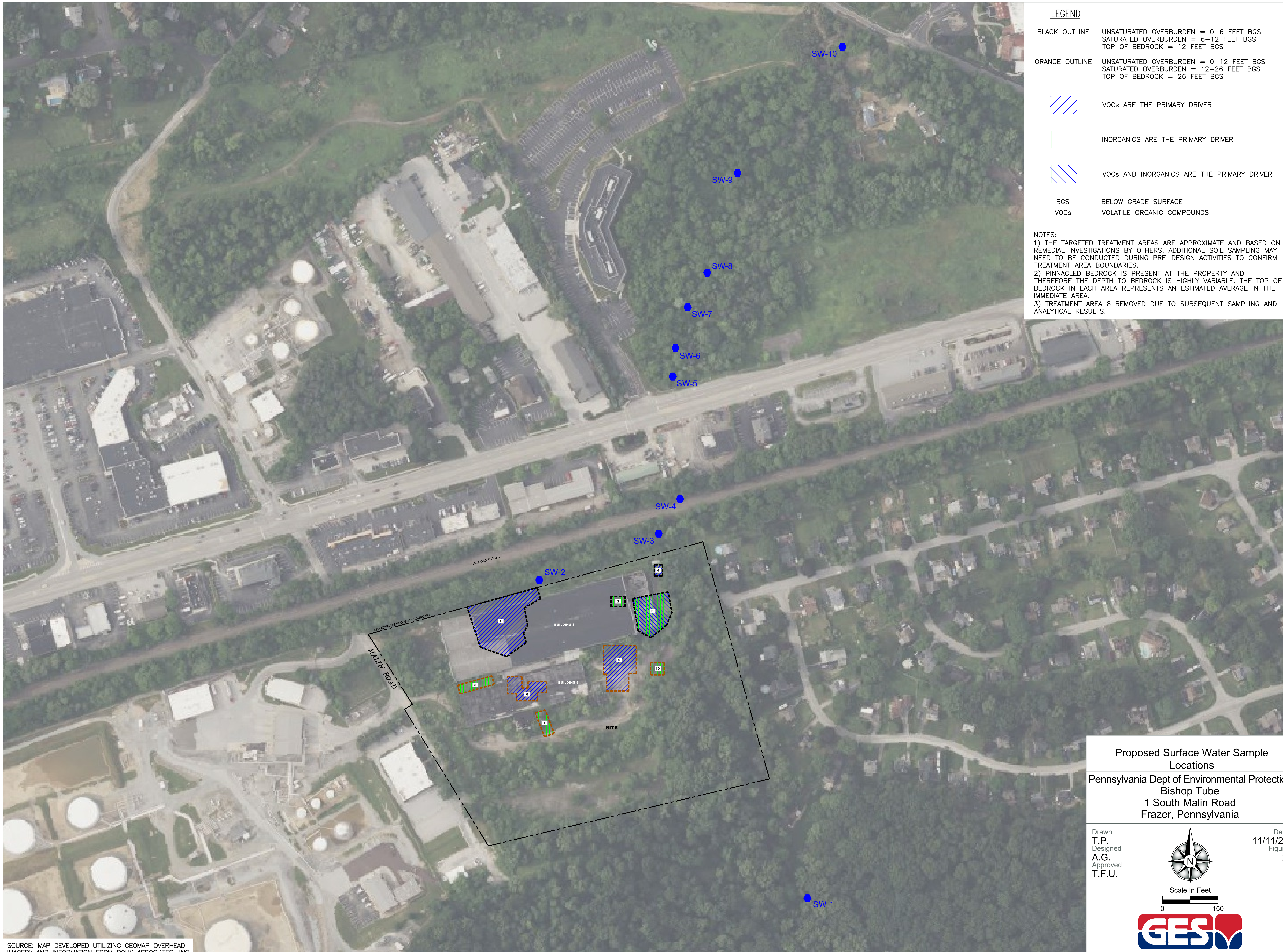
MONITORING WELL LOCATION MAP

FORMER BISHOP TUBE FACILITY
CHESTER COUNTY, PENNSYLVANIA

Prepared For:

BISHOP TUBE PROJECT TEAM

ROUX ASSOCIATES, INC. Environmental Consulting & Management	Compiled by: SSPR	Date: 6/3/2019	FIGURE
	Prepared by: AET	Scale: 1:1,200	17
	Project Mgr: JAK	Office: NJ	
	File No: 1020.F17(DL)	Project: 0539.0003J000	



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Appendix D – Quality Observation Form

HSSE ▸ Site Visit Observation:

Please select form type: ☐HSSE ☑Qualit ☐Both

QUALITY SITE VISIT OBSERVATION FORM

Site ID/Location   Observer Name: Observer Title: Office: 0200 - Exton, PA

*** Please note - new separate entry for client   **Client:** Pennsylvania Dept of Env Protection

Date:

Scheduled or Non-scheduled:

Number of GES Personnel on site:

Title:

Subcontractor(s) or visitors on site:

Associated JLA: **Click here to review**

PSID:

Background Information/Site Conditions/Miscellaneous Comments on Task Observed

Observer's Positive Comments

Questionable Observations (if any)

Attachments:

Quality Near Losses Reported	Person Reported to	Date

Groundwater & Environmental Services, Inc.
Non-scheduled Visit Quality review List

Plan/Expect	COMMENTS
1. Reviewed FWD with PM prior to mobilization to site	
2. Personnel referred to applicable supportive documents to complete the task (e.g. JLAs, SOPs)	
3. Communicated with subcontractor prior to mobilization for field event	
4. Personnel had a contingency contact in case PM could not be contacted	
5. Preparedness and presence of right tools/equipment and supplies for the task	
6. Personnel possessed knowledge to use tools/equipment to correctly complete the task	

7. Other (Specify)	
Execute/Document	**COMMENTS**
8. Personnel referred to FWD while in field	
9. Personnel followed FWD for the site activities	
10. Personnel reviewed Work Order with subcontractor	
11. Personnel ensured Quality was incorporated into the site activities	
12. Does the on-site personnel need added support to conduct the task at this time?	
13. Other (Specify)	
Review/Validate	**COMMENTS**
14. Personnel discussed FWD progress items with PM	
15. Personnel completed all tasks according to the FWD	
16. Personnel communicated with PM on any issues	
17. Other (Specify)	
Act/Adjust	**COMMENTS**
18. Personnel communicated back to office/PM and implemented approved changes	
19. Other (Specify)	