Prepared by

HDR

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Harbor Island
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Remedial Investigation Data Collection Work Plan

Former J.B. Sims Generating Station

July 8, 2025

CONTENTS

FIGURES

TABLES

Attachments

Attachment A - PFAS Data Collection Work Plan

Attachment B - EPA Pore Water Sampling Procedure

1.0 Introduction

The Remedial Investigation Site Specific Data Collection Work Plan (Work Plan) has been developed for the Former J.B. Sims Generating Station (Site or the Island) to support the remedial evaluation of potential alternatives as outlined in the Assessment of Corrective Measures (ACM) published August 5, 2024 (HDR, 2024b). This Work Plan includes activities for data collection related to the remediation of Coal Combustion Residual (CCR) and Per and Polyfluoroalkyl Substances (PFAS) observed/detected at the Island. The Site is located at 1231 North 3rd Street, on Harbor Island, in Grand Haven, Michigan. There are two CCR units at the Site, the Units 1/2 Impoundment and Unit 3A/B Impoundments. Waste disposal into the Units 1/2 Impoundment ceased in 2012 and CCR waste streams into Unit 3A/B Impoundments ceased in July 2020 (HDR, 2024).

In compliance with 40 CFR §257.96 and Michigan Administrative Code R 299.4443 the ACM was completed on August 5, 2024 in response to observed statistically significant levels of arsenic, boron, calcium, fluoride, lead, lithium, sulfate, and total dissolved solids (TDS) that exceed state and/or federal groundwater protection standards (GPS). The GPS are numeric concentrations of constituents of interest that both trigger corrective measures when exceeded and represent cleanup standards. **Figure 1** displays the monitoring wells in which one or more constituents of interest (COIs) have been observed at statistically significant levels (SSLs) and exceeded groundwater protection standards as determined by the CCR Rule assessment monitoring program (HDR, 2024). As outlined in the ACM, the following groundwater corrective measures were proposed and selected for further site-specific evaluation:

- Alternative 1 – Source Control - Removal and In-situ Solidification and Stabilization in combination with additional measures
- Alternative 2 – Hydraulic Containment Wall
- Alternative 3 – Hydraulic Containment Extraction and Treatment
- Alternative 4 – Capping in combination with additional measures

Alternative 1 - A key component to any corrective measure is source control. This would be accomplished by removal and/or in-situ solidification (ISS) of the CCR waste from the (1) inactive Units 1/2 Impoundment, (2) the former Unit 3 A/B Impoundments, and (3) other source areas, such as PFAS source areas or CCR management units (CCRMU). Removal and/or ISS may be used to meet the corrective action objectives at the Site. Solidification involves injecting a binding agent into the waste while mixing it together with a large auger driven by a crane. The binding agent is a cement-like substance that consolidates material to form a block that eliminates leaching from the ash. Ash removal from the Unit 3A/B Impoundments was partially completed in 2020, removing ash from the impoundments down to the clay liner. As discussed in the ACM, the documentation of the horizontal extent of CCR and subsequent removal of ash observed on the roads adjacent to the impoundment was deemed insufficient (HDR, 2024b). Further discussion of this topic is provided in later sections.

Alternative 2 - Two types of hydraulic containment walls are under consideration. Interlocking sealed steel sheet pile containment wall or slurry wall would provide a barrier to impacted groundwater flow and prevent future off-site migration of dissolved constituents of concern (COCs). The walls also would provide a barrier preventing unimpacted surface and groundwater from flowing into the Site, which would reduce the volume of groundwater required to be extracted to achieve corrective action objectives. In general, a wall keyed into the top of the aquifer lower confining unit would be designed to provide containment fully around the impacted area and would be combined with groundwater extraction and treatment to control the groundwater level in the containment area

Alternative 3 - Hydraulic containment by extraction and treatment (E&T) is the use of groundwater pumping to capture and control impacted groundwater. Extraction wells and/or trenches can be used to capture impacted groundwater for ex-situ treatment prior to being discharged to a receiving water feature, reinjection to the aquifer, or reuse.

Alternative 4 - Capping involves placing a cover over waste, source areas, or contaminated materials. Capping prevents infiltration of precipitation and would be used in conjunction with other measures to increase the efficiency of an E&T system, reduce the cost of water treatment, and reduce the time of remediation.

Figure 1. Monitoring Wells with GPS Exceedances as of October 2023

2.0 Phased Data Collection Approach

Groundwater flow and water quality data has characterized the groundwater system and identified nature and extent of groundwater impacts. The purpose of this Work Plan is to gather site-specific information to support the remedial investigation and to aid in the design of the selected remedy. The following data collection tasks will be conducted in parallel with groundwater assessment monitoring. The remedial alternative data collection process will be phased to ensure only necessary information is collected. Additionally, data collected in earlier phases will be utilized in the development later phase tasks.

2.1 Phase 1 Data Collection

2.1.1 Unit 3A/B Impoundments Road Ash Investigation

The GHBLP ceased all waste disposal into Unit 3A/B Impoundments on July 30, 2020. The GHBLP commenced removal of CCR from Unit 3A/B in July 2020. On December 10, 2020, Golder considered the unit at final closure to 95 percent confidence of CCR removal (Golder, 2020). Following the submission of closure documentation on January 27, 2021, EGLE denied the closure certification. EGLE noted the following reasons for denial:

- *“GHBLP only utilized one soil sample to verify ash removal using colorimetric methods. EGLE stated one sample could not represent all liner areas accurately.*
- *The methodology for microscopy did not include preprocessing of samples to ensure bottom ash could properly be identified.*
- *GHBLP did not provide sufficient demonstration that the horizontal extent of coal ash had been defined, noting a 2014 EPA report showing photographic evidence that coal ash was present outside the Unit 3A/B boundary (i.e., on adjacent roadways).”*

As noted by EGLE, photographic evidence indicated ash was present on the roads adjacent to the impoundment following the cleanout of Unit 3A/B Impoundments. Using areal imagery from August 2019, a study area was delineated as shown in **Figure 2**. In compliance with EGLE Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria (ST3M), a grid system was developed for ash identification. The focus area consists of 0.84 acres and the EGLE guidance considers this a medium size site. The equation provided in Section 2.2.1.2 of the ST3M yields a grid size of 27 by 27 feet. The cells of the grid will inform whether ash is present. If ash is identified, the extent of any ash will be determined by stepping out at each location until the extent of ash is fully delineated. Ash present within this study area will be delineated using visual inspection and photography.

Within each grid cell, areas within the Ash Verification Focus Area (red boundary, Figure 2) will be assessed. However, the field team will have the flexibility to adjust locations to be assessed within each cell. Due to the proximity of the grid to site features, significant portions of several grid cells may be inaccessible, and the following areas will be excluded from the evaluation:

- Side slopes along the Units 3A/B cells and the Grand River.

- Within 3 feet of the substation fence.
- Within the substation.

The ground surface of the study area will be visually examined for ash. Because ash is not expected to be at depth, but could potentially have been graded over or minimally covered by some erosion, a hand auger will be used to dig up to two feet below the surface in one or two locations within each cell to visually examine for ash. If ash is found, the extent of the ash will be delineated horizontally and vertically with a shovel. If the soil is too dense to allow for such digging, or if ash extends too deep to continue hand augering or digging, a Geoprobe will be mobilized to the Site to perform the delineation.

Photographs will be taken during this work to establish current Site conditions. The methodology for photo collection will be as follows:

- Photographs will be taken within the cells shown on **Figure 2** of grid nodes.
- HDR will locate cell boundaries in the field using ESRI FieldMaps.
- Photographs will be taken at each selected node with 12” x 12” frame indicating surficial soil area.
- A whiteboard will be present in each photo to document the Site name/project identification, date, time, and cell identification.
- Photographs will be taken from a standardized height (approximately 2.5 feet)
- The camera will be positioned directly over the excavated surfaced facing downwards with as little tilt as possible.
- Photographs will have a pixel resolution of 24 megapixels.

Deliverable

A memorandum will be produced summarizing the findings of the ash delineation. This will include maps of ash locations and depths, and tables of ash quantities within the focus area shown on **Figure 2**.

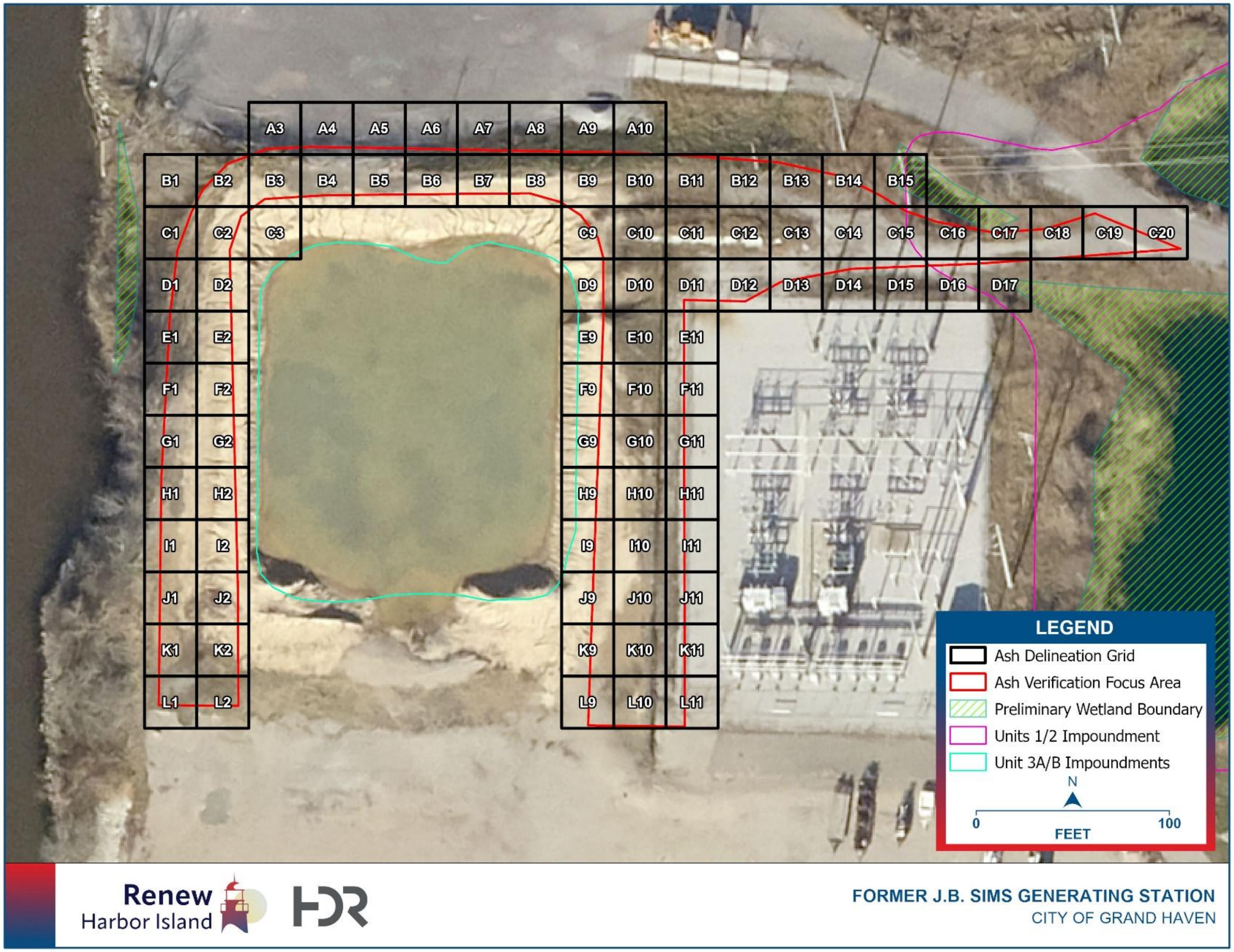

Figure 2. Unit 3A/B Impoundments Focus Area

2.1.2 Exploratory Borings

Objective

The conceptual site model consists of data collected from borings completed since 2017 at the Site. The borings indicate a clay layer is present below sands and silt that slopes from 23 feet below surface (ft. BGS) at PZ-25 on the east to 48 ft. bgs on the western side of the Island at PDR-3, as shown in **Figure 3**. Additional borings that noted clay on the logs but were not confirmed to intersect the confining unit are shown in **Figure 4**. It should be noted that borings completed on the eastern side of the Island (PZ-25 and PZ-26) reached a depth of 30 feet below ground surface, shown in **Table 1**. The thickness of the clay is considered a data gap because it is not known whether the clay is present below the end of the boring. The proposed borings would confirm if the clay is a confining unit for the aquifer, the elevation at which the clay unit is encountered, and the permeability of the clay. Soil samples from the aquifer and clay unit will be collected and analyzed for grain size and permeability by a subcontracted laboratory.

Table 1. Clay (Assumed Confining Unit) Depth Table

Boring ID	Depth of Clay (ft. bgs)	Total Boring Depth (ft. bgs)
PDR-1	42	97
PDR-2	47	97
PDR-3	48	152
PZ-16	32	35
PZ-17	39	40
PZ-25	23	30
PZ-26	21	30

Implementation

Four exploratory borings will be conducted at the locations shown in **Figure 5**. Prior to drilling each location will have a utility locate conducted. The borings will be advanced via hollow-stem auger through the surficial aquifer into the suspected confining unit. The anticipated depth of the borings is 70 feet; however, the final depth could change based on field observations. The objective of the borings is to advance 20 feet into the suspected confining unit. The borehole diameter at each location is anticipated to be 7 inches. The borings will be sampled continuously with a split-spoon and logged by an onsite HDR geologist. Soil samples will be collected during the drilling process and containerized in new polyethylene 5-gallon buckets. Two of the locations will be sampled with a Shelby Tube and retained for geotechnical analysis (Figure 4) – the southern location (DB-03) and the western location (DB-04). Spoils from the drilling process will be disposed of onsite. Borings will be grouted to surface following completion.

Geotechnical analysis will be performed by SME in Grand Rapids, Michigan. Samples will be delivered following collection and analyzed using ASTM D5084 or equivalent for measuring permeability of clay and ASTM E112 for grain size analysis.

Deliverable

The deliverable from this task will be a memorandum summarizing the field work, and include boring logs, updated cross sections, and results of the geotechnical analysis conducted on clay soil samples.

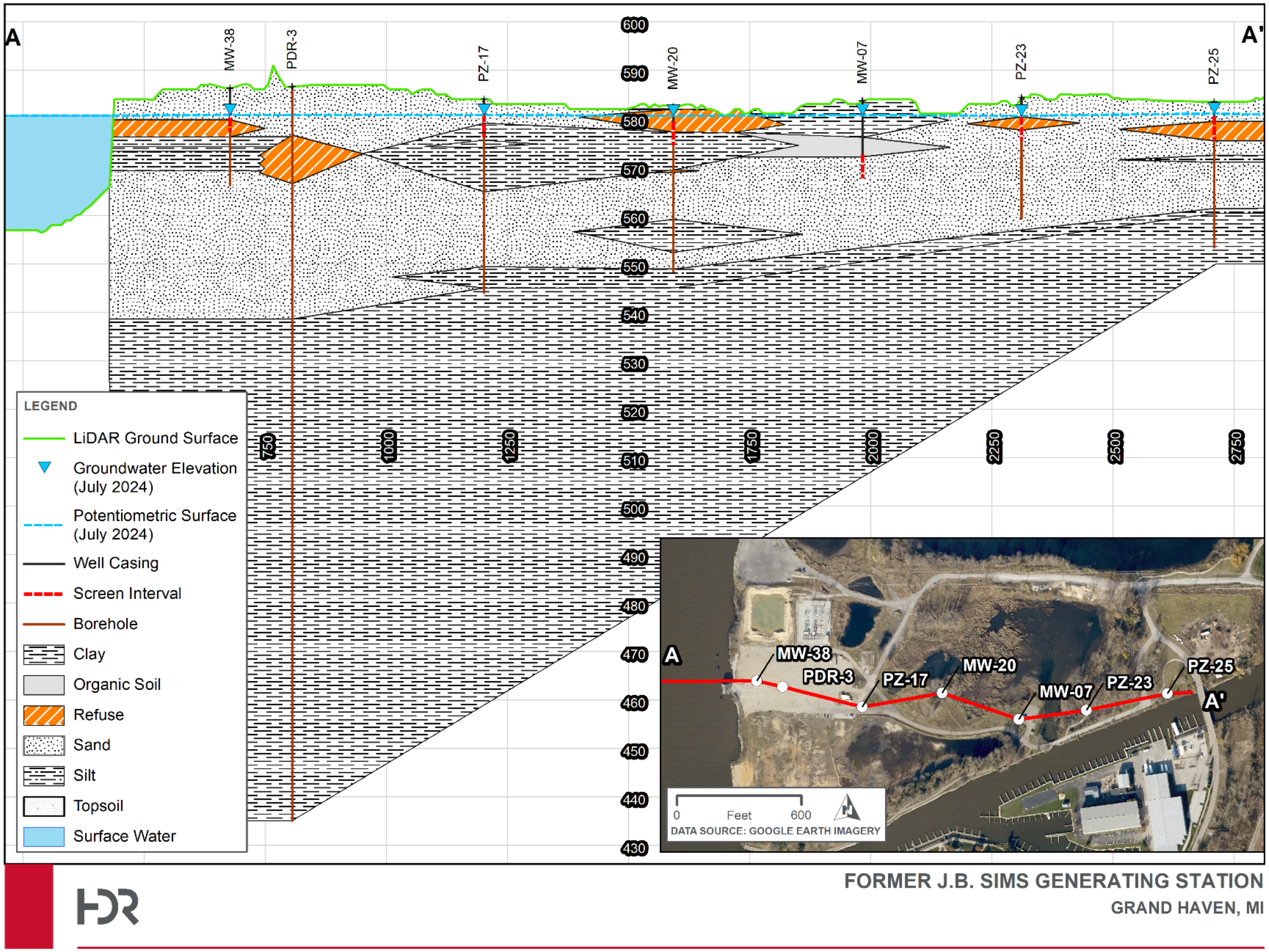

Figure 3. East-West Cross Section of Harbor Island

Figure 4. Depth to Anticipated Confining Unit

Figure 5. Proposed Deep Boring Locations

2.1.3 Deep Monitoring Well Installation

Objective

The maximum depth of existing monitoring wells and piezometers is 20 feet below surface and are generally screened across the top of the water table. This is considered a data gap as the vertical extent of the COI plume has not been delineated. Additionally, the conceptual site model is that groundwater at the Island discharges to the Grand River and South Channel. Data is required to confirm whether groundwater could flow under these channels to the other side of the river and channel. Therefore, the proposed deep monitoring wells will provide necessary information on the direction of flow.

Three of the four exploratory borings shown in **Figure 5** will be converted to monitoring wells (MW-09B, PZ-15B, MW-44B), shown in **Figure 6**. One of the wells will be screened within the suspected confining unit (MW-44B), and two will be screened above the suspected confining unit (PZ-15B and MW-09B). The three monitoring wells will be paired with an existing shallow monitoring well. The borings for the wells will also be used to confirm the top of the suspected confining unit. The final depths of the wells will be based on the depth to the top of the clay.

Implementation

The three monitoring wells will be constructed of 2-inch schedule 40 polyvinyl chloride (PVC). The anticipated lithology at the screen interval is fine to medium sand or clay, so the screen slot size is anticipated to be 10-slot; however, a 20-slot screen will be onsite should it be appropriate based on field observations. The screen length will be 5 or 10 feet, depending on observed geology. Filter sand will be placed from screen bottom to two feet above the top of the screen, and the remaining annulus will be grouted to the surface. Monitoring wells will be constructed with a 2 by 2-foot cement pad and stick-up cover. The wells will be developed using airlift methods by the driller with an HDR representative onsite to record development progress. Development will be measured using a water quality meter (YSI or similar) and a turbidity meter. The proposed monitoring wells will be slug tested to estimate the hydraulic conductivity of the screened lithology. Additionally, each well will be sampled and analyzed by Trace Analytical Laboratories in Muskegon, MI for the constituents in **Table 2**. The results of the sampling will be evaluated to determine if constituents exceed groundwater protection standards.

Table 2. Groundwater Quality Parameters For Analysis

Antimony	Lithium
Arsenic	Mercury
Barium	Molybdenum
Beryllium	Nickel
Boron	pH
Cadmium	Radium 226 and 228 combined
Calcium	Selenium
Chloride	Silver
Chromium	Sulfate
Cobalt	Thallium
Copper	Total Dissolved Solids (TDS)

Table 2. Groundwater Quality Parameters For Analysis	
Fluoride	Vanadium
Iron	Zinc
Lead	Total Suspended Solids (TSS)

Deliverable

Details of monitoring well installation will be provided in revisions to the Monitoring Well Installation Report, Hydrogeologic Monitoring Plan, and Groundwater Monitoring Certification Report. The results of groundwater analytical testing will be included in the next quarterly groundwater monitoring report submitted after this work is completed.

Figure 6. Deep Monitoring Well Location Map

2.1.4 Expansion of Monitoring Well Network

Objective

Following the identification of Statistically Significant Levels (SSLs) above Groundwater Protection Standards (GPS) at the nature and extent monitoring wells during the 2nd quarter 2024 sampling event in April 2024, nature and extent wells were added to each unit to further delineate the groundwater plumes. For the Units 1/2 Impoundment: MW-16, MW-17, MW-28, MW-36, and MW-37 were added. For the Unit 3A/B Impoundments, MW-38 was added. The constituents that exceeded GPS to date include arsenic, boron, calcium, chloride, fluoride, lead, lithium, sulfate, and total dissolved solids (HDR, 2024). A map showing the total extent of each plume is provided in **Figure 7**. The exceedance of GPS at nature and extent wells indicates that further expansion of the monitoring well network in the downgradient direction is necessary to further delineate the contaminant plumes. The proposed expansion of the monitoring well network is as follows:

- The inclusion of MW-39 and MW-13 as nature and extent wells for Unit 3A/B Impoundments.
- A new monitoring well (MW-41) north of MW-10 for Units 1/2 Impoundment and Unit 3A/B Impoundments to further delineate extent of CCR COCs.
- A new monitoring well (MW-42) for Units 1/2 between MW-30 and MW-08 to investigate the source and extent of CCR COCs.
- A new monitoring well (MW-43) for Units 1/2 west of MW-07 to investigate the source and extent of CCR COCs, is shown on **Figure 7**. Note this monitoring location will also be utilized as a part of the PFAS investigation as further explained in **Section 2.1.6**.
- A new monitoring well (MW-44) will be located northwest of PZ-24, shown on **Figure 8**. Note this monitoring location will be utilized as a PFAS monitoring location as further explained in **Section 2.1.6**.

Implementation

The chosen drilling method is hollow-stem auger utilizing a 24-inch length and 1.5-inch diameter split-spoon sampler. Prior to drilling boring locations will have a utility locate completed. The borehole diameter at each location is anticipated to be 6 inches. The borings will be sampled continuously and logged by an onsite HDR geologist. Spoils will be collected and disposed of onsite. Monitoring wells will be constructed of 2-inch Schedule 40 PVC. The anticipated lithology at the screen interval is fine to medium sand or clay, so the screen slot size is anticipated to be 10-slot, however a 20-slot screen will be onsite if deemed appropriate based on field observations. The screen length will be 5 feet. The screen will be installed near the water table, consistent with nearby wells. At monitoring well MW-43, the screen may be slightly deeper (i.e., 11 to 16 feet below grade) and similar to the screened interval at monitoring well MW-07 to avoid screening the well in shallow clay and peat. Filter sand will be placed from screen bottom to two feet above the top of the screen, and the remaining annulus will be grouted to surface. Monitoring wells will be constructed with a 2-foot by 2-foot cement pad and stick-up cover. The wells will be developed using airlift methods by the driller with an HDR representative onsite to record development progress. Development will be measured using a water quality meter (YSI or similar) and a turbidity meter. Following development, each well will be sampled and analyzed for the constituents in **Table 2,** apart from MW-44. The proposed monitoring wells will be slug tested to estimate the hydraulic conductivity of the screened lithology. Proposed well MW-41 will have bollards installed to prevent damage from heavy traffic. HDR will contract a licensed surveyor to provide easting/northing coordinates, ground surface, and top of casing elevations.

Existing piezometers PZ-13 and MW-39 will be included with the monitoring wells and be added to the quarterly sampling program starting with the third quarter 2025 sampling event. The next quarterly sampling event is scheduled for August 2025 and the three new monitoring wells (MW-41, MW-42, and MW-43) will be sampled during the fourth quarter 2025 event, and quarterly thereafter until further notice.

Deliverable

The results from this work will be outlined in updates to the Monitoring Well Installation Report, Hydrogeologic Monitoring Plan, Groundwater Monitoring System Certification, and Quarterly Reports Groundwater Monitoring Reports.

Figure 7. Proposed Monitoring Well Map

Figure 8. PFAS Monitoring Well Location Map

2.1.5 Units 1/2 Impoundment Ash Characterization

Objective

Superior Environmental (Superior), Environmental Resource Management (ERM), and Golder previously collected samples of ash or ash-bearing sediment from within the boundary of the Units 1/2 Impoundment. However, the prior analysis did not include the full suite of State CCR regulation constituents. Additional sampling of ash and pore water is necessary for characterization of the chemical and physical properties. Sample volume also will be provided to contractors for physical properties bench testing for potential future design of ISS methods.

Information regarding the chemical and physical properties of the ash within Units 1/2 Impoundment will aid in the feasibility assessment of remedial alternatives. Since the operating life of the impoundment spanned approximately 50 years, it is possible that the character of the ash varied during that time. Variations in ash properties will be addressed with nine samples from within the unit boundary, which is also the minimum number of samples required by EGLE for statistical analysis of the chemical properties. The following information is provided in the Coal Ash Definition Sampling Results report (ERM, 2016):

- Northern Pond – Ash was identified between pond bottom and 2 feet below bottom
- Southern Pond – Ash was identified between pond bottom and 2 feet below bottom
- Eastern Wetlands – Ash was identified intermittently between 1 and 14 feet below surface

Utilizing the information above, the anticipated ash sampling locations are provided in **Figure 9**.

Implementation - Ash Sampling

Prior to beginning ash sampling, a Joint Permit Application (JPA) submission will be submitted to EGLE since the sampling locations on the eastern side of the impoundment are located within potential wetlands.

- Northern and Southern Ponds - As noted above, the ash in both locations was observed between pond bottom and two feet below pond bottom. Five samples of ash from these locations west of the drive will be collected using a scoop, shovel, auger, or other appropriate container capable from the bottom sediments and sides of the impoundment (Figure 9). Sample locations will be recorded utilizing ESRI FieldMaps.

- Eastern Wetlands –To minimize any disturbance to the wetland, four ash samples will be collected utilizing a *Vibracore* soil-sampling device. This method uses a handheld oscillating motor to advance polyethylene cylinders into the soil. Boring depth will vary depending on each location and field observations.

    - The maximum depth of the borehole advancement on the eastern wetland of the unit is 15 feet below surface. Sample volume will be extracted utilizing direct push methods in which a 2-inch diameter tube is advanced into the subsurface. Borings will be continuously logged by an HDR geologist. One ash sample will be collected from each hole. Any ash encountered to a maximum depth of 15 feet will be collected. Previous borings completed within the wetland collapsed due to saturation and loose soil. Following removal of the sampling equipment, should the borehole remain open, bentonite chip will be placed to seal the bore hole. Sample locations will be recorded utilizing ESRI FieldMaps.

- Each sample will be analyzed for the constituents in **Table 3** by an HDR contracted laboratory. The soil will be analyzed for total metals using EPA method SW6020a or equivalent. Soils will also be analyzed using Synthetic Precipitation Leaching Procedure (SPLP) and Toxicity Characteristic Leaching Procedure (TCLP) to determine leaching characteristics of the ash.

If ash is not encountered in one of the nine proposed boring locations, additional locations within the Units 1/2 Impoundment boundary will be identified and sampled until nine ash samples have been collected for analysis.

Implementation – Pore Water Sampling

During the soil sample collection, the location and depth will be recorded for reference. Pore water samples will be collected within 1-foot of the soil sample locations, shown in **Figure 9**, and correspond with the soil sample depth interval. Pore water samples will be collected using the PushPoint^{TM} sampler (Henry Sampler). The PushPoint^{TM} sampler is a pointed tubular stainless-steel tube with a screened zone at one end and a sampling port at the other. The pointed end with the screened zone consists of a series of very fine interlaced machined slots to allow groundwater to enter the sampler. The sampler is pushed to the desired depth and the groundwater is collected through the opposite end of the devise by connecting flexible tubing to a peristaltic pump to extract the sample (EPA, 2016). The EPA developed a pore water sampling procedure that is provided in **Attachment B** and this procedure will be followed. Pore water from each sample will be extracted and analyzed to determine in-situ groundwater concentrations of analytes contained in **Table 3**. Pore water samples will be analyzed by Trace Analytical Laboratories in Muskegon, Michigan.

Deliverable

The deliverable will be a memorandum explaining the field activities and sampling results.

Table 3. Ash Characterization Methods and Analytes

Soil - Total Metals Analysis	Soil – TCLP Analysis	Soil – SPLP Analysis	Pore Water – Metals Analysis
Metals (Method SW 6020A) - mg/Kg	**Metals (Method SW-846 or equivalent) – mg/Kg**	**Metals (ASTM 1320) - mg/Kg**	**Metals (EPA 200.7) - mg/L**
Aluminum	Aluminum	Aluminum	Antimony
Antimony	Antimony	Antimony	Arsenic
Arsenic	Arsenic	Arsenic	Barium
Barium	Barium	Barium	Beryllium
Beryllium	Beryllium	Beryllium	Boron

Table 3. Ash Characterization Methods and Analytes

Soil - Total Metals Analysis	Soil – TCLP Analysis	Soil – SPLP Analysis	Pore Water – Metals Analysis
Metals (Method SW 6020A) - mg/Kg	**Metals (Method SW-846 or equivalent) – mg/Kg**	**Metals (ASTM 1320) - mg/Kg**	**Metals (EPA 200.7) - mg/L**
Boron	Boron	Boron	Cadmium
Cadmium	Cadmium	Cadmium	Calcium
Calcium	Calcium	Chromium	Chromium
Chromium	Chromium	Cobalt	Cobalt
Cobalt	Cobalt	Copper	Copper
Copper	Copper	Iron	Lead
Iron	Iron	Lead	Lithium
Lead	Lead	Lithium	Molybdenum
Lithium	Lithium	Manganese	Nickel
Manganese	Manganese	Molybdenum	Selenium
Molybdenum	Molybdenum	Nickel	Silver
Nickel	Nickel	Selenium	Thallium
Selenium	Selenium	Silver	Vanadium
Silver	Silver	Thallium	Zinc
Thallium	Thallium	Vanadium	**Metals (EPA 200.7) - mg/L**
Vanadium	Vanadium	Zinc	Mercury
Zinc	Zinc	Mercury	**Metals (EPA 300) - mg/L**
Mercury (Method SW 7471B) - mg/Kg	Total Sulfate	Fluoride	Chloride
Mercury		Moisture (%)	Iron
Fluoride (Method A4500) - mg/Kg			Sulfate
Fluoride			**Metals (EPA 9056) - mg/L**
Moisture (%)			Fluoride
			Metals (EPA SM2540C) - mg/L
			Total Dissolved Solids
			Metals (EPA SM2540D) - mg/L
			Total Suspended Solids
			Inorganics ASTM 7511
			Cyanide
			EPA 335.4 Rev 1.0
			Ammonia

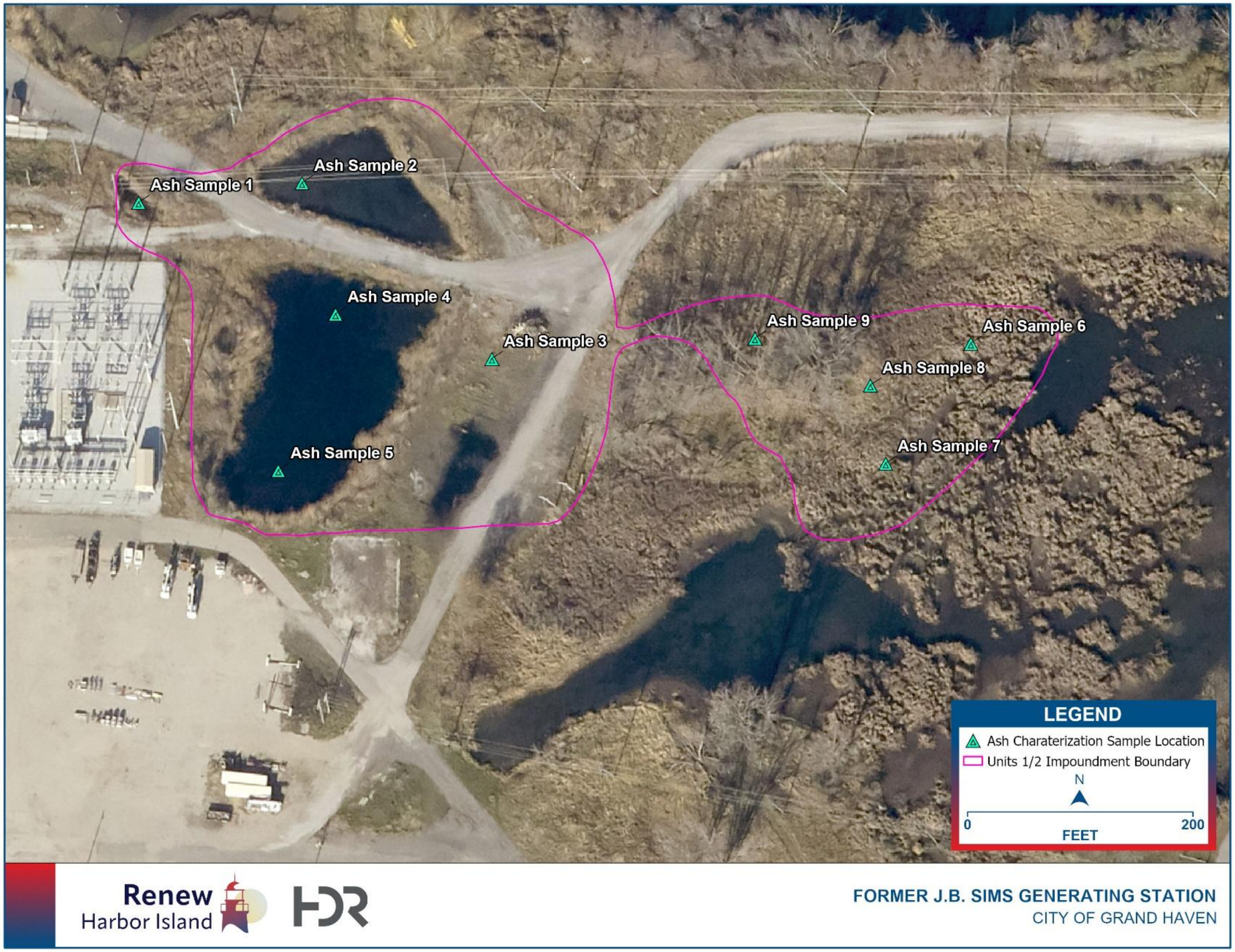

Figure 9. Ash Sampling Location Map

2.1.6 PFAS Remedial Work Plan

An initial PFAS investigation was performed to investigate the potential presence of PFAS in groundwater at the Island in 2023. This study was summarized in Non-CCR Data Gap Investigation Report (DGI) (WSP, 2023). The DGI work identified PFAS compounds at concentrations above groundwater-surface water interface (GSI) criteria. To develop conceptual designs for remediation alternatives, additional data is required to further delineate the vertical and horizontal extents of PFAS at the Site. Therefore, additional groundwater and surface water sampling will be conducted. The details of the PFAS remedial investigation are contained in **Attachment A**.

2.2 Phase 2 Data Collection

2.2.1 Aquifer Test Design

Additional data will be collected to inform remedy selection according to 40 CFR §257.97. A pump test will be implemented to collect hydrogeologic data to evaluate the feasibility of groundwater extraction at the Site, and to support design of a groundwater extraction and treatment (GWET) system and groundwater modeling efforts. The pump test will be designed utilizing the lithologic data, depth to suspected confining unit, and slug test information from the deep monitoring wells. As data collected during Phase 1 will be utilized in the final design of the pump test, aquifer testing is anticipated to be conducted in Q4 2025.

2.2.2 Topographical and Bathymetry Survey

Survey data is required to determine the following:

- Surface configuration of the Island.
- The location and volume of clean fill material.
- Estimate of the land surface for designing potential remedial alternative measures.
- The size and depth of each internal water body and wetland as well as depths for the northern wetland, Grand River, and South Channel.

The start of surveying activities is weather and Site condition dependent and is anticipated to be conducted in Q4 2025.

2.3 Phase 3 Data Collection

2.3.1 Transport and Contaminant Groundwater Modeling

Due to the heterogeneous nature of the lithology encountered, and the variable flow observed, a groundwater model will be developed in Phase 3 to support the development of remedial alternatives. Groundwater modeling will use data collected from both Phase 1 and Phase 2. The anticipated start of this task is Q4 2025.

2.3.2 Wetland Function Assessment

Delineation of wetlands on the Island was completed in the 2nd quarter 2024. Additional data may be required, however, for permitting and to determine resource value following selection of a remedial alternative. The anticipated start of this task is Q3 2025.

3.0 References

U.S Environmental Protection Agency Region 4 (EPA), Science and Ecosystem Support Division, Athens Georgia, December 2016. Pore Water Sampling, SESDPROC-513-R3

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Attachment A

PFAS Data Collection Work Plan

Renew
Harbor Island

Limited PFAS Remedial Investigation Work Plan

Former J.B. Sims Generation Station/Harbor Island

City of Grand Haven
July 1, 2025

Contents

List of Figures

List of Appendices

Appendix A: Standard Operating Procedures
Appendix A: Field Forms

Abbreviations and Acronyms

Abbreviation	Definition
AST	above ground storage tank
ALN&M	Ayres, Lewis, Norris & May, Inc.
bgs	below ground surface
CCR	coal combustion residuals
COC	constituents of concern
DGI	Data Gap Investigation
DO	dissolved oxygen
DTW	depth to water
EGLE	Michigan Department of Environment, Great Lakes, and Energy
EM	electromagnetic induction
ft	feet
GCC	Generic Cleanup Criteria
GHBLP	Grand Haven Board of Light & Power
Golder	Golder Associates, USA Inc.
GPR	ground-penetrating radar
HASP	Health and Safety Plan
HDR	HDR Michigan, Inc.
IDW	investigation derived waste
MS/MSD	matrix-spike/matrix-spike duplicate
ORP	oxidation reduction potential
%	percent
PFAS	per-and polyfluorinated alkyl substances
PPE	personal protective equipment
QA	quality assurance
QC	quality control
RIWP	Remedial Investigation Work Plan
SOP	Standard Operating Procedure
SVOC	semi-volatile organic compound
TD	total depth
USACE	U.S. Army Corp of Engineers
USEPA	United States Environmental Protection Agency
VAS	vertical aquifer sampling
VOC	volatile organic compound
Wood	Wood Environment & Infrastructure Solutions, Inc.
WSP USA	WSP USA, Inc.

1.0 Introduction

WSP USA Inc. (WSP), formerly Wood Environment & Infrastructure Solutions, Inc. (Wood) (hereafter referred to as WSP), has prepared this Limited Per-and polyfluorinated alkyl substances (PFAS) Remedial Investigation Work Plan (RIWP) for the southwest portion of Harbor Island (Island), located in in Grand Haven, Michigan (Site) and shown on **Figure 1**). The Site includes the former J.B. Sims Generating Station, which was located on the west side of Harbor Island with an address of 1231 North 3rd Street. The former J.B. Sims Generating Station was a coal-fired power generation facility operated by Grand Haven Board of Light & Power (GHBLP) that ceased operations in February 2020. This RIWP briefly summarizes PFAS data collected prior to and during the November 2022 through May 2023 Data Gap Investigation (DGI) and details proposed activities to be performed during the Limited Remedial Investigation.

1.1 Site Description

The Site is the southwestern portion of Harbor Island, an island located in the Grand River on the north side of the City of Grand Haven, Michigan. The Island is bounded by the Grand River on the north and west, US-31 on the east, and the Grand River's South Channel on the south. The Island lies in the center of three major water bodies: Lake Michigan, the Grand River, and Spring Lake. **Figure 1** depicts the location of the Site relative to the surrounding area.

According to the 1998 Harbor Island Master Plan: Implementation Plan, portions of the Island were historically used for fishing, shipbuilding, and lumber storage prior to and into the early 1900s. In the early to mid-1900s, the Island was primarily used for industrial purposes including a power plant, coal docks, and a petroleum bulk storage facility. A portion of the Island was used as a City dump that accepted both household and industrial waste; however, the exact location of the dump is unknown. **Figure 2** shows the approximate man-altered locations within the Site as referenced in the 1993 Harbor Island Master Plan prepared for the City of Grand Haven by Ayres, Lewis, Norris & May, Inc. (ALN&M). The Man–Altered locations include the suspected historical dump locations.

The City dump stopped accepting waste in 1970. From the 1970s until the 1990s, a 30-acre area of the Island was diked, capped, and used by the U.S. Army Corp of Engineers (USACE) for disposal of harbor material dredged from the Grand River (City of Grand Haven, 1998).

Aerial imagery acquired for Harbor Island shows that the Island was being accessed via a network of roads from the 3rd Street Bridge as early as 1938. By 1955, aboveground storage tanks (ASTs) can be seen on the southeastern portion of the Island, adjacent to the South Chanel of the Grand River and the 3rd Street Bridge. By 1962, the former J.B Sims Generating Station is present and an east to west trending road that bisects and cuts off a portion of the north wetland has been constructed, creating a wetland in the interior of the Island. Additional manmade alterations are present on the southwest portion of the Island where material has been placed to reclaim portions of the river environment. By 1968, the framework for the existing road network is in place by the construction of three roads providing access to the interior of the Island. An east to west trending road was constructed to provide access from US-31; a north-south route was constructed to provide access to the Grand River from the interior of the Island; and an east-west route was constructed to provide access to the northeastern portion of the Island from the north-south interior road. The construction of the road network resulted in extensive filling of portions of the wetland and, in some areas, the destruction of the channel that connected the wetland area to the South Channel of the Grand River.

By 1974, additional portions of land had been reclaimed from the river channel for construction of a boat launch to provide access to the Grand River from the northern part of Harbor Island. By 1986, two clay-lined ponds were constructed to hold coal ash from the J.B Sims Generating Station, and the northeastern portion of Harbor Island began to be filled with coal ash, transforming the area from a wetland to its current form. By 2006, the ASTs on the southeastern portion of the Island had been demolished and several parking areas had been constructed on the northern portion of the Island. After 2006, manmade activities do not appear to have significantly altered the appearance or form of the Island until 2020 when decommissioning of the former J.B. Sims Generating Station began.

Coal combustion residuals (CCR) generated at the J.B. Sims Generating Station were stored in two CCR units on the Island: the inactive Units 1/2 Impoundment and the excavated Unit 3A/B Impoundments (**Figure 2**). The Units 1/2 Impoundment was a depression in the ground where sluiced ash was disposed. The Units 1/2 Impoundment ceased receiving CCR materials in 2012. The U.S. Environmental Protection Agency's (USEPA) CCR Rule 40 CFR §257 and Michigan's Part 115 Solid Waste Management of the Natural Resources and Environmental Protection Act, 1994 PA 451 (Part 115), establish a comprehensive set of requirements for the management and disposal of CCR (or coal ash) in surface impoundments by electric utilities. The monitoring associated with the CCR is being conducted by HDR, Inc. (HDR) and follows the 2022 Harbor Island Work Plan for CCR Compliance (HDR, 2022) with results provided in subsequent HDR monitoring reports.

In preparation for work associated with the coal ash impoundments, GHBLP collected groundwater samples for PFAS analysis in 2021. Results showed that concentrations of PFAS were present in groundwater above Michigan Part 201 Generic Cleanup Criteria (GCC). The source of the PFAS is not known but could be associated with the historical dump, the former J.B. Sims Generating Station, and other operations conducted on the Island.

1.2 Geological and Hydrogeological Setting

The Site is located on the southwestern portion of Harbor Island. Large portions of Harbor Island have been altered using fill from various sources, including household and industrial waste and dredge material.

1.2.1 Geology

Harbor Island is situated with the Grand River and the South Channel of the Grand River surrounding the Island. The Grand River flows westerly toward Lake Michigan, approximately one mile to the west of the Site. The Site is located within an area of glacial drift (consisting of fine to medium sand with occasional beds of gravel) which is underlain by Marshall Sandstone. The glacial drift is between 100 to 200 feet (ft) thick in the area (ERM, 2017).

Above the glacial drift, portions of Harbor Island were developed by creating land with the use of unconsolidated fill, waste, dredge material, and historical ash fill. Soil borings advanced at the Site indicate a mixture of unconsolidated fine sand fill with intervals of silt and sand, historical ash fill, and solid waste within the first 20 to 40 ft below ground surface (bgs). The unconsolidated fill material consists of fine sand, ash, and waste, with discontinuous silt and/or clay seams. Materials documented from the former dump during a 2016 investigation consisted of a layer of mixed debris which includes glass, wood, plastic, ceramic, concrete, leather, brick, and metal within a matrix of dark gray to black, fine-grained sand. (ERM, 2016).

1.2.2 Hydrogeology

Groundwater is encountered between approximately 1 and 15 ft bgs within the unconsolidated fill material. In 2021, Site aquifer performance testing was conducted and summarized in the *Field Summary Report of Results from Approved Work Plan – Piezometer Installation & Additional Data Collection, Former JB Sims Generating Station, Harbor Island, Michigan* (Golder Associates, USA Inc. [Golder], 2022). This testing provided additional data for understanding the variability of the hydraulic conductivity. Testing was performed at 10 wells and generally, hydraulic conductivity values across the Site range from 0.19 feet per day to 18.76 feet/day. Higher hydraulic conductivity values were calculated at two locations (172.51 and 242.25 feet per day, respectively). Additional aquifer testing will be conducted by HDR to validate these results.

Groundwater flow is influenced by the elevation of the Grand River and the South Channel. In general, localized groundwater flow is radially inward when river levels are high and radially outward when river levels are low. Localized flow direction and gradients across the Island are also influenced by precipitation and surface infiltration, particularly in wetland areas where the water table is in direct contact with surface water. The fill material placed on the Island is variable in both thickness and hydraulic conductivity, resulting in variable infiltration rates from precipitation. The variation in both hydraulic gradients and hydraulic conductivity results in variable lateral flow rates (Golder, 2022).

Groundwater elevations are monitored as part of CCR compliance following the *2022 Harbor Island Work Plan for CCR Compliance* (HDR, 2022). Groundwater elevations measured by HDR indicate that groundwater is discharging to surface water, including the Grand River on the west side of the Island, the South Channel on the south side of the Island, the north wetland area, the interior wetland areas, and the Units 1/2 Impoundment. Groundwater flow patterns on the Island are variable and change seasonally. HDR is collecting additional data to further understand the Site's hydrogeological setting and groundwater flow variability (HDR, 2024).

1.2.3 Hydrology

Prior to reaching Harbor Island, the Grand River is approximately 3,000 ft wide and includes many relatively undisturbed marshy islands. The river narrows to approximately 500 ft as it approaches Harbor Island. The configuration of Harbor Island is largely influenced by water levels on Lake Michigan and the Grand River. Seasonal fluctuations are common and cyclical fluctuations of up to four feet are not unusual. As a result of these fluctuations, the shape and character of the wetlands on Harbor Island vary. Surface water and wetlands dominate the central portion of Harbor Island, which are classified by the National Wetlands Inventory as freshwater emergent wetland, freshwater pond, and lake (National Wetlands Inventory, 2023). A current wetland survey is being completed by HDR.

2.0 Site Background/Previous Investigations

Groundwater samples at the Site were first collected by GHBLP for PFAS analysis in preparation for work associated with the coal ash impoundments where there was potential for dewatering and discharge of groundwater and ponded stormwater to the Grand River. Below is a summary of subsequent sampling to investigate PFAS impact on Harbor Island. For a detailed summary of historical sampling results, refer to the *Non-CCR Data Gap Investigation Report* (WSP, 2023) or documents referenced below.

May 2021

- Groundwater samples were collected for PFAS analysis from 10 monitoring well locations (MW-01R through MW-10) and analyzed for the Michigan-28 PFAS list compounds (Golder, 2021a).

June 2021

- Groundwater samples were collected for PFAS analysis from the same 10 monitoring wells sampled in May 2021 (MW-01R through MW-10) to confirm the detections of PFAS compounds (Golder, 2021b).
- Surface water samples were collected for PFAS analysis from five locations (one from the Grand River, two from the north wetland area, and two from interior wetland areas). Additionally, two water samples were collected from the Units 1/2 Impoundment: one near MW-5 and one near Staff Gauge 2 (Golder, 2021b).

July 2021

- Two surface water samples were collected (one from the north wetland area and one from an interior wetland area) and five water samples were collected from stormwater collection areas (two water samples were collected from the Unit 3A/3B impoundments, and three water samples were collected from the former coal pile stormwater collection area) for PFAS analysis (Golder, 2021c).

October 2021

- Samples were collected for PFAS analysis from 10 monitoring wells (MW-01R through MW-10) and 17 piezometers (PZ-13 through PZ-20, PZ-23 through PZ-28, and PZ-30 through PZ-32) (Golder, 2021d).
- Surface water samples were collected for PFAS analysis at seven locations: one from the Grand River, three from the north wetland area, and three from interior wetland areas (Golder, 2021d).

January 2022

- Samples were collected for PFAS analysis from 10 monitoring wells (MW-01R through MW-10), and 14 piezometers (PZ-11 through PZ-16, PZ-23 through PZ-28, and PZ-31 and PZ-32) (Golder, 2021e). Surface water samples were not collected during this event due to frozen surface water bodies (WSP, 2023).

November – December 2022

- Groundwater samples collected from 40 vertical aquifer sampling (VAS) locations (VAS-01 through VAS-40) were analyzed for PFAS. Two samples were collected from each VAS location (one shallow and one deep) at maximum depths of 20-ft below ground surface (bgs), except for VAS-01 where a deep sample was not collected due to the presence of consolidated soils (WSP, 2023).
- Additional sampling and analyses for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals from 19 of the 40 VAS locations were conducted where waste materials were encountered to evaluate other potential non-CCR impacts (WSP, 2023).

December 2022

- One subsurface soil sample was collected for PFAS analysis from each of 11 VAS locations (VAS-13, VAS-15, VAS-19, VAS-21, VAS-23, VAS-26, VAS-31, VAS-32, VAS-33, VAS-34, and VAS-39) (WSP, 2023).
- Surface water samples were collected for PFAS analysis at six locations: one from the north wetland area, two in the south channel of the Grand River, and three in the Grand River (WSP, 2023).
- One sediment sample was collected for PFAS analysis from the south channel of the Grand River (WSP, 2023).
- Groundwater samples were collected from two monitoring wells (MW-33 and MW-34) for analysis of PFAS, VOCs, SVOCs, and metals (WSP, 2023).

January – February 2023

- Six permanent groundwater monitoring wells were installed at previous VAS locations (MW-35 through MW-40) to expand the spatial distribution of the existing monitoring well network at the Site (WSP, 2023).
- Groundwater samples were collected from 38 of the 40 existing monitoring wells and piezometers for PFAS analysis (PZ-21 and PZ-22 were not sampled due to access issues) (WSP, 2023).

May 2023

- Groundwater samples were collected from 18 monitoring wells/piezometers for PFAS analysis: MW-01R, MW-03, MW-04, MW-08, MW-10, PZ-13, PZ-14, PZ-23, PZ-28, MW-32, MW-33, MW-34, MW-35, MW-36, MW-37, MW-39, MW-39, and MW-40 (WSP, 2023).
- Five surface water samples and one storm water sample were collected for PFAS analysis (SW-01 through SW-06): three from the Interior Wetland, one from the South Channel of the Grand River, and one from the north Wetland. The stormwater sample was collected from the Former Coal Pile, (WSP, 2023). The surface water sample collected from the South Channel of the Grand River (SW-06) was collected by skimming the surface of the water. According to the EGLE Surface Water PFAS Sampling Guidance (EGLE, 2022a), surface water samples should not be taken from the top layer of the water body. PFAS are expected to accumulate at the surface water-air interface, so samples taken at the surface are likely to result in high biased results that are not representative of the bulk surface water and should not be compared to Rule 57 Surface Water Quality Values.

3.0 Limited Remedial Investigation Activities

The following subsections detail the limited remedial investigation activities planned to obtain data needed to assess potential remedial alternatives to address PFAS-impacted groundwater that may pose a risk to surface water and/or address data gaps identified in the *2023 Non-CCR Data Gap Investigation Report* (WSP, 2023).

3.1 Surface Water Sampling

3.1.1 Surface Water Sampling Location

During the DGI, one surface water sample collected from the South Channel (SW-06-2023-05-01) was collected by skimming the water surface. This sample had considerably higher PFAS concentrations than other surface water samples collected during the DGI, which was attributed to the sample collection method. According to the *EGLE Surface Water PFAS Sampling Guidance* (EGLE, 2022a), PFAS are expected to accumulate at the surface water-air interface. Therefore, surface water samples should not be taken from the top layer of the water body as results are likely to be biased high and may not be representative of the bulk surface water. To confirm PFAS concentrations at this surface water sample location, another surface water sample will be collected from a location proximate to the original sample, located approximately 50 feet upstream of the 3rth Street Bridge in the South Channel of the Grand River (**Figure 3**).

3.1.2 Surface Water Collection Procedures

To collect a representative surface water sample, a weighted bottle sampler will be used to collect the surface water sample from approximately 6-inches below the water surface in accordance with the *EGLE Surface Water PFAS Sampling Guidance* (EGLE, 2022a) and *Standard Operating Procedure (SOP) 12 – Surface Water Sampling Procedure* (**Appendix A**). Additionally, field protocols as indicated in *SOP 13 – Field Sampling Protocols to Avoid Cross-Contamination of PFAS* (**Appendix A**) will be followed to limit the potential for cross-contamination of PFAS. The sample will be collected from the 3rd Street Bridge by use of a weighted bottle sampler and rope. The bottle will be lowered from the bridge to approximately 6-inches below the water surface, collected, and retrieved. Surface water sampling will be documented on a Sample Collection Log (**Appendix B**).

3.2 Groundwater Sampling

Groundwater samples were collected from VAS07 and VAS10 during the DGI to evaluate any PFAS concentrations in groundwater that may be venting to surface water on the eastern side of the interior wetland area. Results indicated that PFOS concentrations exceeded the exceeded the EGLE Part 201 Groundwater-Surface Water Interface Criteria. To confirm the VAS results, two permanent groundwater wells will be installed by HDR in their former locations (**Figure 4**). Each monitoring well will be screened at the same interval as the original VAS location; VAS07 at 3-8 ft bgs and VAS10 at 2-7 ft bgs. After development of the permanent monitoring wells, one groundwater sample will be collected from each well. Groundwater samples will be collected by WSP using low-flow methods as detailed in *SOP 11 – Groundwater Sampling Procedure* (**Appendix A**). Additionally, field protocols as indicated in *SOP 13 – Field Sampling Protocols to Avoid Cross-Contamination of PFAS* (**Appendix A**) will be followed to limit the potential for cross-contamination of PFAS. Samples will be collected quarterly for one year to evaluate seasonal variability, with results being summarized in a letter memorandum following each sampling event (four total).

Wells will be gauged prior to sampling. The wells will be opened to the atmosphere for a minimum of 15 minutes to allow pressure differentials to dissipate. The depth to water (DTW) and total well depth (TD) will then be measured from the top-of-casing at the surveyor's mark, or from the north side of the casing if a mark is not present, using an electronic water level indicator. Monitoring well gauging data will be documented on a Groundwater Gauging Form (**Appendix B**).

To remove potential stagnant water and to allow for collection of samples representative of groundwater conditions in the water-bearing zone, the well will be purged using low-flow methods. Low-flow methods require a low pumping rate to establish an isolated, discrete, horizontal flow zone directly adjacent to the pump intake tubing. Low pumping rates (typically 0.1 to 0.5 liters per minute) will be used to minimize stress on the surrounding formation and reduce the geochemical alteration of the groundwater caused by pumping. To set up for low-flow sampling, the pump intake tubing will be slowly lowered to the screen interval depth. The discharge tubing will be connected to an in-line flow-through cell equipped with a multi-parameter real-time water quality meter. The pump will then be started and a steady pump rate maintained to achieve a stabilized water level (less than 0.3 feet of drawdown). During purging, DTW, pH, specific conductance, temperature, dissolved oxygen (DO), turbidity, and oxygen-reduction potential (ORP) will be recorded at 3-minute intervals. Other pertinent details will be recorded such as visual quality of the water (e.g., color, presence of suspended particulates), odor, and the withdrawal rate. Purging will continue until the criteria presented in **Table 3.1** below are achieved over three successive measurements.

Table 3.1: Low-Flow Purge Stabilization Parameters

Water Level Drawdown	<0.3 feet
pH	± 0.1 standard units
Specific Conductance	± 3 percent (%)
Temperature	± 3%
DO	± 0.2 milligrams per liter or 10%
Turbidity	± 10% for values greater than 10 nephelometric turbidity units
ORP	± 10 millivolts

Once purging criteria has been achieved over three successive measurements, the discharge tubing will be disconnected from the flow-through cell, and the groundwater sample will be collected from the discharge tubing. If parameter stabilization does not occur within five well volumes, a groundwater sample will be collected. If the well has slow recharge which causes significant drawdown, the well may be purged dry and allowed to recharge to a level approximately 90% of the static water elevation before collection a groundwater sample. Groundwater will be collected in lab-provided sample containers and labeled accordingly.

Groundwater sampling procedures and details will be logged on a Groundwater Sampling Record presented in **Appendix B**. Refer to **Section 4.7** for sample packaging and shipping procedures.

3.3 Underground Utility Survey

Underground utility survey activities will be conducted to identify potential preferential pathways for migration of impacted groundwater to surface water. Prior to exploration activities, historical utility documentation will be reviewed to determine locations where subsurface utilities may exist. If areas that are not accessible for utility survey are found to contain possible exiting subsurface utilities that may create preferential pathways, additional steps will be taken as feasible to allow for accessibility of these areas for utility survey (e.g., vegetation removal). Ground penetrating radar (GPR) in conjunction with electromagnetic induction (EM) will be performed in areas of the Site that are accessible to map existing utility locations.

3.4 Field Health and Safety Procedures

Field activities will be conducted in accordance with the Site-Specific Health and Safety Plan (HASP). Field members will conduct daily safety tailgate meetings prior to beginning work each day. Documentation of tailgate meetings will be recorded on a Tailgate Safety Meeting Report shown in **Appendix C**. Activities and hazards associated with planned fieldwork, as well as personal protective equipment (PPE) requirements are included in the HASP.

3.5 Investigation Derived Waste

Investigation Derived Waste (IDW) will consist of purged groundwater, disposable PPE, and general refuse. Purged groundwater will be poured on the ground next to the monitoring well or returned to the borehole from which it came. Decontamination water will be containerized and disposed of offsite. PPE will be placed in general refuse containers for disposal at a sanitary landfill.

4.0 Quality Assurance / Quality Control

4.1 Field Sample Identification

Sample identification will be conducted in accordance with *SOP 04 – Sample Collection and Quality Assurance Procedure* included in **Appendix A**. Sample-specific sample identification designations will identify the following information:

1. Media Type
    - Surface Water – SW
    - Groundwater – GW
2. Sample Location Identifier
3. Date (DD/MM/YY)

For example, a groundwater sample collected from sampling location MW-33 on September 1st, 2024 would be labeled as GW-MW33-090124.

4.2 Prevention of Cross-Contamination

PFAS can be introduced into samples from various sources, such as field clothing, PPE, personal care products, sampling equipment, food packaging, or the surrounding environment. The *EGLE Surface Water PFAS Sampling Guidance* (EGLE, 2022b), *EGLE General PFAS Sampling Guidance* (EGLE, 2024) and *SOP 13 – Field Sampling Protocols to Avoid Cross-Contamination of PFAS* (**Appendix A**) outline procedures to be followed to mitigate potential cross-contamination. These actions include, but are not limited to, the following:

- Use of laboratory verified PFAS-free water for decontamination of sampling equipment
- Use of dedicated PFAS-free sampling equipment
- Use of PFAS-free field clothing and PPE
- Use and frequent changing of powderless nitrile gloves
- Use of PFAS-free sunscreens and insect repellants with restricted use near sampling areas
- Restricted application of personal care products near sampling areas
- Restricted use of pre-wrapped food or snacks near sampling and staging areas
- Proper sample handling, collection, and shipment techniques
- Proper decontamination techniques

4.3 Field Quality Control Samples

Quality control (QC) samples will be collected during the field investigation to evaluate field and laboratory variability. These samples will assess the reliability, repeatability, and confidence of the data collected. The following are the required minimum QC measures for analytical field sampling:

- Equipment Blanks: An equipment blank is used to document contamination attributable to the use of field sampling equipment. To prepare an equipment blank, the equipment will be filled or rinsed with laboratory-verified PFAS-free water, and the rinsate collected in the appropriate sample container(s). Equipment blanks will be collected at a rate of one per day. Identification for equipment blank samples will contain the prefix “EB”, the date, and the order of equipment blanks collected that day (e.g. the first equipment blank collected on September 1, 2024 would be labeled as EB-090124-1)

- Field Duplicates: A field duplicate is used to measure variability and document the precision of the sampling process. Field duplicates will be collected at the same time, from the same sample aliquot, and in the same sampling order (if applicable) as their respective parent samples. Field duplicates will be assigned arbitrary sample identification with false collection times so they are not identified by the laboratory. Duplicate samples will be randomly selected in the field and collected at a rate of one per 10 or fewer samples. Field duplicates will be identified by the prefix “FD”, the date, and the order of the specific media collected during that day (e.g. FD-090124-1).

- Matrix Spike and Matrix Spike Duplicates (MS/MSD): MS/MSD samples are used to determine the accuracy and precision of an analytical method for a specific sample matrix. MS/MSD samples will be collected as duplicates to a parent sample at a rate of 1 MS and 1 MSD per 20 or fewer samples per matrix. The MS and MSD will follow the same sample identification as the parent sample, but with an MS or MSD added after the sample name (e.g. GW-VAS10-090124-MS).

- Temperature Blanks: Temperature blanks are used to determine if the samples are at the appropriate temperature at the time the sample container (cooler) is received by the laboratory. The temperature blank will be provided by the laboratory and will be included in each sample cooler used to ship and store sample bottles during the event.

4.4 Field Data Records

Field logs and other forms (e.g. sampling forms, boring logs) will be completed in accordance with *SOP 01 – Note Taking and Field Book Entries* Procedure (**Appendix A**). A Daily Field Activity Log will be maintained to document daily activities and serve as a reference for future reporting and analysis. Samples will be recorded on Sample Control Logs. In addition, digital photographs will be taken to document significant observations during activities. Field documentation including field notes, photographs, and other forms (e.g., sampling forms, etc.) will be included in the Final Limited Remedial Investigation Report. Examples of the sampling forms to be used are included in **Appendix B**.

4.5 Field Equipment Calibration

During groundwater sample collection, an in-line flow-through cell equipped with a multi-parameter real-time water quality meter will be used. To ensure field parameters are correctly measured, the flow-through cell will be calibrated each day before use. Proper calibration will be conducted in accordance with *SOP 07 – Water Quality Monitoring Equipment Procedure* and manufacturer's instructions (**Appendix A**). Calibration records will be recorded on the Water Quality Sampling Instrument Calibration Form (**Appendix A**) and performed with calibration fluids provided by the equipment vendor.

4.6 Laboratory Services

Groundwater and surface water samples will be analyzed for PFAS by Merit Laboratories, Inc. in East Lansing, Michigan or another Michigan certified PFAS laboratory. Samples will be analyzed via modified ASTM Method D7979-19 with isotopic dilution for the determination of the following PFAS compounds:

- Perfluorobutanoic Acid (PFBA)
- Perfluoropentanoic Acid (PFPeA)
- 4:2 Fluorotelomer Sulfonic Acid (4:2 FTSA)
- Perfluorohexanoic Acid (PFHxA)
- Perfluorobutane sulfonic Acid (PFBS)
- Perfluoroheptanoic Acid (PFHpA)
- Perfluoropentane Sulfonic Acid (PFPeS)
- 6:2 Fluorotelomer Sulfonic Acid (6:2 FTSA)
- Perfluorooctanoic Acid (PFOA)
- Perfluorohexane Sulfonic Acid (PFHxS)
- Perfluorohexane Sulfonic Acid - LN (PFHxS-LN)
- Perfluorohexane Sulfonic Acid – BR (PFHxS-BR)
- Perfluorononanoic Acid (PFNA)
- 8:2 Fluorotelomer Sulfonic Acid (8:2 FTSA)
- Perfluoroheptane Sulfonic Acid (PFHpS)
- Perfluorodecanoic Acid (PFDA)
- N-methyl perfluorooctanesulfonamidoacetic acid (N-MeFOSAA)
- N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (EtFOSAA)
- Perfluorooctane Sulfonic Acid (PFOS)
- Perfluorooctane Sulfonic Acid – LN (PFOS-LN)
- Perfluorooctane Sulfonic Acid – BR (PFOS-BR)
- Perfluoroundecanoic Acid (PFUnDA)
- Perfluorononane Sulfonic Acid (PFNS)
- Perfluorododecanoic Acid (PFDoDA)
- Perfluorodecane Sulfonic Acid (PFDS)
- Perfluorotridecanoic Acid (PFTrDA)
- Perfluorooctane Sulfonamide (FOSA)
- Perfluorotetradecanoic Acid (PFTeDA)
- 11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)
- 9-chlorohexadecafluoro-3-oxanone1-sulfonic acid (9Cl-PF3ONS)
- 4,8-dioxa-3H-perfluorononanoic acid (ADONA)
- Hexafluoropropylene oxide dimer (HFPO-DA)
- 3-Perfluoroheptyl propanoic acid (7:3 FTCA)
- 3-Perfluoropentyl propanoic acid (5:3 FTCA)
- 3-Perfluoropropyl propanoic acid (3:3 FTCA)
- Perfluorobutanesulfonamide (PFBSA)
- Perfluoro-4-ethylcyclohexanesulfonate (PFECHS)
- Perfluorohexanesulfonamide (PFHxSA)

4.7 Sample Packaging and Shipment

In accordance with *SOP 3 – Sample Packaging and Shipment Procedure* (**Appendix A**), samples will be packed in a cooler in a manner that prevents breakage and with enough ice to ensure samples arrive at the laboratory at or below the required temperature criteria. Each cooler packaged for shipment will contain an original, laboratory provided chain of custody (COC) identifying sample information and requested analysis methods. Coolers will be taped closed to prevent opening during shipment. Laboratory sample receipt will be confirmed via laboratory contact or shipment tracking.

5.0 Reporting

Daily reporting will be conducted via submission of the forms and logs mentioned in previous sections of this report, including the following:

- Health and safety tailgate meetings
- Groundwater and surface water sampling forms
- Daily activity logs
- Photographs
- Copies of COCs
- Calibration records

After project completion, a Limited Remedial Investigation Report will be prepared by WSP documenting activities associated with sample collection and subsurface utility exploration. The Limited Remedial Investigation Report will document the following information:

- Summary of field activities, including descriptions of Work Plan deviations, if any
- Written summary of laboratory results
- Data will be validated to document that appropriate quality assurance and quality control (QA/QC) procedures were followed. Data will be reviewed and qualified when QA/QC criteria are not met and documented in a data validation report.
- Summary tables of laboratory data
- Figures depicting subsurface utility locations, groundwater sample locations, surface water sample location, and laboratory data results
- Appendices of laboratory reports, soil boring logs, monitoring well construction and development logs, groundwater and surface water sample records, and data validation reports
- Conclusions and Recommendations.

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6.0 References

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Figures

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FORMER JB SIMMS
GENERATING STATION
HARBOR ISLAND
GRAND HAVEN, MICHIGAN

Renew
Harbor Island

SITE LOCATION MAP

FIGURE 1

Imagery provided by google

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▭ Approximate Man-Altered Locations*

*From City of Grand Haven, Michigan, Harbor Island Master Plan 1993 Update (Ayers, Lewis, Norris & May)

FORMER JB SIMMS GENERATING STATION HARBOR ISLAND GRAND HAVEN, MICHIGAN	Renew Harbor Island	APPROXIMATE MAN-ALTERED LOCATIONS FIGURE 2

Imagery provided by google

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⊕ Former Surface Water Sample Location (SW-06-2023-05-01)

⊕ Approximate Proposed Surface Water Sample Location

FORMER JB SIMS GENERATING
STATION HARBOR ISLAND
GRAND HAVEN, MICHIGAN

Renew Harbor Island

SURFACE WATER SAMPLE LOCATION

FIGURE 3

Imagery provided by google

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● Groundwater Sampling Location (Future Monitoring Well)
▲ Vertical Aquifer Sampling (VAS) Location

Prepared/Date: DGJ 8/29/2023
Checked/Date: DH 8/29/2023

FORMER JB SIMS GENERATING
STATION HARBOR ISLAND
GRAND HAVEN, MICHIGAN

Renew
Harbor Island

GROUNDWATER SAMPLE
LOCATIONS

FIGURE 4

Imagery provided by google

Appendix A

Standard Operating Procedures

FIELD STANDARD OPERATING PROCEDURE #1

NOTE TAKING AND FIELD BOOK ENTRIES PROCEDURE

The field book is a record of the day's activities that serves as a reference for future reporting and analyses. The field book is also a legal record for projects that may be used during legal proceedings. It is of the utmost importance that all notes are complete and comprehensive. The user is advised to read the entire standard operating procedure (SOP) and review the project site health and safety plan (HASP) and/or project safety plan (PSP) before beginning any onsite activities.

1.1 ACRONYMS AND ABBREVIATIONS

HASP	Health and safety plan
IDW	Investigation-derived waste
PSP	Project safety plan
SOP	Standard operating procedure

1.2 MATERIALS

- Permanently-bound waterproof field book (e.g., Rite-in-the-Rain® #550, or equivalent)
- Black or blue ballpoint pen (waterproof ink recommended; do not use felt-tip pens)

1.3 PRECONDITIONS AND BACKGROUND

This SOP has been prepared as part of the company’s Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of company employees and will be revised periodically to reflect updates to company policies, work practices, and the applicable state and/or federal guidance. Employees must verify that this document is the most recent version of the company’s SOPs. Employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

WSP requires that all personnel performing specific project assignments be appropriately qualified, including having required certifications or licenses, and properly trained in accordance with the requirements of their assignment, the Environmental Service Line’s field standard operating procedures, and the Quality Management System.

The purpose of the field book is to provide a written log of all of field events and conditions. The notes must include sufficient detail (i.e., who, what, when, where, why, and how) to enable others to reconstruct the day’s activities for analysis, reporting, or litigation. It is important to be objective, factual, and thorough. Language must be free of personal comments or terminology that might prove inappropriate. Additional data logs or worksheets, such as low flow groundwater sampling sheets, may be used as a supplement; however, under no circumstances should the data sheets be used as a substitute for the daily record of events to be recorded in the field book.

The field book forms the foundation upon which most of the project work (reports, subsequent work plans, etc.) is based. It is critical that the field book’s chain of custody be maintained at all times.

1.4 SET-UP PROCEDURES

The first step in setting up a new field book is to add the information necessary for you to identify the field book in the future and for others to return the book to the company, should it be lost. On the first page of the field book (or, for some field books, the inside cover), place a "Return for Reward" notice. Include the following information:

- An "If Found – Return for Reward" notice in bold letters
- Our company name
- Our company address (usually the office where the project is being managed)
- Our company phone number

Reserve the second page of the field book for project-specific information, such as:

- The project name and number
- The project manager's name
- The site telephone number, address, and onsite contact (if appropriate)
- The names and telephone numbers for all key (onsite) personnel
- The emergency telephone numbers including the police, fire, and ambulance (found in the HASP)

Business cards from individuals who visit the site, (including the person in charge of the field book) can be affixed to the inside back cover.

1.5 FIELD BOOK ENTRIES

Start each day on a new page. Include the following information in the header of the first page (and all subsequent pages):

- The date
- The project name
- The page number (if not pre-printed in the field book)

Precede field book entries by the time entered along the left margin of the page using a 24-hour or military clock (e.g., 1330 for 1:30 PM). The first entry of the day must include your and your subcontractor's arrival time at the site, a description of the planned activities, key onsite personnel (including subcontractors), and the weather forecast. The first entry must also detail the tailgate review of the site-specific HASP or PSP with the onsite personnel. Be sure that field book entries are LEGIBLE and contain factual, accurate, and inclusive documentation of project field activities. Blank lines between field book entries should not be included unless necessary to accommodate a large entry (e.g., table or sketch); if blank lines are necessary, draw a line diagonally through any blank lines and initial at the end of the diagonal line. If a mistake is made in an entry, cross out the mistake with a single line and place your initials at the end of the line. Any acronyms written in the field book (including your initials) must be spelled out prior to the first use.

Subsequent log entries must document the day's activities in sequence and must be completed throughout the day as events occur (i.e., do not wait until the end of the work day to complete the notes); should notes need to be entered out of sequence, please identify the non-sequential entries using a footnote or by clearly indicating "Late Entry." Notes must be descriptive and provide location information or diagrams (if appropriate) of the work area or sample locations. Note any changes in the weather and document all deviations from the work plan. Arrival and departure times of all personnel, operational periods of standby, decontamination, and specific activities must be recorded.

Include the following information in entries describing field activities:

- The equipment, materials and methods used by subcontractors, if appropriate (e.g., drill rig type, boring diameters, well casing materials, etc.)
- The equipment, materials and methods used to obtain samples (e.g., split-spoon sampler, polyethylene bailer, pump types, geochemical, water or air monitoring equipment, low-flow purging procedures, etc.)
- The sample identification, which should include the location and depth, as appropriate
- The sample location, including a description of the approximate location as measured from a known point (e.g., 50 feet north of the building entrance; for points not yet surveyed)

- Any air or water monitoring equipment used, associated calibration activities, and measurements
- The sample collection time
- The sample identification of associated quality assurance/quality control samples (e.g., blind duplicate)
- The sample media and analyses to be performed; sizes, numbers, and types of containers; preservation (if any), and any resulting reactions (e.g., effervescence)
- If supplemental data recording logs (digital or hard copy) are used, such as groundwater sampling logs, chains-of-custody, and shipping records, the above information must be entered in the field book and the supplemental records cross-referenced
- The decontamination and disposal procedures for all equipment, samples, and personal protective equipment
- An inventory of the investigation-derived waste (IDW) materials generated during the site activities
- A description of the IDW labeling procedures and the onsite staging information; other sampling-specific information to be included in the IDW log is provided in SOP 5

Maintain a sequential log if the sample locations and areas of interest are photographed (strongly recommended). The photographic log must include:

- The date and time of the photograph
- The sequential number of the photograph (e.g., photograph-1, photograph-2, etc.)
- The general direction faced when the photograph was made
- A description of the subject in the image

1.6 CLOSING NOTES

The last entry of the day must include a brief wrap up of the work accomplished, a description of how the site is being secured, and a description of any near hits, accidents, and incidents that occurred during the day’s work. Draw a line through the remainder of the page from the row of text diagonally through any blank lines and initial at the end of the diagonal line.

FIELD STANDARD OPERATING PROCEDURE #3

SAMPLE PACKAGING AND SHIPMENT PROCEDURE

Shipping samples is a basic but important component of field work. The majority of field activities include the collection of environmental samples. Proper packing and preservation of those samples is critical to ensuring the integrity of our work product. The user is advised to read the entire standard operating procedure (SOP) and review the site health and safety plan (HASP) and/or project safety plan (PSP) before beginning any onsite activities. In accordance with the HASP or PSP, proper personal protective equipment (PPE) must be selected and used appropriately.

3.1 ACRONYMS AND ABBREVIATIONS

CFR	Code of Federal Regulations
DOT	U.S. Department of Transportation
IATA	International Air Transport Association
HASP	Health and safety plan
PPE	Personal protective equipment
PSP	Project safety plan
SOP	Standard operating procedure

3.2 MATERIALS

- Suitable shipping container (e.g., plastic cooler)
- Chain-of-custody forms
- Custody seals
- Sample container custody seals (as necessary)
- Mailing address labels (as necessary)
- Shipping form (with account number, as necessary)
- Tape (e.g., strapping, clear packing)
- Permanent marker
- PPE
- Bubble wrap or other packing material

Temperature-preserved samples:

- Large plastic garbage bag
- Wet ice
- Heavy-duty zipper-style plastic bags
- Universal sorbent materials

Note: Some materials will be supplied by the laboratory, while others are must be supplied by the sampler. Confirm supplier of materials prior to mobilizing to the field.

3.3 PRECONDITIONS AND BACKGROUND

This SOP has been prepared as part of the company's Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel

and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of company employees and will be revised periodically to reflect updates to company policies, work practices, and the applicable state and/or federal guidance. Employees must verify that this document is the most recent version of the company SOPs. Employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

WSP requires that all personnel performing specific project assignments be appropriately qualified, including having required certifications or licenses, and properly trained in accordance with the requirements of their assignment, the Environmental Service Line’s field standard operating procedures, and the Quality Management System.

This SOP is designed to provide the user with a general outline for shipping samples and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), sample collection and quality assurance procedures (SOP 4), and investigation derived waste management procedures (SOP 5).

Most environmental samples are classified non-hazardous materials due to unknown characteristics and hazardous classes, however environmental samples can meet the definition of U.S. Department of Transportation (DOT) hazardous materials when shipped by air, ground, or rail from a project site to the laboratory (e.g., free product, samples preserved with a hazardous material [TerraCore® samplers]). As such, field staff must work with their assigned company compliance professional to determine whether the sample shipment is subject to any specific requirements (e.g., packaging, marking, labeling, and documentation) under the DOT hazardous materials regulations.

3.4 SAMPLE SHIPMENT PROCEDURES

The two major concerns in shipping samples are incidental breakage during shipment and complying with applicable DOT and courier requirements for hazardous materials shipments.

> **NOTE: Many couriers, including Federal Express and United Parcel Service, have requirements that the company register with them before shipping hazard materials. In most cases, it is the sampling location, not the company office address, which needs to be registered. Therefore, each project will likely have unique requirements. Please contact your company compliance professional to determine whether or not you will be required to register for your shipment.**

Protecting the samples from incidental breakage can be achieved using "common sense." Pack all samples in a manner that will prevent them from moving freely about in the cooler or shipping container. Do not allow glass surfaces to contact each other. When possible, repack the sample containers in the same materials that they were originally received in from the laboratory. Cushion each sample container with plastic bubble wrap, styrofoam, or other nonreactive cushioning material. A more detailed procedure for packing environmental samples is presented below.

3.4.1 NON-HAZARDOUS MATERIAL ENVIRONMENTAL SAMPLES

The first step in preparing your samples for shipment is securing an appropriate shipping container. In most cases, the analytical laboratory will supply the appropriate container for bottle shipment, which can be used to return samples once they have been collected. Be sure that the container is large enough to contain the samples plus a sufficient amount of packing materials, and if applicable, enough wet ice to maintain the samples at the preservation temperature (usually 4 degrees Celsius). Use additional shipping containers as needed so that sample containers are protected from breakage due to overcrowding. Do not use lunch-box sized coolers or soft sided coolers, which do not offer sufficient insulation or protection from damage.

3.4.1.1 TEMPERATURE-PRESERVED SAMPLE CONTAINER PREPARATION

Temperature-preserved samples should be shipped to the laboratory in an insulated container (e.g., cooler). If using a plastic cooler with a drain, securely tape the inside of the drain plug with duct tape or other material to ensure that no water leaks from the cooler during shipment. Place universal sorbent materials (e.g., sorbent pads) in the bottom of the insulated container. The amount of sorbent material must be sufficient to absorb any condensation from the wet ice and a reasonable volume of water from melted wet ice (if a bag were to rupture) or a damaged (aqueous) sample container.

The next step is to line the insulated container with a large, heavy-duty plastic garbage bag. If shipping breakable sample containers (e.g., glass), place bubble wrap or other packing materials on the bottom of the container. Place the samples, including a temperature blank, on the packing materials with sufficient space to allow for the addition of more bubble wrap or other packing material between the sample containers. Place large or heavy sample containers on the bottom of the cooler with lighter samples placed on top to minimize the potential for breakage. Place all sample containers in the shipping container right-side up. Do not overfill the cooler with samples; room must be left for a sufficient volume of wet ice. Wet ice must be double-bagged in heavy-duty zipper-style plastic bags (1 gallon-sized, or less); properly seal both bags before placing in the insulated container. Place the bags of ice on top of or between the samples. Place as much ice as possible into the cooler to ensure the samples arrive at the lab at the required preservation temperature, even if the shipment is delayed. Fill any remaining space in the container with bubble wrap or other packing material to limit the airspace and minimize the shifting of the sample containers and in-transit melting of ice. Securely close the top of the heavy-duty plastic bag and knot or seal with tape.

3.4.1.2 NON-TEMPERATURE-PRESERVED SAMPLE CONTAINER PREPARATION

Non-temperature-preserved samples should be shipped to the laboratory in a durable package (e.g., hard plastic container or cardboard box). If shipping breakable sample containers (e.g., glass), place bubble wrap or other packing materials on the bottom of the container. Place the samples on the packing materials with sufficient space to allow for the addition of more bubble wrap or other packing material between and on top of the sample containers. Place large or heavy sample containers on the bottom of the container with lighter samples placed on top to minimize the potential for breakage. Place all sample containers within the shipping container right-side up. Fill any remaining space in the container with bubble wrap or other packing material to limit the airspace and minimize the shifting of the sample containers and in-transit melting of ice.

3.4.1.3 CONTAINER SHIPMENT

Samples in the container should be cross-checked against the chain-of-custory before signing off on the form and sealing the cooler. Place the original chain-of-custody form (i.e., laboratory copy) into a heavy-duty zipper-style plastic bag, affix/tape the bag to the shipping container's inside lid, and then close the shipping container; as required, include return shipping labels for the laboratory to return company-owned coolers. Only one chain-of-custody form is required to accompany one of the shipping containers per sample shipment; the other coolers in the shipment do not need to include chain-of-custody forms, unless required by the project. At this point, sample shipment preparations are complete if using a laboratory courier.

Once the shipping container is sealed, shake test the shipping container to make sure that there are no loose sample containers. If loose sample containers are detected, open the shipping container, repack the contents, and reseal the shipping container. If sending the sample shipment through a commercial shipping vendor, place two signed and dated chain-of-custody seals on alternate sides of the shipping container lid so that it cannot be opened without breaking the seals. Securely fasten the top of the shipping container shut with clear packing tape; carefully tape over the custody seals to prevent damage during shipping.

Affix a mailing label with the ship to and return to addresses to the top of the shipping container using clear shipping tape. Use the pre-printed return mailing label from the laboratory, if provided, or complete a new mailing label from the shipping carrier. Ship environmental samples to the contracted analytical laboratory using an appropriate delivery schedule. **Note: Samples can be shipped for Saturday delivery once the lab has been verified to be open and receiving samples on the weekend.**

Verify whether the shipment cost should be billed to the sender or recipient, and ensure the internal billing reference section on the mailing label includes either the laboratory's billing reference number, if the shipment is billed to the laboratory, or the project billable number, if the shipment is billed to WSP.

Declare the value of samples on the shipping form for insurance purposes, if applicable. When shipping samples to a lab, identify a declared value equal to the carrier's default value ($100); additional fees will be charged based on a higher value declared. Our preferred carrier, Federal Express, will only reimburse for the actual value of the cooler and its contents if a sample shipment is lost; they will not reimburse for the cost of having to re-collect the samples. [Please note: if you are shipping something other than samples, such as field equipment, declare the replacement value of the contents.]

Record the tracking numbers from the shipping company forms (i.e., the airbill number) in the field book and retain a copy of the shipping airbill. On the expected delivery date, confirm sample receipt by contacting the laboratory or tracking the package using the tracking number; provide this confirmation information to the project manager.

> **NOTE: Most shipping carriers adhere to transit schedules with final pickup times each day; these schedules are subject to change and vary by service location. If shipping containers are dropped off at a service location after the final pickup time, transit to the laboratory will not be initiated until the following day, and samples may not be properly preserved. Therefore, confirm transit schedules in advance of each sampling event, and ensure samples are delivered to the carrier before the final pickup time of the day.**

3.4.2 HAZARDOUS MATERIALS SAMPLES

Employees rarely ship hazardous materials due to DOT shipping requirements. If you find that your samples could be considered a DOT hazardous material, first coordinate with the assigned company compliance professional and project manager to make a hazardous material classification and, if necessary, establish the necessary protocols and to receive the appropriate training/certification.

> **NOTE: Employees shipping samples regulated as hazardous materials or exempt hazardous materials by air must have International Air Transport Association (IATA) training. IATA training is a separate training required in addition to DOT hazardous materials training for such shipments. Most of our employees do not have IATA training and therefore, anyone who needs to ship by air MUST consult with a company IATA-trained compliance professional.**

FIELD STANDARD OPERATING PROCEDURE #4

SAMPLE COLLECTION AND QUALITY ASSURANCE PROCEDURE

The purpose of this procedure is to assure that sample volumes and preservatives are sufficient for analytical services required under U.S. Environmental Protection Agency (EPA) or other agency approved protocols. This operating procedure describes sample identification procedures, sampling order for select analytes, quality control and quality assurance (QA/QC) sampling procedures, and custody documentation. The user is advised to read the entire standard operating procedure (SOP) and review the site health and safety plan (HASP) and/or project safety plan (PSP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

4.1 ACRONYMS AND ABBREVIATIONS

ºC	degrees Celsius
COC	chain-of–custody [form]
DI	laboratory-grade, analyte-free deionized water
DOT	US Department of Transportation
EDD	electronic data deliverable
EPA	US Environmental Protection Agency
HASP	health and safety plan
ID	identification [number]
MS/MSD	matrix spike and matrix spike duplicate
MSA	master services agreement
PPE	personal protective equipment
PSP	project safety plan
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
SOP	standard operating procedure
VOCs	volatile organic compounds

4.2 MATERIALS

- Field book
- Indelible (waterproof) markers or pens
- PPE
- Sampling containers and labeling/shipping supplies

- Deionized (DI) water
- Cleaned or dedicated sampling equipment

4.3 PRECONDITIONS AND BACKGROUND

This SOP has been prepared as part of the company's Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of employees and will be revised periodically to reflect updates to company policies, work practices, and the applicable state and/or federal guidance. Employees must verify that this document is the most recent version of the company's SOPs. Employees are also strongly advised to review relevant state and federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

WSP requires that all personnel performing specific project assignments be appropriately qualified, including having required certifications or licenses, and properly trained in accordance with the requirements of their assignment, the Environmental Service Line's field SOPs, and the Quality Management System.

This SOP is designed to provide the user with a general outline for collecting environmental and quality assurance samples and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), sample shipment procedures (SOP 3), investigation derived waste management procedures (SOP 5), and equipment decontamination (SOP 6). This SOP does not cover investigation planning, nor does it cover the analysis of the analytical results. These topics are more appropriately addressed in a site-specific work plan or a dedicated quality assurance project plan (QAPP). This SOP does not include an special handling requirements for specific parameters such as low-level mercury or per- and polyfluoroalkyl substances. These requirements should be included in the QAPP.

4.4 SAMPLE IDENTIFICATION PROCEDURES

All sample containers (e.g., glass bottles, plastic jars, foil bags, plungers, etc.) should be identified by an affixed sample label. Unless otherwise approved by your project manager or specified in your site-specific work plan/QAPP, information on the sample container labels must include the site/project name, project/task number, unique alpha-numeric sample identification (ID) number, sample collection date, time of collection using the military or 24-hour clock system (i.e., 0000 to 2400 hours), analytical parameters, preservative, and the initials of the sampling personnel. Employees are advised to use pre-printed waterproof mailing labels (e.g., Avery® 5xxx-series Waterproof Address Labels) for all sample identification. Electronic label templates are available.

The sample identification (ID) number must, unless otherwise approved by your project manager or specified in your site-specific work plan/QAPP, follow the company's naming protocol. This protocol was developed to aid in determining the type of sample collected (e.g., soil, groundwater, vapor, etc.), the sample location, and, where appropriate, the sample depth. This protocol was also designed to ensure consistency across the company.

Construct sample IDs in the following format:

SB-10A (4-6)

Where, in this example:

- SB = the first two or three characters will define the sample type (see list of approved prefixes below); in this case, a soil boring
- 10A = the next two or three alpha-numeric digits (separated by a dash from the sample type identifier) indicate the location of the boring on the site; in this case, boring number 10A
- (4-6) = the depth the sample was collected, with the first number (including decimals, if necessary) indicating the top of the sample interval (in feet) and the second number indicating the bottom of the sample interval (in feet); not all sample types will include depth information.

Additional label information may be added after the last character of the sample ID number (e.g., sample date, underground storage tank number, area of concern number, "Area" number, client identifier, etc.). Separate any additional information from the required portion of the sample name by dash(es).

Sample Prefix	Permitted Use
AA	Ambient outdoor air sample
CC	Concrete core/chip sample
CS	Confirmation/verification soil sample collected from an excavation
HA	Soil sample collected with a hand auger
IAB	Indoor air sample – basement
IAC	Indoor air sample – crawl space
IAF	Indoor air sample – first floor
MW	Soil sample collected from a monitoring well borehole or a groundwater sample collected from a monitoring well
PZ	Groundwater sample collected from a piezometer
SB	Soil sample collected from boreholes that will not be converted to monitoring wells
SED	Sediment sample
SG	Soil gas sample other than a sub-slab sample (e.g., sample collected from a temporary or permanent polyvinyl chloride sample point or stainless steel screen implant)
SL	Sludge sample
SS	Surface soil sample collected using hand tools (e.g., trowel, spoon, etc.) and typically at depths less than 2 feet below ground surface
SSV	Sub-slab vapor sample
SW	Surface water sample
TC	Tree core sample
TP	Soil sample collected from a test pit
WC	Waste characterization sample
WP	Wipe sample
WW	Wastewater

4.5 SAMPLE CONTAINERS, PRESERVATIVES, AND HOLDING TIMES

The first step in sample collection is to verify that the correct number and type of sample containers were provided, and that each contains the appropriate preservatives for the proposed project (i.e., check against the sampling plan requirements outlined in the site-specific QAPP or, for those projects without a site-specific QAPP, the laboratory Task Order). Inspect all containers and lids for flaws (cracks, chips, etc.) before use. Do not use any container with visible defects or discoloration. Report non-receipt and any discrepancies of specific types of sample containers to the team leader or project manager immediately. Make arrangements to have missing or additional sampling containers provided on an expedited basis.

Precautions must be taken to prevent cross-contamination and contamination of the environment when collecting samples. Wear a clean pair of new, disposable gloves each time a different sample is collected and don the gloves immediately prior to collection. This limits the possibility of cross-contamination from accidental contact with gloves soiled during collection of the previous sample. The gloves must not contact the medium being sampled and must be changed any time during sample collection when their cleanliness is compromised. ***In no case should gloved hands be used as a sampling device: always use the appropriate sampler to move the sample from the sampling device to the laboratory-supplied containers.***

Sample collection must follow all appropriate SOPs, state and federal regulations, or guidance, for the collection of environmental samples; the recommended order of sample collection is:

- Geochemical measurements (e.g., temperature, pH, specific conductance)
- Volatile organic compounds (VOCs)
- Extractable organics, petroleum hydrocarbons, aggregate organics, and oil and grease
- Per- and Polyfluoroalkyl substances
- Total metals
- Dissolved metals
- Inorganic non-metallic and physical and aggregate properties
- Microbiological samples
- Radionuclides

Fill the sample bottles to the appropriate level for the parameter analyzed including eliminating head space, as appropriate. Collected samples that require thermal preservation must be immediately (within 15 minutes) placed in a cooler with wet ice and maintained at a preservation temperature of 4° Celsius (ºC).

4.6 FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

Field quality assurance/quality control (QA/QC) samples may include equipment blanks, trip blanks, temperature blanks, duplicates, matrix spike and matrix spike duplicate samples, field blanks, and split samples. The project manager or QAPP must specify the type and frequency of QA/QC sample collection. The QA/QC sample identification number must, unless otherwise approved by your project manager or specified in your site-specific work plan, follow the company’s naming protocol as discussed in the sections below. QA/QC samples must be clearly identified on our copy of the chain-of-custody (COC) form (described below) and in the field book. Failure to properly collect and submit required QA/QC samples can result in invalidation of an entire sampling event.

Several blanks, discussed below, require laboratory-grade analyte-free, deionized water (DI) be used. Only if all options to obtain laboratory-grade DI have been exhausted should store-grade distilled water be used to prepare blanks. If store-grade distilled water is used, be sure to record the source and lot number in the field book.

Collect, preserve, transport and document split samples using the same protocols as the related samples.

4.6.1 EQUIPMENT BLANKS

Equipment blanks, or rinsate blanks, are used to document contamination attributable to using non-dedicated equipment (i.e., equipment that must be decontaminated after each use). Collect equipment blanks in the field at a rate of one per type of sampling equipment per day, unless otherwise specified. If the site-specific work plan or QAPP indicates that an equipment blank is to be collected from dedicated sampling equipment, collect the equipment blank in the field before sampling begins. If field decontamination of sampling equipment is required, prepare the equipment blanks after the equipment has been used and field-decontaminated at least once.

Prepare equipment blanks by filling or rinsing the pre-cleaned equipment with DI and collecting the rinsate in the appropriate sample containers. Record the type of sampling equipment used to prepare the blank and how the equipment blank was generated in the field book. Decontamination of the equipment following equipment blank procurement is not required.

The samples must be labeled, preserved, and filtered (if required) in the same manner as the environmental samples. Have the equipment blanks analyzed for all the analytes for which the environmental samples are being analyzed, unless otherwise specified. Designate equipment blanks using “EB”, followed by the date, and in the order of equipment blanks collected that day. For example, the first equipment blank collected on July 4, 2015, would be designated EB070415-1.

4.6.2 TRIP BLANKS

Trip blanks are used to document VOC contamination attributable to shipping and field handling procedures. Trip blanks are only required when analyzing samples for VOCs. The blanks are prepared by the analytical laboratory and shipped along with the empty sample containers. These pre-filled blanks should accompany the environmental sample containers wherever they are stored onsite (i.e., keep the trip blank sample bottles in the same shipping container used to ship and store VOC sample bottles during the sampling event). Never open the laboratory-supplied trip blank sample bottles. Only as a last resort, store-grade distilled water, can be poured into empty VOC sample bottles to generate event-specific trip blanks (or augment the laboratory-supplied ones, if they are provided in insufficient numbers).

The trip blanks, even those provided by the analytical laboratory, should be labeled in the field like other environmental samples collected during the investigation activities. Identify trip blanks using the prefix “TB”, followed by the date. For example, the trip blank shipped with a cooler of samples on July 4, 2019, would be designated TB070419-1. If a second trip blank is needed on that same day, the designation would be TB070419-2. A minimum of one trip blank should accompany each shipping container of VOC samples, unless more stringent project requirements are in place. The number of trip blanks needed per shipment can be minimized by shipping all the VOC samples in the same shipping container (if possible).

4.6.3 FIELD BLANKS

The field blank is analogous to the trip blank in that it is designed to assess and document any contamination to the environmental samples that can be attributable to the (ambient) field conditions. Not all projects require the use of field blanks. Their use, if required, and the frequency of collection (often 1 blank per 10 or 20 environmental samples collected) is detailed in the QAPP and the site-specific work plan. The sample is collected by pouring DI water into empty glassware at the site during the sampling event. The intent is to expose the field blank to the same conditions in the atmosphere as those present when the environmental samples were collected.

Identify field blanks using the prefix “FB”, followed by the date. For example, the field blank shipped collected on August 22, 2019, would be designated FB082219. If a second field blank is needed on that same day, the designation would be FB082219-2. At least one field blank should be collected for each analytical parameter identified in the sampling event.

4.6.4 TEMPERATURE BLANKS

Temperature blanks are used to determine if the samples are at the appropriate temperature for preservation at the time the sample container (cooler) is received by the analytical laboratory. The temperature is determined by measuring the temperature blank, which provides a proxy for the temperature of the sample container upon arrival at the laboratory. These temperature blanks are typically provided by the laboratory and should be included in each sample cooler used to ship and store the sample bottles during the sampling event. If laboratory-provided temperature blanks are not available, fill a clean, unpreserved sample bottle with potable, DI, or store-grade distilled water and identify the bottle as a temperature blank.

4.6.5 DUPLICATES

Duplicate samples, which are used for measuring the variability and documenting the precision of the sampling process, should be collected at a rate of at least 1 duplicate per 20 environmental samples collected, unless specific project requirements (as detailed in a QAPP) are in place. Be sure that the location selected for duplication has sufficient sample volume and is within the area of contamination, if known. Under no circumstances can equipment or trip blanks be used as duplicates.

Collect each duplicate sample at the same time, from the same sample aliquot, and in the same sampling order (i.e., volatile organic compounds, then semivolatile organic compounds, then inorganics, etc.) as the corresponding environmental sample. Sample bottle aqueous duplicate samples, for example, should be alternately filled with the environmental sample bottles (i.e., the actual sample bottle and the bottle to be used for the duplicate) from the same sampling device. If the sampling device does not hold enough volume to fill the sample containers, fill the first container with equal portions of the sample, and pour the remaining sample into the next sample containers. Obtain additional sample volume and pour the first portion into the last sample container, and pour the remaining portions into the first containers. Continue with these steps until all containers have been filled.

Duplicate samples will be assigned arbitrary sample ID and a false collection time so that they are not identified as duplicates by the laboratory (i.e., submit the duplicates samples as *blind* to the lab). The blind duplicate sample "location designation" will be left up to the project manager; however, in no case will "Dup" be allowed to appear in the sample name. The duplicate samples should be analyzed for the same analytes as the original environmental sample. Be sure to record the sampling method, duplicate sample ID, the false time, and the actual time of collection in the field notebook. The duplicate should also be indicated in separate documentation, such as on our carbon copy of the chain-of-custody (i.e., the yellow copy), and not on the original chain-of-custody that accompanies the samples to the laboratory.

4.6.5 MATRIX SPIKE AND MATRIX SPIKE DUPLICATES

Matrix spike and matrix spike duplicate samples (i.e., MS/MSD samples) are used to determine the bias (accuracy) and precision of an analytical method for a specific sample matrix. Many of the company’s projects require the collection of MS/MSD samples; however, laboratory generated MS/MSD samples are sufficient for some projects (as detailed in the QAPP or site-specific work plan). Collect MS/MSD samples at a rate of 1 MS and 1 MSD (i.e., 2 samples) for every 20 environmental samples, unless more stringent project requirements (as detailed in a QAPP) are in place. Clearly convey the MS/MSD identity to the laboratory by adding “MS" or "MSD” after the sample name (e.g., MW-01MS) and/or in the comments section of the chain-of-custody on the same line as the parent sample. Under no circumstances can equipment or trip blanks be used as MS/MSD samples.

4.6.6 SPLIT SAMPLES

Split samples may be collected as a means of determining compliance or as an added measure of quality control. Split samples measure the variability between laboratories and not the variability of sample collection and laboratory procedures (i.e., they are not equivalent to duplicate samples). The split samples must be subsamples of the same parent material used for the environmental sample: soil should be collected from the same in-place material (for VOCs) or, for non-discrete samples, the same mixing vessel after homogenization. Collect aqueous split samples using the same alternating bottle approach detailed in the duplicate sample description above. These procedures will ensure that the split samples are valid and are representative of the environmental sample collected as part of the investigation.

Collecting split samples of soil, sediment, waste, and sludge is not recommended because the homogenization necessary for a true split sample in these matrices is not possible and the resulting laboratory results would not be comparable.

Spilt samples should have the same sample location designation (e.g., MW-01, SB-03 (4-6), but are differentiated from each other by inserting the laboratory analyzing or the agency/consultant collecting the sample after the sample location (e.g., MW-01-WSP and MW-01-EPA).

4.7 CUSTODY DOCUMENTATION

Sample custody protocols are used to demonstrate that the samples and sample containers were handled and transferred in such a manner as to prevent tampering. Legal COC begins when the pre-cleaned sample containers are dispatched to the field from the laboratory and continues through sample analysis and eventual disposal of the sample and sample containers. Maintaining custody requires that samples must be in the actual possession or view of a person who is authorized to handle the samples (e.g., sample collector, laboratory technician, etc.), secured by the same person to prevent tampering, or stored in a designated secure area.

It is a good idea to limit, to the extent possible, the number of individuals who physically handle the samples. Samples must be placed in locked storage (e.g., locked vehicle, locked storeroom, etc.) when not in the possession or view of authorized personnel. Do not leave samples in unoccupied motel or hotel rooms or other areas where access cannot be controlled by the person(s) responsible for custody without first securing samples and shipping or storage containers with tamper indications in place (i.e., custody seals).

The COC form is used to trace sample possession from the time of collection to receipt at the analytical laboratory. It is recommended that the company's COC be used rather than the laboratory-supplied COC form to ensure that all necessary data are recorded. Submit one COC form per sample shipment, unless more stringent project requirements are in place (as detailed in the QAPP or site-specific work plan). The COC needs to have a unique COC number (pre-printed on the form), accompany all the samples, and include all appropriate project-specific information, such as:

- Project number, name, and location
- Sampler's printed name(s) and signature(s)
- Sample identification number
- Date and time (using the 24-hour clock) of collection
- Sample matrix (e.g., soil, aqueous, solid, etc.)
- Total number of containers per sample
- Parameters requested for analysis including number of containers per analyte.
- Remarks (e.g., irreducible headspace, field filtered sample, expected concentration range, specific turn-around time requested, etc.)
- Signatures of all persons involved in the chain of possession in chronological order
- Requested turn-around-time
- Name and location of analytical laboratory
- Custody seal numbers
- Shipping courier name and tracking information
- Internal temperature of shipping container upon shipment to laboratory, as needed
- Internal temperature of shipping container upon delivery to laboratory
- Employee contact information

Affix custody seals to all storage and shipping container closures when transferring or shipping sample container kits or samples to an off-property party. Place the seal so that the closure cannot be opened without breaking the seal. In the field book, record the time, date and signatures of responsible personnel affixing and breaking all seals for each sample container and shipping container. Affix new custody seals every time a seal is broken until continuation of evidentiary custody is no longer required.

FIELD STANDARD OPERATING PROCEDURE #6

DECONTAMINATION PROCEDURE

The decontamination procedures outlined in this standard operating procedure (SOP) are designed to ensure that all sampling equipment is free from the analytes that could potentially interfere with sample results. The user is advised to read the entire SOP and review the site health and safety plan (HASP) and/or project safety plan (PSP) before beginning any onsite activities. In accordance with the HASP or PSP, proper personal protective equipment (PPE) must be selected and used appropriately.

6.1 ACRONYMS AND ABBREVIATIONS

DI	deionized water
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
HASP	health and safety plan
PPE	personal protective equipment
PSP	project safety plan
QAPP	quality assurance project plan
SOP	standard operating procedure

6.2 MATERIALS

- Field book
- PPE
- Polyethylene sheeting and/or garbage bags
- Laboratory-grade non-phosphate detergent[1] (e.g., Luminox® or Liquinox®)
- Cleaning reagents, as needed (e.g., isopropyl alcohol, methanol, hexane, nitric acid)
- Potable water
- Deionized (DI) water
- Containers (e.g., plastic buckets)
- Bristle brushes
- Aluminum foil
- Spray bottles
- Paper towels
- Pressurized steam cleaner (e.g., steam jenny), as needed
- Waste collection containers (e.g., drums), as needed
- Decontamination pad, as needed

6.3 PRECONDITIONS AND BACKGROUND

This SOP has been prepared as part of the company's Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel

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[1] Not all laboratory-grade detergents are phosphate free. Be sure to verify the detergent's phosphate content before use.

and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of company employees and will be revised periodically to reflect updates to company policies, work practices, and the applicable state and/or federal guidance. Employees must verify that this document is the most recent version of the company's SOPs. Employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

WSP requires that all personnel performing specific project assignments be appropriately qualified, including having required certifications or licenses, and properly trained in accordance with the requirements of their assignment, the Environmental Service Line's field SOPs, and the Quality Management System.

This SOP is designed to provide the user with a general outline for decontamination and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), sample shipment procedures (SOP 3), sample collection and quality assurance procedures (SOP 4), and investigation-derived waste management procedures (SOP 5). All decontamination references must be available for consultation in the field, including:

- Company's SOPs
- Applicable state and federal guidelines or procedures
- Manufacturer's manuals
- Project-specific work plan, PSP and/or HASP, and QAPP

6.4 GENERAL PROCEDURES

The cleaning and decontamination procedures described below are designed to ensure that the equipment used for sample collection is free of analytes that could potentially alter the analytical results. These procedures are primarily targeted at preventing the incidence of cross-contamination (i.e., compounds of interest being transferred on the sampling equipment from one sample to another) in order to produce high quality, representative sample results. As with all analytical sampling, the effectiveness of the cleaning procedures must be demonstrated with the collection of equipment blanks; equipment blank sample collection procedures and frequency are discussed in SOP 4.

6.4.1 EQUIPMENT AND REAGENT SELECTION

It is important for employees to evaluate the expected types of contamination before mobilization to a site. State programs (or the U.S. Environmental Protection Agency [EPA], depending on the site) may require more stringent decontamination procedures than those listed in this SOP, specify the types and grades of various cleaning detergents and reagents (e.g., acids and solvents), or allow the use of phosphate-containing detergents, such as Liquinox® liquid detergent (preferred[2]) or the powdered Alconox®. Decontamination equipment (e.g., spray bottles, brushes, etc.) should be constructed of non-reactive, non-leachable materials (e.g., metal, glass, Teflon®-coated, polyethylene, etc.) which are compatible with the reagents and solvents being used for decontamination.

Many of the cleaning reagents (e.g., nitric acid, hexane, methanol) are U.S. Department of Transportation (DOT) hazardous materials and must be shipped using a ground delivery service. The Safety Data Sheets (SDSs) for any hazardous cleaning reagents to be used onsite must be reviewed before the commencement of work, and the potential hazards and protective measures to be employed must be addressed in the HASP. Do not use decontamination liquids that have been improperly stored (e.g., unsealed containers).

In specific cases, it may be necessary to steam clean the field equipment before proceeding with the decontamination steps presented in Section 6.5 (e.g., hollow stem augers). Generally, the company's subcontractors are responsible for bringing or building a decontamination pad, if necessary, to contain the spray from a steam jenny. As possible, decontamination pads should be constructed on a level, paved surface in an area known or believed to be free of surface contamination, and should be of sufficient size to contain the decontamination water. Equipment that is steam cleaned should be placed on racks or saw horses and not on the floor of the

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[2] Liquinox® liquid detergent, manufactured by Alconox, Inc., is phosphate-free and does not contribute to nutrient loading or algae blooms in the environment.

decontamination pad. Decontamination water should be removed from the decontamination pad frequently to minimize the potential for leaks or overflow.

Consult and involve the company's compliance professionals for storage procedures and disposal requirements of cleaning reagents, detergents, wastes, and other decontamination-related materials.

6.4.2 OTHER CONSIDERATIONS

In preparing for decontamination, you should perform the following activities (with all observations and measurements noted in the field book):

- Perform a quick reconnaissance of the site to identify a decontamination (pad) area and evaluate the accessibility to and safety of the location.
- If working in a hazardous waste exclusion area, the decontamination area should be located in the contaminant reduction zone.
- Record a description of the decontamination (pad) area.

Survey the breathing zone around the decontamination area with the appropriate air quality meter(s), as necessary (see HASP), to ensure that the level of PPE is appropriate. When decontaminating equipment, it is important to find a suitable location away from any sources of cross-contamination that could compromise the integrity of the decontamination. As possible, position the decontamination area away from fuel-powered equipment, such as drill rigs or excavators, and upwind of other site activities (e.g., purging, sampling).

6.5 DECONTAMINATION PROCEDURES

The decontamination procedures described below are a four- to nine-step process, depending on the the applicable federal or state guidelines, the project-specific work plan, or the QAPP. Sampling activities must be initiated with clean, decontaminated equipment. Decontaminate all non-dedicated equipment that contacts the sample directly (e.g., spoons, trowels, pumps), before and between each sample location and sampling interval. record decontamination procedures in the field book. Disposable, single use items, such as bailers or tubing, do not require decontamination.

The decontamination process includes the following four basic steps:

1. Physical removal of soil or debris
2. Wash with non-phosphate detergent, such as Liquinox®, and nylon brush
3. Potable water rinse
4. Laboratory-supplied deionized (DI), analyte-free water rinse (distilled water can be used as a substitute, if necessary)

The first step is to remove as much soil or other debris from the sampling device as possible near the sampling area to limit the spread of potentially-contaminated materials into clean areas of the site. Containerize all soil or debris in DOT-compliant containers in accordance with SOP 5 or the project-specific work plan. Dispose of all wastes in conformance with the project-specific work plan and applicable regulations.

Cleaning and decontamination should occur at a designated area(s) (i.e., decontamination pad) on the site. If gross contamination or an oily film or residue is observed on the equipment, use a steam jenny or wash by hand, using a brush, to remove the particulate matter or surface film. Heavy oils or grease may be initially removed with paper towels soaked with isopropyl alcohol.

The physical removal of debris process is followed by soaking (a simple dunk of the equipment is insufficient) and hand scrubbing the equipment with a solution of potable water and non-phosphate detergent (mixed to the manufacturer's instructions) followed by a potable water rinse. If not using a decontamination pad, the most common set-up uses multiple 5-gallon plastic buckets (or equivalent) for washing and rinsing. The decontamination containers should be labeled as to their contents and pertinent information from original source, such as the date opened or transferred, and the expiration date (as well as any applicable hazardous labels), placed on polyethylene sheeting (to contain drips of decontamination fluids during the decontamination process), and sealed when not in use to prevent accidental release of the fluids. If decontaminating sealed submersible pumps, pump both the non-phosphate detergent wash fluid and the potable water rinse through the pump body itself (usually done in separate buckets) to ensure that the internal components are thoroughly cleaned. Replace the detergent solution and rinse water at least daily or when it becomes oily or silty.

Next, place the DI water for the rinse in a small spray bottle or pour over the equipment after the potable water rinse.

Typically, this level of decontamination (i.e., steps 1 through 4) is sufficient.

Following Steps 1 through 4, additional decontamination (steps 5 through 9) may be required by the applicable federal or state guidelines, the project-specific work plan, or the QAPP. Typically, these decontamination steps are performed when sampling for inorganics or oil-related substances using non-motorized equipment. These steps include:

5. 10% nitric acid rinse (if metals are part of the analyses)
6. Laboratory-supplied DI water rinse
7. Pesticide-grade solvent rinse (e.g., acetone [preferred], hexane, or isopropyl alcohol)
8. Air dry (solvent must evaporate)
9. Laboratory-supplied DI water rinse

Isopropyl alcohol is the recommended solvent for organic contaminants because it is readily available and is not a DOT hazardous material; where possible, lab-grade isopropyl alcohol should be used . However, other solvents (e.g., hexane and methanol) may be more effective in removing certain contaminants, such as oils or polychlorinated biphenyls, but any waste generated using these solvents must be managed accordingly. Solvents are never used for decontamination if sampling for volatiles organic compounds.

Handle the solvents and acid with care and store unused chemicals in their original, labeled, protective containers when not in use. It is a good idea to transfer small quantities of each solution into labeled, laboratory-grade spray bottles, which offer a convenient and controllable way to rinse the equipment. The equipment can then be rinsed over a 5-gallon plastic bucket or other suitable container placed on plastic sheeting as with the first part of the cleaning process. Nitric acid rinses must be used only on non-carbon steel sampling devices. Do not spray acid or solvent into pumps.

Decontamination steps used at sites where radioactive materials are contaminants of concern are similar with a few special considerations. Radiation contamination monitoring is used to help locate contamination and guide the success of the decontamination process. The liberal use of water and fluids as a decontamination agents are minimized, where practicable, because of the expense that can be incurred with disposing of radioactively contaminated decontamination water. Containerized decontamination wastes must be evaluated for radioactive content and disposed of appropriately depending on their content.

6.6 HANDLING DECONTAMINATED EQUIPMENT

Handle any decontaminated equipment using clean gloves to prevent re-contamination. Place the equipment away (preferably upwind) from the decontamination area once the process has been completed on clean plastic sheeting to allow it to air-dry. Once the equipment is dry, protect it from re-contamination by securely wrapping and sealing with aluminum foil (shiny side out) or clean, disposable plastic bags (inorganics only). Plastic bags may be wrapped directly around wet or dry equipment except when the expected contaminants include volatile and extractable organics; under those circumstances, allow the equipment to completely dry or wrap it in aluminum foil.

All sampling equipment must be decontaminated at the end of the investigation (i.e., prior to departure from the site). Label each piece of equipment with the date of decontamination, the initials of personnel performing the decontamination, and the type of decontamination solution(s) used. Containerize all decontamination fluids, and other disposable decontamination materials in DOT-compliant containers in accordance with SOP 5 or the project-specific work plan. Dispose of all wastes, including open and unused solvents or acids, in conformance with the project-specific work plan and applicable regulations.

FIELD STANDARD OPERATING PROCEDURE #7

WATER QUALITY MONITORING EQUIPMENT PROCEDURE

The procedures outlined in this Standard Operating Procedure (SOP) are designed to ensure that water quality monitoring equipment is calibrated and used properly. Specifically, this SOP addresses the short-term or discrete-measurement use of portable water quality monitoring equipment for the collection of physical, chemical, or biological field measurements. Common field parameters include temperature, pH, specific conductance (SC), turbidity, oxidation-reduction potential (ORP), and dissolved oxygen (DO). The user is advised to read the entire SOP and review the site health and safety plan (HASP) and/or project safety plan (PSP) before beginning any onsite activities. In accordance with the HASP or PSP, proper personal protective equipment (PPE) must be selected and used appropriately.

7.1 ACRONYMS AND ABBREVIATIONS

DI	deionized water
DO	dissolved oxygen
°F	degrees Fahrenheit
HASP	health and safety plan
IDW	investigation derived waste
mg/l	milligrams per liter
mV	millivolts
NTU	nephelometric turbidity units
ORP	oxidation-reduction potential
PPE	personal protective equipment
PSP	project safety plan
QAPP	quality assurance project plan
SC	specific conductance
SDS	safety data sheets
SOP	standard operating procedure
SU	standard units
µS/cm	microsiemens per centimeter
(mS/cm)	millisiemens per centimeter

7.2 MATERIALS

- Field book
- PPE
- Water quality meter
- Flow-through cell, as appropriate
- Display/logger
- Communication cables
- Calibration cup or beaker

- Calibration reagents and standard solutions, as appropriate
- Deionized water (DI) or distilled water
- Decontamination supplies

7.3 PRECONDITIONS AND BACKGROUND

This SOP has been prepared as part of the company's Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of company employees and will be revised periodically to reflect updates to company policies, work practices, and the applicable state and/or federal guidance. Employees must verify that this document is the most recent version of the company SOPs. Employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

WSP requires that all personnel performing specific project assignments be appropriately qualified, including having required certifications or licenses, and properly trained in accordance with the requirements of their assignment, the Environmental Service Line's field SOPs, and the Quality Management System.

This SOP is designed to provide the user with a general outline for preparing water quality monitoring equipment for use and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), investigation derived waste (IDW) management procedures (SOP 5), and equipment decontamination (SOP 6). This SOP does not cover the selection of water quality monitoring equipment, nor does it cover water quality monitoring equipment-specific instructions. These topics require a significant amount of planning and are more appropriately addressed in a project-specific work plan. Be sure to review the project-specific work plan or Quality Assurance Project Plan (QAPP) and any applicable state and federal guidelines or calibration procedures. The sampler should be familiar with the use and calibration of all sampling and monitoring equipment. All sampling references must be available for consultation in the field, including:

- Company's SOPs
- Applicable state and federal guidelines or sampling procedures
- Manufacturer's manuals
- Project-specific work plan, PSP and/or HASP, and QAPP

7.4 GENERAL EQUIPMENT HANDLING AND MANAGEMENT PROCEDURES

Multi-parameter water quality meters are typically bundled in a single housing unit known as a sonde. These types of units offer a single, convenient device that is capable of measuring most or all of the parameters monitored during a typical sampling event. Individual parameter water quality meters are available and, in some cases, offer a higher degree of accuracy, although the difficulty in deploying multiple meters for most tasks relegates them to specialty use.

Field personnel must consult their assigned company compliance professionals for assistance in proper use, storage, and disposal of all calibration standard solutions.

The manufacturer's recommendations and instructions vary from one instrument to the next; however, all types of water quality monitoring equipment share common handling and management procedures designed to ensure the integrity of the measurements collected. Based on these procedures, the user should:

- Follow the manufacturer's instructions for transportation, assembly, operation, calibration, and maintenance specific to your equipment. The manufacturer's instructions should be followed explicitly in order to obtain accurate results.
- Keep either the sensor guard or transportation/calibration cup installed when not in use to avoid damaging the sensors. Some sensors require a small amount of water in the transportation/calibration cup; follow the manufacturer's recommendations.
- Inspect the sensors to be sure that they are clean, installed properly and are not damaged.

- Ensure that all equipment is in proper working condition, and that batteries are properly charged before using the equipment for field testing measurements.
- Protect instruments that are sensitive to static electricity.
- Record manufacturer name and model number for each instrument used in the field book.
- Calibrate the instrument, as close to the time of use as possible, and repeat at the frequency suggested by the project-specific work plan, QAPP, or manufacturer. All calibration records must be maintained in the project files.
- Protect the instrument from direct sunlight, precipitation, and extremely hot or cold temperatures.
- Store cables only after they are clean, dry, and neatly coiled – do not bend or crimp cables, and attach any provided storage caps.
- Protect cables from abrasion or unnecessary tension when in use.
- Unless otherwise instructed by the manufacturer, decontaminate water quality monitoring equipment using a non-phosphate detergent solution with a small, nonabrasive brush, cotton swab or cloth, followed by a thorough DI water rinse.

7.5 CALIBRATION PROCEDURES

Water quality monitoring equipment must be inspected and the sensors calibrated before use. Calibration frequency is dependent upon project specifications, instrument performance, and manufacturer's recommendations; repeat the calibration procedures as directed in the project-specific work plan, QAPP, or manufacturer's guidance. Consult the manufacturer's guidelines before beginning the calibration process and contact the manufacturer's technical support if problems or questions arise. Maintain all calibration records in the project files.

Conduct the following procedures to ensure proper calibration and record observations in the field book:

- Complete field calibration in an area sheltered from wind, dust, and temperature/sunlight fluctuations such as inside a room or vehicle in which the ambient temperature of the standards is maintained at a temperature greater than 40 degrees Fahrenheit (°F) and less than 100°F, unless otherwise specified by the manufacturer.
- Use standard calibration solutions in accordance with the project-specific work plan, QAPP, or manufacturer's guidance. Allow water quality monitoring equipment to equilibrate to the air temperature for at least 15 minutes after being powered on, or for the specified time period recommended by the manufacturer.
- Record the brand, concentration, lot numbers and expiration dates of standard solutions in the field book.
- Handle standard solutions in a manner that prevents their dilution or contamination. Do not use expired standard solutions. Do not reuse standard solutions or pour solutions back into the bottle; ensure that proper chain-of-custody has been followed for standard solutions stored at a site.
- Ensure that the water quality monitoring equipment has been set to display or record the appropriate measurement units, as available – be sure to record the units of measure in the field book or field form.
- Unless otherwise instructed by the manufacturer, use the calibration cup that comes with the instrument for calibration.
- Use the recommended volume of standard solution when filling the calibration cup (e.g., the standard solution must cover the temperature sensor, as most sensors require temperature compensation).
- Be careful not to over tighten the calibration cup; many calibration cups have vents that allow their equilibration with ambient pressure.
- Rinse sensors thoroughly with DI water after use of each standard solution, followed by a rinse with the next standard solution to be used.
- Wait for readings to stabilize (approximately 30 seconds under normal conditions) before adjusting and saving the calibration point.
- If calibration fails to meet criteria, follow the manufacturer's instructions for corrective action to adjust instrument performance and note any indication of a substandard calibration.
- If the instrument does not start up, meet the requirements above, or calibrate properly, the instrument should not be used.
- Document the time, date, serial number (or other identifier) and calibration status for each instrument.

7.5.1 SPECIFIC CONDUCTANCE

Specific conductance, or, more commonly conductivity, measures the ability of water to conduct an electric current. It is generally reported in either microsiemens per centimeter (μS/cm) or millisiemens per centimeter (mS/cm); be sure to note the units used in the field book. Natural waters, including groundwater, commonly exhibit SC below 1 μS/cm. Elevated SC measurements (i.e., greater than 500 μS/cm) are a proxy for the amount of dissolved solids, which may be indicative of inadequate well development, grout contamination (or an inadequate grout seal), or contamination.

When calibrating water quality monitoring equipment for SC:

- If not specified in the project-specific work plan, choose a SC standard solution recommended by the instrument manufacturer; otherwise, select a standard that is similar to the anticipated conductivity of the water being sampled.
- The presence of air bubbles in conductivity electrodes will cause erroneous readings and incorrect calibration. Transmission lines, alternating-current electrical outlets and radio-frequency noise sources may cause interference; check with the instrument manufacturer's specifications for troubleshooting procedures.

7.5.2 DISSOLVED OXYGEN

Dissolved oxygen measurements are used to assess the water quality with respect to certain metals (the amount of oxygen can control the valence state of metals) and, more typically, biological activity. Concentrations of DO in groundwater under ambient conditions generally range from 1 to 4 milligrams per liter (mg/l). Erratic or elevated (greater than 4 mg/l) DO readings may indicate equipment maintenance issues, such as a fouled sonde, torn membrane, a sensor out of calibration range; or inappropriate monitoring procedures that are causing excessive agitation and aeration of the water column. The meters are sensitive to atmospheric interference: *ex situ* measurements (i.e., those measured outside of the well itself) should only be collected using a flow-through cell.

Dissolved oxygen meters vary widely in their sensitivity. Select the type of DO sensor (i.e., the polarographic [or Clark cell] sensor or the luminescent [optical] sensor) that is most appropriate for the scope of work detailed in the project-specific work plan. The guidance below is for the more common polarographic sensor; consult the manufacturer's guidance for maintenance and calibration procedures specific to optical DO meters.

- Check the DO membrane for bubbles, wrinkles or tears. If necessary, install a new membrane and replace worn or stretched O-rings. Manufacturer guidance generally specifies membrane replacement should be completed at least 3 to 4 hours before use.
- Most manufacturers recommend that the sensor be allowed to equilibrate to the temperature of the water-vapor-saturated air before calibration, as specified in the manufacturer's instructions.
- Fill the calibration cup with less than 1/8 inch of water, or as recommended by the manufacturer.
- Remove any water droplets from the sensor without wiping the membrane. Water droplets on the sensor can cause a temperature compensation error in the DO calibration.
- Do not submerge or wet the sensor when loosely attaching the calibration cup.
- Enter the barometric pressure and wait for readings to stabilize before adjusting and saving the calibration point.

7.5.3 PH

The effective concentration (or activity) of hydrogen ions on a numerical scale known as pH, which is expressed as the negative base-10 logarithm of the hydrogen-ion activity in moles per liter. Natural (uncontaminated) waters typically exhibit a pH ranging from 5 to 9 Standard Units (SU). Deviation of pH from background may indicate the presence of groundwater contamination or well construction problems.

Typically, a two-point calibration is used for pH (i.e., a zero-point and span calibration[s]):

- If not specified in the project-specific work plan, select a 7 SU buffer (zero-point) plus a second pH buffer (4 SU or 10 SU) that brackets the range of expected pH.
- If applicable, calibrate the conductivity and DO sensors before calibrating the pH sensor. This helps prevent cross-contamination of the conductivity sensor from pH buffer solutions (pH buffers have much higher conductivities than most environmental waters).
- Allow time for the pH and temperature sensors to equilibrate to the temperature of the buffer and stabilize before adjusting and saving the calibration point. Record the temperature reading and use the chart provided by the buffer manufacturer to determine the true pH of the buffer at that temperature and adjust the calibration reading to that value.
- Repeat the calibration process with the second buffer.

7.5.4 OXIDATION-REDUCTION POTENTIAL

Oxidation-reduction potential is a numerical index of the intensity of the oxidizing or reducing conditions within an aqueous solution. Oxidizing conditions are indicated by positive potentials and reducing conditions are indicated by negative potentials. These values are frequently used when evaluating the biodegradation capacity of a system. The ORP of natural (uncontaminated) waters typically ranges from +500 to -100 millivolts (mV). The meters for ORP, like those for DO, are sensitive to atmospheric interference and must be measured using a flow-through cell. Avoid touching the sensors during calibration and measurement as calibration can be affected by static electricity.

A one-point calibration, at a known temperature, is used to calibrate the ORP sensor:

- Fill the calibration cup with enough standard solution (i.e., ZoBell's solution) to completely cover the temperature and ORP sensors.
- Allow time for the ORP and temperature sensors to equilibrate to the temperature of the buffer and stabilize before adjusting and saving the calibration point. Record the temperature reading and use the chart provided by the manufacturer to determine the true ORP of the solution at that temperature and adjust the calibration reading to that value.

7.5.5 TURBIDITY

Turbidity is the presence of suspended mineral and organic particles in a water sample. Turbid water may indicate inadequate well construction, development or improper sampling procedures, such as purging at an excessive rate that exceeds the well yield. Purging and sampling in a manner that minimizes turbidity is particularly important when analyzing for total metals and other hydrophobic compounds, such as polychlorinated biphenyls, which may exhibit artificially elevated concentrations in high-turbidity samples due to their adsorption to colloidal material. Generally, the turbidity of *in situ* groundwater is very low (at or below 10 nephelometric turbidity units, NTUs); however, some groundwater zones may have natural turbidity higher than 10 NTUs.

Standard turbidity solutions are not necessarily interchangeable. Serious calibration errors can result from using inappropriate standards. Use only those standard turbidity solutions that are prescribed for the sensor by the instrument manufacturer.

Turbidity consists of a zero-point calibration and a span calibration(s):

- Fill the calibration cup to the reference line with DI or a zero-point standard.
- Allow time for the turbidity sensors to stabilize before adjusting and saving the calibration point.
- Record the temperature and use the chart provided by the manufacturer to determine the true turbidity of the standard and adjust the calibration reading to that value.
- Repeat the calibration process with the standard span calibration standard(s).

7.6 EQUIPMENT USE PROCEDURES

The monitoring equipment is ready to use once the calibration has been completed. The specific use of the device will be dictated by the project-specific work plan or QAPP; however, all projects should follow these general procedures during use:

- Charge instrument batteries per the manufacturer's instructions, as necessary.
- Ensure that instrument is warmed up and the measured value(s) on the water quality monitoring equipment are equilibrated (i.e., readings are representative of the solution, not ambient air) before recording in the field book.
- Biological growth or debris in the water can foul sensors; as possible, avoid inserting the sonde in areas that will result in having to stop and clean algae, sediment, or debris from the sensors (e.g., do not place on bottom of a well or streambed).
- If continuous monitoring is required, follow the manufacturer's instructions for performing continuous data logging events.

For flow through cells:

- Inspect the integrity of the flow-through cell and O-rings.
- Connect the discharge tubing to the bottom of the flow-through cell using properly-sized tubing and fittings. Connect the effluent tubing to the top of the flow-through cell and secure the end of the tubing into the designated groundwater purge container.
- Shield the flow-through cell from direct sunlight to minimize changes in the temperature.

- Do not record any measurements until all the air from the flow-through cell and the effluent tubing has been displaced and the sensors have equilibrated. The presence of air bubbles in the flow-through cell will result in highly biased readings.
- Do not collect samples for laboratory analysis from the groundwater in the flow-through cell.

7.7 CLOSING NOTES

Once field activities are complete, secure the site in accordance with the project-specific work plan. Decontaminate all equipment prior to departure and properly manage all PPE and IDW in conformance with SOP 6, the project-specific work plan, and applicable regulations.

FIELD STANDARD OPERATING PROCEDURE #11

GROUNDWATER SAMPLING PROCEDURE

Groundwater sampling procedures outlined in this Standard Operating Procedure (SOP) are designed to ensure that collected samples are representative of current site conditions. These procedures can be applied to permanently or temporarily installed monitoring wells, direct-push sample points, water supply wells with installed plumbing, extraction wells for remedial groundwater treatment systems, and excavations where groundwater is present. The user is advised to read the entire SOP and review the site health and safety plan (HASP) and/or project safety plan (PSP) before beginning any onsite activities. In accordance with the HASP, proper personal protective equipment (PPE) must be selected and used appropriately.

11.1 ACRONYMS AND ABBREVIATIONS

ID	inside diameter
DI	deionized
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DTW	depth-to-water
HASP	health and safety plan
IDW	investigation-derived waste
l/min	liters per minute
LNAPL	light non-aqueous phase liquid
mg/l	milligrams per liter
mV	millivolts
NAPL	non-aqueous phase liquid
NTU	nephelometric turbidity unit
ORP	oxygen reduction potential
PID	photoionization detector
PPE	personal protective equipment
PSP	project safety plan
QAPP	quality assurance project plan
SOP	standard operating procedure
SU	standard units
TD	total depth
TOC	top-of-casing
VOCs	volatile organic compounds

11.2 MATERIALS

- Field book
- PPE
- Air quality monitoring equipment (e.g., photoionization detector [PID]) with calibration reagents and standards, as needed
- Electronic water level indicator or interface probe
- Water quality meter(s) with a flow-through cell, and calibration reagents and standards, as needed
- Field test kits, as needed
- Adjustable wrench or manhole wrench, as needed
- Well key(s), as needed
- Power supply, as needed
- Sampling containers and labeling/shipping supplies
- Deionized (DI) water
- Container(s) for water storage (e.g., bucket, drum)
- Pump or bailers, tubing, and associated lanyard materials
- Filters, as needed
- Decontamination supplies

11.3 PRECONDITIONS AND BACKGROUND

This SOP has been prepared as part of the company's Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel and will ensure that the tasks are performed in a safe, consistent manner; are in accordance with federal and state guidance; and are technically defensible.

This SOP is written for the sole use of company employees and will be revised periodically to reflect updates to company policies, work practices, and the applicable state and/or federal guidance. Employees must verify that this document is the most recent version of the company SOPs. Employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

WSP requires that all personnel performing specific project assignments be appropriately qualified, including having required certifications or licenses, and properly trained in accordance with the requirements of their assignment, the Environmental Service Line's field SOPs, and the Quality Management System.

This SOP is designed to provide the user with a general outline for conducting groundwater sampling and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), utility location (SOP 2), sample shipment procedures (SOP 3), sample collection and quality assurance procedures (SOP 4), investigation derived waste (IDW) management procedures (SOP 5), equipment decontamination (SOP 6), and use and calibration of all sampling and monitoring equipment (SOPs 7 and 8). This SOP does not cover investigation planning, nor does it cover the analysis of the analytical results. These topics are more appropriately addressed in a project-specific work plan. Before groundwater sampling, be sure to review the project-specific work plan or quality assurance project plan (QAPP) and any applicable state and federal guidelines or sampling procedures. All sampling and monitoring references must be available for consultation in the field, including:

- Company SOPs
- Applicable state and federal guidelines or sampling procedures
- Manufacturer's manuals
- Project-specific work plan, PSP and/or HASP, and QAPP

11.4 GENERAL PROCEDURES

Although the techniques used to sample groundwater are varied, most sampling events can be broken down into a three-step sequence:

1 Gauging: The measurement of the water column height (i.e., total well depth less depth-to-water) within the well.

2. Purging: The removal of stagnant water from the well bore to ensure that samples collected are representative of groundwater conditions in the water-bearing zone surrounding the well.
3. Sample Collection: After purging, the collection of aliquots of groundwater in method-specific, preserved (as needed) containers.

The procedures and equipment that are used to accomplish these steps are project-specific and should be discussed by the project team before arriving onsite. All types of groundwater sampling, however, regardless of the equipment used, share common handling and management procedures that are designed to ensure the integrity of the samples collected. These procedures include:

- The use of new, disposable, decontaminated, or dedicated sampling equipment
- The use and rotation of the appropriate PPE
- Selection of a suitable sampling location and staging area

Wear a clean pair of new, disposable gloves each time a different sample is collected and don the gloves immediately prior to collection. This limits the possibility of cross-contamination from accidental contact with gloves soiled during collection of the previous sample. The gloves must not contact the medium being sampled and must be changed any time during sample collection when their cleanliness is compromised. ***Gloved hands should not be used as a sampling device; always use the appropriate equipment to move the sample from the sampling device to the laboratory-supplied containers.***

11.5 EQUIPMENT SELECTION

Collect all samples using either new, disposable equipment or properly decontaminated sampling equipment. Groundwater purging and sampling equipment should be selected based on the analytical requirements of the project and the project-specific conditions (e.g., well diameter, depth to water, dissolved constituents, etc.) likely to be encountered. The equipment should be constructed of non-reactive, non-leachable materials (e.g., stainless steel, Teflon®, Teflon®-coated steel, polyethylene, polypropylene, etc.) that are compatible with the chemical constituents at the site. Note that project or regulatory guidance may limit the type of equipment for groundwater sampling.

Consider the following when choosing groundwater purging and sampling equipment:

- the diameter and depth of the well
- the depth to groundwater
- the volume of water to be withdrawn
- the sampling and purging technique
- the volume of sample required
- the analytes of interest

Select the decontamination procedures based on the types of sampling to be performed and media encountered; decontamination may require multiple steps or differing cleaning methods (see SOP 6 for decontamination procedures). In no case, should disposable, single-use materials be used to collect more than one sample.

11.6 PRE-SAMPLING CONSIDERATIONS

You should perform the following activities in preparing for sampling with all observations and measurements noted in the field book and on the project-specific groundwater monitoring log, if appropriate:

- Perform a quick reconnaissance of the site to identify sampling locations and evaluate the accessibility to the sampling location.
- Record the approximate ambient air temperature, precipitation, wind (direction and speed), tide, and other field conditions. In addition, any site-specific conditions or situations that could potentially affect the samples at the sample locations should be recorded.
- Record temporary sampling locations with respect to approximate distance to and direction from at least one permanent feature.
- Survey the breathing zone around the sampling location with the appropriate air quality meter(s), as necessary (see HASP), to ensure that the level of PPE is appropriate.
- Install the pump, tubing, passive sampler or other appropriate sampling equipment to the depth prescribed in the project-specific work plan or QAPP.

- Containerize and manage purge water in accordance with the project-specific work plan.

It is important to minimize any sources of cross-contamination that could compromise the integrity of the groundwater samples. Consider the following:

- Position fuel-powered equipment away from the sample collection area, such as drill rigs or excavators, and upwind of other site activities (e.g., purging, sampling, decontamination) that could influence the sample. This is particularly important when screening samples in the field for volatile organic compounds with a PID but should not be limited to the active sample collection.
- Establish a secure sample staging area in an uncontaminated area of the site.

11.7 GAUGING PROCEDURES

All wells should be opened to the atmosphere in advance of sampling to allow any pressure differentials, which could artificially raise or depress the water column in the well, to dissipate. The wells should be inspected to ensure that the protective casing is intact and has not been damaged. Remove the well covers and all standing water around the top of the well casing (for flush mounted-protective covers), as necessary, before opening the inner well cap or plug. Unlock and carefully remove well cap and allow the well to stand undisturbed for a minimum of 15 minutes, or as required by the project-specific work plan, before conducting any down-hole testing or measurements. If required by the HASP, survey the open well casing and the breathing zone around the wellhead with a PID to ensure that the level of PPE is appropriate.

11.7.1 GROUNDWATER LEVEL AND TOTAL DEPTH MEASUREMENT PROCEDURES

Depth to water (DTW) and total depth (TD) measurements are collected prior to sampling and are used to determine the volume water to be purged from the well (if using techniques other than no-purge or low flow sampling). The DTW measurements are also used after the field event to establish the groundwater elevation, flow direction, and gradient. Unless otherwise directed, do not place any objects inside the casing of private water wells; accordingly, DTW and TD measurements should not be collected at private water wells. Measurements of TD are not required for low flow and no-purge sampling applications and should not be measured before sampling the well.

Water level measurements must be collected within the shortest interval possible from all the wells to be gauged during the event before beginning any purge and sampling procedures at the site. This will ensure a nearly instantaneous snapshot of the water levels before the formations are disturbed by pumping or acted upon by other outside influences, such as tides, precipitation, barometric pressure, river stage, or intermittent pumping of production, irrigation, or supply wells.

Record the following observations and measurements (and the time when they were collected) in the field book:

- Measure the casing inside diameter (ID) and record in inches
- Measure the DTW with an electronic water level indicator (or an interface meter, if non-aqueous phase liquid [NAPL] is potentially present – see procedures below) from the top-of-casing (TOC) at the surveyor's mark, if present, and record the depth (to the nearest 0.01 foot) in feet below TOC
- If no mark is present, measure from the north side of the casing and mark the measuring point with a knife, metal file (if the inner casing is metal) or indelible marker for future reference
- Measure the TD from TOC at the surveyor's mark or north side of the casing, as appropriate.

Measuring the depth of deep wells with long water columns can be problematic due to tape buoyancy and weight effects or sediment in the bottom of the well casing. Care must be taken, and proper equipment selection must be used in these situations to ensure accurate measurements. Multiple TD measurements in silt-laden wells can provide a more precise assessment of the bottom depth.

11.7.2 GAUGING WELLS WITH NON-AQUEOUS PHASE LIQUID

If NAPL is potentially present at the site, the DTW and NAPL thickness measurements are collected using an interface meter capable of distinguishing between the NAPL and the groundwater, or a weighted tape coated with the appropriate reactive indicator paste for the suspected NAPL. Measuring NAPL thicknesses must be done with care to avoid agitating the liquids and generating an emulsion. This is particularly the case for light NAPL (LNAPL; those having a density less than water), which are typically viscous oils that cling to the probe. Oil coating the probe can result in thickness measurements that are biased high (i.e., overestimate the thickness of the NAPL).

Conduct the following procedures to ensure an accurate measurement of the NAPL thickness:

- For LNAPL, slowly lower the electronic interface probe in the well casing until the electronic tone indicates the probe is at the top of the LNAPL layer; measure the depth below the TOC to the nearest 0.01 foot.
- To gauge the NAPL thickness, advance the probe slowly through the layer until the electronic tone indicates top of the water column and then slowly bring the probe back up to the bottom of the LNAPL. Repeat this process several times to ensure an accurate measurement of the bottom of the LNAPL layer (which can include bubbles and an emulsion layer).
- For dense NAPL (DNAPL), advance the probe through the water column until the tone indicates the top of the DNAPL layer; record the depth below TOC.
- To gauge the DNAPL thickness, advance the probe through the layer to the bottom of the well.

11.8 GROUNDWATER PURGING PROCEDURES

Purging is a process whereby potentially stagnant water is removed allowing the collection of samples that are representative of groundwater conditions in the water-bearing zone. The water in a well bore that has not been purged may be different than the surrounding formation due to exposure to ambient air. There are several purging (and no-purge) methods that may be used, depending on specific conditions encountered (e.g., DTW, hydraulic conductivity of the formation, etc.) and the sampling requirements. The purge/no purge options are described below.

- *Multiple Volume Purge:* Traditional well purging technique that relies on the withdrawal of the volume of the well bore and the surrounding filter pack (if present); three to five well volumes are typically removed using pumps or bailers. This methodology relies on equipment that is easy to obtain and use and is generally accepted in most states as an appropriate purging method.
- *Temporary Well Purge:* A variation of the multiple volume purge technique that often uses inertia lift pumps, peristaltic pumps, or bailers to remove water from a temporary well or discrete groundwater sampler (e.g., a groundwater profiler or direct-push screen point sampler). This is a less stringent technique that is typically done to minimize the turbidity of the samples, which can be high due to the lack of a well filter pack.
- *Private Water Well or In-Place Plumbing Purge:* A variation on the multiple volume purge technique whereby a tap or faucet is opened on a fixed water supply pipe and is allowed to remain open until the potentially stagnant water within the well casing and other components of the system (e.g., fixed piping, pressure tanks, etc.) has been removed and groundwater representative of the water-bearing zone is discharged at the tap.
- *Low Flow (Minimal Drawdown/Low Stress) Purge (and Sampling):* A modified purging technique that establishes an isolated, discrete, horizontal flow zone directly adjacent to the pump intake; this method requires the pump to be placed within a screened-interval or open borehole. Pumping rates are typically 0.1 to 0.5 liters per minute (l/min) or less to minimize the stress on the surrounding formation and reduce the geochemical alteration of the groundwater caused by pumping.
- *No-Purge/Passive Sampling Techniques:* These techniques use specialized equipment, such as trap-style samplers or permeable diffusion bags, to sample the undisturbed water column within a screened interval or open borehole. This methodology assumes that the water in the well is representative of the surrounding formation. This approach is well suited for some volatile organic compounds (VOCs), metals, and hydrophobic compounds, depending on the sampling device used.

11.8.1 CALCULATING ONE PURGE VOLUME

Multiple volume purging techniques require that a ***minimum*** of three well volumes of water must be removed before sample collection. The actual amount of water removed may be greater than the three volumes, depending on geochemical parameter stabilization (the field measurement of these parameters is discussed below).

Calculate the volume of water in a well or boring using the following equation:

$$\textbf{Volume (gallons)} = \textbf{(TD – DTW) x ID}^2 \textbf{ x 0.041}$$

where:

TD = total depth (feet)

DTW = depth to water (feet)

ID = inner diameter (inches)

Alternately, the volume of water in a well or boring may also be calculated by multiplying the water column height by the gallons per foot of water for the appropriate well or boring diameter:

ID	Gallons per foot of water	Gallons per three water columns
1-inch	0.04	0.12
2-inch	0.16	0.48
3-inch	0.37	1.11
4-inch	0.65	1.98

Calculate the total volume of the pump, associated tubing and container for in situ measurements (flow-through cell), using the following equation:

Volume (in gallons) = P + ((0.0041)*D2*L) + fc

where:

P = volume of pump (gallons)
D = tubing diameter (inches)
L = length of tubing (feet)
fc = volume of flow-through cell (gallons)

11.8.2 MULTIPLE VOLUME PURGE PROCEDURES

Begin purging at a rate that will not cause excessive turbulence and drawdown in the well; commonly less than 1 gallon per minute for a typical 2-inch diameter monitoring well. You may need to observe the water elevation after the pump is started and adjust the flow rate to minimize the amount of drawdown in the well casing. The objective is to remove the stagnant water in the casing and surrounding filter pack or open borehole allowing water from the surrounding water-bearing zone to enter the well for sampling with as little disturbance as possible. Excessive pump rates or well dewatering can result in higher turbidity, potential volatilization, and geochemical alteration of dissolved parameters.

Typically collect geochemical parameters (i.e., pH, specific conductance, dissolved oxygen [DO], oxygen-reduction potential [ORP], and temperature) at a minimum frequency of once for every well volume of water removed during the purge process. Record the measurements in the field book along with any other pertinent details, such as the visual quality of the water (e.g., color, odor, and presence of suspended particulates) and the approximate withdrawal rate (this can be estimated using a calibrated container and stopwatch). Review the geochemical measurements to ensure that readings have stabilized (after the minimum purge volume has been achieved). This is a proxy for determining that you are purging formation water rather than potentially stagnant water in the casing. Stabilization occurs when at least three consecutive measurements are within the following tolerances:

Multiple Volume Purge Stabilization Parameters	
pH	± 0.1 standard units (SU)
Specific Conductance	± 3%
Temperature	± 3%
Dissolved Oxygen (DO)	± 0.2 milligrams per liter (mg/l) or 10% (flow-through cell only)
Turbidity	± 10% for values greater than 10 nephelometric turbidity units (NTU)
Oxygen Reduction Potential (ORP)	± 10 millivolts (mV; flow-through cell only)

Parameter stabilization that does not occur within five well volumes may require you consult your project manager to decide whether to collect a sample or to continue purging. Wells with extremely slow recharge may also be problematic. Purging these wells, in some cases, may result in dewatering the well before the minimum purge can be completed. Allow wells or borings purged dry to recharge to a level of approximately 90% of the static (pre-purge) water elevation and proceed immediately to sample collection. If recovery exceeds 2 hours, sample as soon as sufficient sample volume is available, in accordance with applicable regulations.

11.8.3 LOW FLOW PURGE PROCEDURES

Low flow purging and sampling is used to obtain representative groundwater samples without removing all the water within the well. The protocol uses relatively low pumping rates (i.e., less than 0.5 l/min) to establish an isolated zone around the inlet of the pump where flow is horizontal (i.e., from the water bearing zone) rather than from the stagnant water in the well casing above and below the pump. Selection of an appropriate pump is critical to establishing the flow zone: it must be well suited for both low pumping rates and the analytes being sampled. Bailers are not appropriate for low flow sampling.

The set-up for low flow sampling includes positioning the pump at the appropriate depth within the casing such that the pump inlet is within the screened section of the well. Slowly lower the pump, where appropriate, and tubing into the water column to avoid agitating the water column; use of a lanyard is recommended (i.e., do not use the extraction tubing to lift or lower the pump). Secure the pump and/or tubing at the wellhead once the specified sampling depth has been achieved and record the depth in the field book. Avoid contacting the bottom of the well by using pre-cut tubing at the appropriate length or by lowering the pump/tubing simultaneously with an electronic water level indicator. Once the pump/tubing has been inserted and secured, allow the water levels to return to static conditions before initiating the purge.

The discharge tubing must be connected to an in-line flow-through cell equipped with a multi-parameter real-time water quality meter. The flow-through cell minimizes the exposure of the groundwater to ambient air, which can influence DO and ORP measurements.

Start the pump and maintain a steady flow rate that results in a stabilized water level (less than 0.3 feet of drawdown or as specified in the project-specific work plan). The pumping rate may need to be adjusted depending on the response of the water levels in the well. Record each adjustment made to the pumping rate and the water level measured immediately after each adjustment. Purging should not exceed 0.5 l/min.

During purging, monitor and record the flow rate and geochemical parameters at 30 seconds to 5-minute intervals (depending on the hydraulic conductivity of the aquifer, diameter of the well, and pumping rate). Stabilization occurs once the following criteria have been met over three successive measurements made at least three minutes apart:

Low Flow Purge Stabilization Parameters	
Water Level Drawdown	<0.3 feet
pH	± 0.1 SU
Specific Conductance	± 3%
Temperature	± 3%
DO	± 0.2 mg/l or 10% (flow-through cell only)
Turbidity	± 10% for values greater than 10 NTU
ORP	± 10 mV (flow-through cell only)

Record any other notable observations in the field book (e.g., groundwater color).

11.8.4 NO-PURGE SAMPLING TECHNIQUES

Several alternate sampling devices are available, such as equilibrated grab samplers, passive diffusion samplers, and other in situ sampling devices, that will allow sample collection without purging the well. These devices may be particularly useful for sampling low permeability geologic materials, assuming the device is made of materials compatible with the analytical parameters, meets data quality objectives, and has been properly evaluated.

No-purge grab or trap samplers are placed in the well before sampling and typically remain closed (i.e., no water is allowed into the sampler during insertion) until the sampler is activated. This allows the sampler device to equilibrate with the surrounding groundwater (to prevent adsorption to the sampler materials) and for the groundwater to recover and re-establish the natural flow after the disturbance caused by the sampler insertion into the well. Typical equilibration times depend on the well recovery rates and the type of sampler used. Samples recovered using the no-purge devices are either transferred to containers at the well head or the sampler itself is shipped to the laboratory for analysis. Examples of equilibrated grab samplers include HydraSleeve™, Snap Sampler™, and Kemmerer samplers.

Equilibration time for diffusion samplers are generally dictated by the diffusion rate through the permeable membrane and, thus, are less sensitive to changes induced within the well during deployment. Most diffusion bag samplers have a minimum equilibration time of 14 days prior to sample collection. The samplers may be deployed for an extended period (e.g., three months or longer), although the continuous exchange between the sampler and the well water means that the sampler will likely reflect only the conditions in the few days preceding the sample collection.

11.8.5 TEMPORARY WELL PURGE PROCEDURES

Procedures used to purge temporary groundwater monitoring wells differ from permanent wells because temporary wells are installed for immediate sample acquisition. Wells of this type may include open bedrock boreholes, standard polyvinyl chloride well screen and riser placed in open boreholes, or drilling rod-based sampling devices (e.g., Wellpoint®, Geoprobe® screen point or Hydropunch® samplers). Purging temporary wells of this type may not be necessary because stagnant water is typically not present. However, if water is used in the drilling process, purging would be necessary. Purging can minimize the turbidity in the sample, which can be significant due to the disturbance caused by the sampler installation and to rinse the sampling system with groundwater. The exception is for groundwater profiling applications (e.g., using a Waterloo Profiler®) where a more rigorous purge is used (using the multiple volume purge techniques described above) to limit the potential for cross-contamination between sample intervals.

11.8.6 PRIVATE WATER WELL OR IN-PLACE PLUMBING PURGE PROCEDURES

The configuration and construction of private water wells varies widely and access points for obtaining groundwater samples may be limited. WSP personnel should coordinate with the property owner or site representative to access functioning ports and valves to avoid causing any inadvertent damage.

Collect the groundwater sample as close to the well as possible (e.g., from a sample port at the well head) to ensure the sample is representative. Ideally, the sample should be collected upstream of the piping and treatment equipment (e.g., particulate filter, water softener, carbon filters, ultra-violet lights), heating unit, or storage tanks. The following potential sampling locations are presented in order of preference:

- Sampling port or spigot near the well head or piping system prior to entry into the storage tank
- Sampling port or spigot at storage tank
- Sampling port or spigot downstream of the pressure tank or holding tank but upstream of any water treatment equipment
- Tap or faucet

If purging from a tap or faucet, try to remove any aerators, filters, or other devices from the tap before purging and work with the property owner or site representative to bypass any water treatment systems. Document where the sample was collected and any steps that were taken to minimize the potential alteration of the water sample in the field book.

Purge the system by opening the tap or spigot and allowing the water to run for several minutes. Observe and record the purge rate for the system. The minimum purge volume must be more than the combined volume of the pump, tanks, piping, etc. Review the geochemical measurements (after the minimum purge volume has been removed) to ensure that readings have stabilized using the same procedures as those used for the multiple volume purge detailed above. Purge the system for a minimum of 15 minutes if the minimum volume is unknown. Sample only after the geochemistry parameters have stabilized and no there are no suspended particles (e.g., iron or rust) visible. Record the final purge volume in the field book and any water quality observations.

11.9 GROUNDWATER SAMPLE COLLECTION PROCEDURES

Collect groundwater samples as soon as possible after the geochemical parameters indicate representative groundwater is present. As practically possible, reduce the pump flow rate, but maintain a flow rate high enough to deliver a smooth stream of water without splashing or undue agitation. Collect samples directly from the tubing as it exits the well bore; do not sample on the downstream side of flow-through cells or any other instrumentation. If using a bailer for sample collection, lower and raise the bailer slowly and smoothly to minimize the disturbance to the water within the well.

Collect groundwater samples in order of volatilization sensitivity with organic compounds sampled first followed by inorganic compounds:

- VOCs
- Extractable organics, petroleum hydrocarbons, aggregate organics, and oil and grease
- Per- and Polyfluoroalkyl substances
- Total metals
- Dissolved metals (see filtering procedures below)
- Inorganic non-metallic and physical and aggregate properties
- Microbiological samples
- Radionuclides

Collect quality assurance/quality control samples in accordance with SOP 4 and the project-specific work plan or QAPP.

As necessary, conduct field tests or screening in accordance with the project-specific work plan and manufacturer’s specifications for field testing equipment. Field samples must be directly transferred from the sampling equipment to the container that has been specifically prepared for that given parameter; intermediate containers should be avoided. If field chemical preservation is required, check the pH preservation by pouring a small portion of sample onto a pH test strip Adjust pH with additional preservative, if necessary.

Record the sample depth interval, if applicable, in the field book. Note the volume, phases, odor, and color of the groundwater.

11.9.1 GROUNDWATER FILTRATION PROCEDURES

Filtered groundwater samples are sometimes used for field kit analyses and should only be collected for laboratory analysis after approval from the appropriate regulatory agency or project manager. The filtered samples can be collected by attaching the in-line filter directly to the outlet tubing for a pressurized bailer, a submersible pump or a peristaltic pump. Intermediate containers can be used with a peristaltic pump if the well is too deep to use the pump to recover the sample directly. The intermediate container should be unpreserved laboratory-supplied glassware to avoid any cross-contamination during the filtering process.

Filtered samples using pumps should use the following procedures:

- Use a variable speed peristaltic pump with the in-line filter fitted on the outlet end of the tubing and the pump inlet tubing into the intermediate container holding the unpreserved groundwater sample; or,
- If a submersible pump is used to collect the groundwater sample, attached the in-line filter to the outlet end of the tubing (do not allow the groundwater to pass through flow-through cells or any other instrumentation while sampling)

Once the filter is connected:

- Turn on the pump and maintain a flow rate high enough to deliver a smooth stream of water without splashing or undue agitation. Hold the filter upright with the inlet and outlet in the vertical position and pump groundwater through the filter until all atmospheric oxygen has been removed and the minimum volume of water has been flushed through the filter, in accordance with the manufacturer's specifications
- Collect the filtered samples by placing the filtered output directly into the sample container
- If sediment is visible in the sample container after filtration, filter break-through has occurred and the sampling and filtering process should be repeated
- Discard the tubing and filter appropriately

Record sample filtration in the field book.

11.9.2 NON-AQUEOUS PHASE LIQUID SAMPLING PROCEDURES

Non-aqueous phase liquid is typically sampled to identify the compound, usually through an analytical "fingerprint" analysis. If samples are to be collected, the sampling options and techniques should be discussed with the assigned WSP compliance professional and project manager to ensure that the NAPL is either not considered to be a hazardous material for shipping to the laboratory or is properly shipped by qualified personnel using appropriate shipping containers (SOP 3). Samples of NAPL should be collected using the same procedures as above and placed in the appropriate laboratory-supplied containers, packed on ice, and shipped to the analytical laboratory using procedures outlined in SOP 3.

11.9.3 SAMPLE LABELING AND PREPARATION FOR SHIPMENT

Groundwater samples for offsite laboratory analysis should be prepared as follows:

1. Clean the outside of the sample container, if necessary
2. Affix a sample tag or label to each sample container and complete all required information (sample number, date, time, sampler's initials, analysis, preservatives, place of collection)
3. Place clear tape over the tag or label (if non-waterproof labels are used), as needed
4. If needed, preserve samples immediately after collection by placing them into an insulated cooler filled with bagged wet ice to maintain a temperature of approximately 4°Celcius
5. Record the sample designation, date, time, and the sampler's initials in the field book and on a sample tracking form, if appropriate
6. Complete the chain-of-custody forms with appropriate sampling information, including:
   - location
   - sample name
   - sample collection date and time
   - number of sample containers

  - analytical method
  - field filtration status

7 Secure the sample packing and shipping in accordance with proper procedures

Do not ship hazardous waste samples without first consulting a WSP compliance professional.

11.10 CLOSING NOTES

Secure and restore the site once sampling is completed. This may include locking permanent monitoring wells, staging the IDW, and disposing of (in conformance with applicable regulations) sampling expendables, such as plastic sheeting, tubing, and PPE. All locations where temporary wells or other sampling devices (e.g., profilers or direct-push equipment) should be marked with spray paint, stakes, or other appropriate method for future reference or survey, including collecting Global Positioning System coordinates and photographs, in accordance with the project-specific work plan. Decontaminate all equipment prior to departure and properly manage all PPE and investigation-derived wastes in conformance with SOP 6, the project-specific work plan, and applicable regulations.

FIELD STANDARD OPERATING PROCEDURE #12

SURFACE WATER SAMPLING PROCEDURE

Surface water sampling procedures outlined in this Standard Operating Procedure (SOP) are designed to ensure that surface water samples are representative of the water body from which they were collected and that they have not been altered or contaminated by the sampling and handling methods. Potential surface water sample locations include freshwater and marine environments such as streams, rivers, ponds, lakes, canals, ditches, wetlands, lagoons, and estuaries. Surface water samples are collected for onsite screening or for offsite laboratory analysis. The user is advised to read the entire SOP and review the site health and safety plan (HASP) and/or project safety plan (PSP) before beginning any onsite activities. In accordance with the HASP or PSP, proper personal protective equipment (PPE) must be selected and used appropriately.

12.1 ACRONYMS AND ABBREVIATIONS

HASP	health and safety plan
IDW	investigation derived waste
NAPL	non-aqueous phase liquid
PPE	personal protective equipment
PSP	project safety plan
QAPP	quality assurance project plan
SOP	standard operating procedure

12.2 MATERIALS

- Field book
- PPE
- Air quality monitoring equipment (e.g., photoionization detector [PID]) with calibration reagents and standards, as needed
- Electronic water level indicator or interface probe
- Water quality meter(s) with calibration reagents and standards, as needed
- Field test kits, as needed
- Power supply, as needed
- Sampling containers and labeling/shipping supplies
- Hip-waders or rubber boots, as needed
- Personal flotation device, as needed
- Expanding ruler or tape measure
- Surface sampler (e.g., dipper, pump, bailer, composite sampler)
- Tubing, as needed
- Lanyard materials (e.g., nylon rope, steel cable), as needed
- Filters, as needed
- Decontamination supplies

12.3 PRECONDITIONS AND BACKGROUND

This SOP has been prepared as part of the company’s Environmental Quality Management Plan and is designed to provide detailed procedures for common field practices. Compliance with the methods presented in this document is mandatory for all field personnel

and will ensure that the tasks are performed in a safe and consistent manner, are in accordance with federal and state guidance, and are technically defensible.

This SOP is written for the sole use of company employees and will be revised periodically to reflect updates to company policies, work practices, and the applicable state and/or federal guidance. Employees must verify that this document is the most recent version of the company's SOPs. Employees are also strongly advised to review relevant state and/or federal guidance, which may stipulate program-specific procedures, in advance of task implementation.

WSP requires that all personnel performing specific project assignments be appropriately qualified, including having required certifications or licenses, and properly trained in accordance with the requirements of their assignment, the Environmental Service Line's field SOPs, and the Quality Management System.

This SOP is designed to provide the user with a general outline for conducting groundwater sampling and assumes the user is familiar with basic field procedures, such as recording field notes (SOP 1), sample shipment procedures (SOP 3), sample collection and quality assurance procedures (SOP 4), investigation derived waste (IDW) management procedures (SOP 5), equipment decontamination (SOP 6), and use and calibration of all sampling and monitoring equipment (SOPs 7 and 8). This SOP does not cover investigation planning, nor does it cover the analysis of the analytical results. These topics are more appropriately addressed in a project-specific work plan. Before sampling, be sure to review the project-specific work plan or Quality Assurance Project Plan (QAPP) and any applicable state and federal guidelines or sampling procedures.

All sampling and monitoring references must be available for consultation in the field, including:

- Company SOPs
- Applicable state and federal guidelines or sampling procedures
- Manufacturer's manuals
- Project-specific work plan, PSP and/or HASP, and QAPP

12.4 GENERAL PROCEDURES

Although the sampling equipment and techniques used to sample surface water are varied, most sampling can be broken down into a two-step sequence:

1. Gauging: provides an indication of the surface water elevation
2. Sample Collection: collection of aliquots in method-specific, preserved (as needed) containers that are representative of the conditions in the surface water body

Be aware that stagnant and moving water bodies may require varying the sampling order and could also require concurrent monitoring and recording of geochemical parameters to assist with identifying a sample interval. Follow your project-specific work plan to accommodate any variances in sampling order.

The procedures and equipment that are used to accomplish these steps are project-specific and should be discussed by the project team before arriving onsite. All types of surface water sampling, regardless of the equipment used, share common handling and management procedures that are designed to ensure the integrity of the samples collected. These procedures include:

- The use of new, disposable or decontaminated sampling equipment
- The use, changing, and disposal of the appropriate PPE
- Selection of a suitable sampling location and staging area

Wear a clean pair of new, disposable gloves each time a different sample is collected and don the gloves immediately prior to collection. This limits the possibility of cross-contamination from accidental contact with gloves soiled during collection of the previous sample. The gloves must not contact the medium being sampled and must be changed any time during sample collection when their cleanliness is compromised. ***Gloved hands should not be used as a sampling device; always use the appropriate equipment to move the sample from the sampling device to the laboratory-supplied containers.***

12.4.1 EQUIPMENT SELECTION

Collect all samples using either new, disposable equipment, or properly decontaminated sampling equipment. Surface water gauging and sampling equipment should be selected based on the analytical requirements of the project and the project-specific conditions (e.g., water body depth, sample volume, chemical constituents in sample water, etc.) likely to be encountered. The equipment should be constructed of non-reactive, non-leachable materials (e.g., stainless steel, Teflon®, Teflon®-coated steel, polyethylene, polypropylene, etc.). Extension rods or other appropriate devices can be used, as necessary, to allow the sample to be collected from a distance (or through deeper water) to minimize the safety risk to the sampler. Note that project or regulatory guidance may limit the type of equipment for sampling.

Consider the following when choosing sampling equipment:

- the type and location of the surface water
- the required depth of the sample
- the volume of sample required
- the analytes of interest

Select the decontamination procedures based on the types of sampling to be performed and decontamination may require multiple steps or differing cleaning methods, depending on the sampling goals (see SOP 6 for decontamination procedures). In no case should disposable, single use materials be used to collect more than one sample.

12.4.2 PRE-SAMPLING CONSIDERATIONS

You should perform the following activities in preparing for sampling with all observations and measurements noted in the field book and on the project-specific groundwater monitoring log, if appropriate:

- Perform a quick reconnaissance of the site to identify sampling locations. Note that project or regulatory guidance may limit the type of equipment for surface water sampling.
- Record the approximate ambient air temperature, precipitation, wind (direction and speed), tide, and other field conditions. In addition, any site-specific conditions or situations that could potentially affect the samples at the sample locations should be recorded.
- Describe the sampling location including the width of the surface water, depth of surface water, water color and clarity (transparency), and approximate surface flow (e.g., slow, fast moving, etc.).
- Record sampling locations with respect to approximate distance to and direction from at least one permanent feature.
- Survey the breathing zone around the sampling location with the appropriate air quality meter(s), as necessary (see HASP), to ensure that the level of PPE is appropriate.

When sampling surface water, it is important to find a suitable sampling location away from any sources of cross-contamination that could compromise the integrity of the samples. Consider the following:

- Position the sample collection area away from fuel-powered equipment, such as drill rigs or excavators, and upwind of other site activities (e.g., purging, sampling, decontamination) that could influence the sample. This is particularly important when screening samples in the field for volatile organic compounds, but should not be limited to the active sample collection.
- If sediment samples are being collected concurrently, collect the surface water samples first to avoid disturbing the bottom and suspending sediment in the water column.
- Avoid wading into surface water, if possible, to avoid sediment suspension and potential cross-contamination.
- If collecting several surface water samples from a stream or river, start sampling at the downstream location and progressively move upstream.
- If using watercraft, orient the watercraft so that the bow is positioned in the upstream direction; collect samples near the bow, away and upwind from any fuel-powered equipment.
- Establish a secure sample staging area in an uncontaminated area of the site.

12.4.3 SAFETY CONSIDERATIONS

Surface water sampling presents a number of unique safety challenges. All water bodies, particularly those with moving water, are inherently dangerous and must be approached with caution. Steep embankments, loose footing, and the potential presence of subsurface hazards (or dangerous plants or wildlife, for some parts of the country) can lead to serious injury or even death.

A minimum of two people must be present during collection and samplers must use appropriate safety equipment (as outlined in the project HASP), such as insulated waders, snake chaps, and flotation devices. If possible, avoid wading into surface water. Be aware of recent weather conditions, tidal changes, or other events (e.g., a dam release), which may result in unexpectedly higher water or flow conditions (or temperature changes) at different times of the year. Do not bodily enter pipes, such as storm sewers or other drainage conveyances during surface water collection as these may be considered confined spaces.

12.5 SURFACE WATER LEVEL MEASUREMENT PROCEDURES

Surface water level measurements are typically collected prior to surface water sampling and are used after the sampling event is completed to establish surface water elevation, discharge, and groundwater/surface water interaction (e.g., gaining or losing stream, flow direction).

Surface water level measurements **MUST** be collected within the shortest interval possible from **all selected existing stream gauges or established measuring points** during the event. If groundwater level measurements are to be collected, gauging should be performed concurrently in accordance with SOP 11. This will ensure a nearly instantaneous snapshot of the water levels before the water body is acted upon by other outside influences, such as tides, precipitation, barometric pressure, river stage, or intermittent pumping of nearby production, irrigation, or supply wells.

Measure the surface water level on the stream gauge or depth to water and total depth from an established measuring point (e.g., bridge) with an electronic water level tape or appropriate equipment and record observations and measurements in the field book. If non-aqueous phase liquids (NAPL) are present on the surface water body, measure the NAPL thickness using the stream gauge (or other appropriate equipment) and record observations and measurements in the field book.

12.6 SURFACE WATER SAMPLE COLLECTION PROCEDURES

Collect surface water samples using the appropriate sampling vessel in accordance with the project-specific work plan. Slowly lower the method-specific sampling vessel (e.g., dippers, sampling container, etc.) into the surface water to the desired sampling depth; Kemmerer, Niskin, Van Dorn, or similar samplers, pumps equipped with tubing, or double check valve bailers can be used to collect samples 12 inches or deeper below the water surface. Allow surface water to slowly enter the sampling vessel until the necessary sample volume has been collected. Once filled, slowly retrieve the sampling vessel and transfer the surface water directly to the sample containers. As applicable, retrieve the sampler at a slightly tilted angle in the upstream direction to minimize the disturbance. If necessary, collect additional surface water to provide sufficient sample volume. Field samples must be directly transferred from the sampling equipment to the container that has been specifically prepared for that given parameter; intermediate containers should be avoided.

Automatic composite samplers are frequently deployed at sites needing long-term surface water sampling. In some sampling situations, automatic composite samplers are permanently installed at surface water stations and remain in the field for months or even years.

Collect surface water samples in order of volatilization sensitivity with organic compounds sampled first followed by inorganic compounds:

- Volatile organic compounds
- Extractable organics, petroleum hydrocarbons, aggregate organics, and oil and grease
- Per- and Polyfluoroalkyl substances
- Total metals

- Dissolved metals (see filtering procedures below)
- Inorganic non-metallic and physical and aggregate properties
- Microbiological samples
- Radionuclides

Water quality parameters (e.g.,temperature, depth, dissolved oxygen, pH, total dissolved solids, specific conductance, turbidity, salinity, oxidation reduction potential, and others) are typically measured in the field as specified in the project planning documents. Collect quality assurance/quality control samples in accordance with SOP 4 and the project-specific work plan or QAPP.

As necessary, conduct field tests or screening in accordance with the project-specific work plan and manufacturer's specifications for field testing equipment. Field samples must be directly transferred from the sampling equipment to the container that has been specifically prepared for that given parameter; intermediate containers should be avoided. If field chemical preservation is required, check the pH preservation by pouring a small portion of sample onto a pH test strip. Adjust pH with additional preservative, if necessary.

Record the depth interval, if applicable, which the sample was collected in the field book. Note the volume, phases, and color of the surface water in the field book.

12.6.1 SURFACE WATER FILTRATION PROCEDURES

Filtered surface water samples are sometimes used for field kit analyses and should only be collected for laboratory analysis after approval from the appropriate regulatory agency and/or project manager. If surface water sample filtration is necessary, the following procedures should be followed:

Filtered samples using pumps should use the following procedures:

- Use a variable speed peristaltic pump with the in-line filter fitted on the outlet end; pressurized bailers or submersible pumps can also be used if sampling the surface water body directly.
- Insert the pump inlet tubing into the intermediate container holding the unpreserved surface water sample or surface water body.

Once the filter is connected:

- Turn on the pump and reduce the flow rate, but maintain a flow rate high enough to deliver a smooth stream of water without splashing or undue agitation, hold the filter upright with the inlet and outlet in the vertical position and pump surface water through the filter until the minimum volume of water has been flushed through the filter, in accordance with the manufacturer's specifications.
- Collect the filtered samples directly into the sample container from the pump-filter assembly.
- If sediment is visible in the sample container after filtration, filter break-through has occurred and the sampling and filtering process should be repeated; the sediment-containing sample should be discarded appropriately.
- Discard the tubing and filter appropriately.
- Record sample filtration in the field book.

12.6.2 NAPL SAMPLING PROCEDURES

NAPL samples are not typically collected from surface water. If samples are to be collected, sampling options and techniques should be discussed with the assigned project compliance professional and project manager; ensure that the NAPL is not considered to be a hazardous material for the purpose of shipping to the laboratory (SOP 3). Samples of NAPL should be placed in the appropriate laboratory-supplied containers, packed on ice, and shipped to the analytical laboratory using procedures outlined in SOP 3.

12.6.3 SAMPLE LABELING AND PREPARATION FOR SHIPMENT

Samples for offsite laboratory analysis should be prepared as follows:

1. Clean the outside of the sample container, if necessary

2. Affix a sample tag or label to each sample container and complete all required information (sample number, date, time, sampler's initials, analysis, preservatives, place of collection)
3. Place clear tape over the tag or label (if non-waterproof labels are used)
4. If needed, preserve samples immediately after collection by placing them into an insulated cooler filled with bagged wet ice to maintain a temperature of approximately 4°Celcius
5. Record the sample designation, date, time, and the sampler's initials in the field book and on a sample tracking form, if appropriate
6. Complete the chain-of-custody forms with appropriate sampling information, including:
   - location
   - sample name
   - sample collection date and time
   - number of sample containers
   - analytical method
   - field filtration status
7. Secure the sample packing and shipping in accordance with proper procedures

Do not ship hazardous waste samples without first consulting a WSP compliance professional.

12.7 CLOSING NOTES

Once sampling is completed, secure the locations in accordance with the project-specific project work plan. Mark all sample locations with stakes or other appropriate markers for future reference or survey, including collecting Global Positioning System coordinates and photographs, in accordance with the project-specific work plan. Decontaminate all equipment prior to departure and properly manage all PPE and IDW in conformance with SOP 6, the project-specific work plan, and applicable regulations.

FIELD SAMPLING PROTOCOLS TO AVOID CROSS-CONTAMINATION OF PER- AND POLYFLUORINATED ALKYL SUBSTANCES (PFAS)

SOP 13

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures/considerations when collecting soil, sediment, surface water, groundwater, and potable water samples at potential per- and polyfluorinated alkyl substances (PFAS) release areas. This SOP also describes a tiered approach that should be used to assist with field decisions. Sampling specific SOPs should also be reviewed prior to conducting field sampling activities at PFAS areas. The information contained within this SOP is included within sampling specific SOPs as applicable.

2.0 SCOPE

This procedure applies to all Wood Environment & Infrastructure Solutions, Inc. (Wood) personnel and subcontractors who collect or otherwise handle samples of soil, sediment, surface water, groundwater, and potable water for analysis of PFAS. This SOP should be reviewed by all on-site personnel prior to implementation of field activities.

3.0 REFERENCES

Transport Canada, 2013. *Perfluorochemical (PFC) Field Sampling Protocol*. May.

Delta Consultants, 2010. *Report of Investigation Activities at Select Firefighting Foam Training Areas and Foam Discharge Sites in Minnesota*. February.

MPCA, 2008. *Closed Landfill Program Sampling Protocol for Monitoring Wells.* October.

4.0 GENERAL

Given the low detection limits associated with laboratory PFAS analysis, and the many potential sources of trace levels of PFAS, field personnel are advised to act on the side of caution by strictly following the subject protocols, frequently replacing nitrile gloves, and rinsing field equipment with lab certified ultra-pure water to help mitigate the potential for false detections of PFAS. Specific items related to field sampling are discussed below.

5.0 PROCEDURES

This section contains both the responsibilities and procedures involved with field sampling for analysis of PFAS. Proper procedures are necessary to ensure the quality and integrity of the samples. The details within this SOP should be used in conjunction with installation-specific work plans. At a minimum, the procedures outlined in this SOP for field sampling will be followed. The installation-specific work plans will generally provide the following information:

- sample collection objectives;

- locations to be sampled;
- number and volume of samples to be collected at each location;
- types of chemical analyses to be conducted for the samples;
- specific quality control (QC) procedures and sampling required; and
- any additional sampling requirements or procedures beyond those covered in this SOP, as necessary.

5.1 RESPONSIBILITIES

Project Manager

The Project Manager (PM) shall provide the Quality Assurance Project Plan (QAPP), and installation-specific work plan to the Field Lead, which shall include the sampling requirements for each investigation area. The PM will report deviations to the procedure provided in this SOP to the Quality Assurance / Quality Control (QA/QC) Manager and the Air Force Civil Engineer Center Contracting Officer Representative (COR).

Field Lead

The Field Lead shall ensure that samples are collected using procedures that are in accordance with the QAPP, installation-specific work plans, and applicable SOPs. The Field Lead shall also be required to make rational and justifiable decisions when deviations from these procedures are necessary because of field conditions or unforeseen issues and report the deviations to the PM.

Quality Assurance / Quality Control (QA/QC) Manager

The QA/QC Manager will be responsible for conducting field audits during selected sampling activities. During these audits, the QA/QC Manager will ensure that field crews are adhering to the procedures provided in the QAPP and in the installation-specific work plans, including, but not limited to, sampling techniques, field documentation, decontamination, sample packaging, chain of custody documentation procedures, and equipment calibration.

Field Personnel

Field personnel assigned to sampling activities are responsible for completing their tasks according to specifications outlined in the QAPP, installation-specific work plans, applicable SOPs, and other appropriate procedures. Field personnel are responsible for reporting deviations from procedures to the Field Lead.

5.2 FIELD PROCEDURES/CONSIDERATIONS

The following are procedures/considerations to be made during field activities at potential PFAS release areas. A summary of the prohibited and acceptable items for PFAS investigation areas is included in Table 1, *Summary of Prohibited and Acceptable Items for PFAS Sampling.* A checklist, provided as Attachment 1, shall be used by the Field Lead daily prior to the commencement of fieldwork to ensure the field team is in compliance with this protocol.

Field Equipment

- **Do not use Teflon®-containing materials** (e.g., Teflon® tubing, bailers, tape, plumbing paste, or other Teflon® materials) since Teflon® contains fluorinated compounds.
- Additional prohibited items are Polyvinylidene fluoride (PVDF) Kynar®, Polychlorotrifluorethylene (PCTFE) Neoflon®, Ethylene-tetrafluoroethylene (ETFE) Tefzel®, Fluorinated ethylene propylene (FEP) Teflon®FEP and Hostaflon® FEP, as well as other fluoropolymer containing materials (e.g. tubing, valves or pipe thread seal tape).
- High-density polyethylene (HDPE), low-density polyethylene (LDPE), and silicon materials are acceptable for sample collection, as they do not contain fluorinated compounds. However, samples may not be stored in containers made of LDPE materials because PFAS can stick to LDPE and bias sample results low.
- Wood will use peristaltic pumps for groundwater sample collection at depths shallower than 25 feet. Wood will use ProActive SS Pumps with polyvinyl chloride (PVC) leads or Geotech SS Geosub pumps for groundwater sample collection at depths greater than 25 feet. These pumps are constructed with stainless steel and will minimize introductions of PFAS.
- When using liners to collect soil samples during direct-push technology or during conventional drilling and sampling methodologies, acetate liners are to be used.
- **Rite in the Rain products are the only waterproof field books that may be used**. To avoid plastic coating or glue materials, do not use other brands of waterproof field books. If Rite in the Rain products are not available, field reports will be documented on loose paper secured on masonite or aluminum clipboards (i.e. plastic clipboards, binders, or spiral hard cover notebooks are not acceptable) using a pen or pencil. Sharpies®/markers may also be used.
- **Post-It Notes are not allowed** on project sites.
- **Do not use markers other than Sharpies®markers.** Ballpoint pens will be used when documenting field activities in the field log and on field forms as well as labeling sample containers and preparing the Chain of Custody.
- Preprinted standard (non-weatherproof) Avery sample labels provided by the Wood quality assurance team will be used on sample containers. Sample labels will be placed on containers after sampling is complete and container lids are in place to prevent possible cross contamination.
- **Do not use chemical (blue) ice packs** during the sampling program. This includes the use of ice packs for the storage of food and/or samples.

Field Clothing and Personal Protective Equipment

- **Do not wear water resistant, waterproof, or stain-treated clothing** during the field program, including Tyvek® which contains fluorinated compounds. Field clothing made of synthetic and natural fibers (preferably cotton) are acceptable. Field clothing should be laundered without the use of fabric softener. Preferably, field gear should be cotton construction and well laundered (i.e., washed a minimum of 6 times prior to use after purchase). New clothing may contain PFAS related treatments. **Do not use new clothing while sampling or sample handling.**

- **Do not wear clothing or boots containing Gore-Tex™** during the sampling program as it contains a PFAS membrane.
- Safety footwear will consist of steel-toed boots made with polyurethane and PVC, untreated leather boots, or well-worn leather boots. Newer leather boots may be worn if they are covered with polypropylene, polyethane, or PVC boot covers.
- Disposable nitrile gloves must be worn at all times. Further, a new pair of nitrile gloves shall be donned prior to the following activities at each sample location:
  - Decontamination of re-usable sampling equipment;
  - Prior to contact with sample bottles or water containers;
  - Insertion of anything into the well (e.g., HDPE tubing, HydraSleeve bailer, etc.);
  - Insertion of silicon tubing into the peristaltic pump;
  - Completion of monitor well purging, prior to sample collection;
  - Handling of any quality assurance/quality control samples including field blanks and equipment blanks; and
  - After the handling of any non-dedicated sampling equipment, contact with non-decontaminated surfaces, or when judged necessary by field personnel.

Sample Containers

- Different laboratories may supply sample collection containers of varying sizes dependent on the type of media to be sampled (e.g., soil, groundwater, etc.). All samples should be collected in polypropylene or HDPE bottles. The screw cap will be made of polypropylene or HDPE and may be lined or unlined. However, if lined, the liner may not be made of Teflon® or contain PFAS.
- Container labels will be completed using pen after the caps have been placed back on each bottle.
- Glass sample containers are not to be used due to potential loss of analyte through adsorption.

Wet Weather

- Field sampling occurring during wet weather (e.g., rainfall and snowfall) should be conducted while wearing appropriate clothing that will not pose a risk for cross-contamination. Teams will avoid synthetic gear that has been treated with water-repellant finishes containing PFAS. Use rain gear made from polyurethane, vinyl, and wax or rubber-coated materials.
- Teams should consider the use of a gazebo tent, which can be erected overtop of the sample location and provide shelter from the rain. It should be noted that the canopy material is likely a treated surface and should be handled as such; therefore, gloves should be worn when setting up and moving the tent, changed immediately afterwards and further contact with the tent should be avoided until all sampling activities have been finished and the team is ready to move on to the next sample location.

Equipment Decontamination

- Field sampling equipment, including oil/water interface meters and water level indicators, and other downhole equipment used at each sample location, will require cleaning between uses. Alconox® and Liquinox® soap is acceptable for use since the Safety Data Sheets do not list fluoro-surfactants as an ingredient. However, Decon 90 will not be used during decontamination activities. Water used for the final rinse during decontamination of sampling equipment will be laboratory certified "ultra-pure" water (PFAS free).
- For larger equipment (e.g., drill rig and large downhole drilling and sampling equipment), decontamination will be conducted with potable water using a high-pressure washer and then rinsed using potable water.

Personnel Hygiene

- Field personnel will not use cosmetics, moisturizers, hand cream, or other related products as part of their personal cleaning/showering routine on the morning of a sampling event, unless the products are applied to a part of the body that will be coved by clothing. These products may contain surfactants and represent a potential source of PFAS.
- Many manufactured sunblock and insect repellants contain PFAS and should not be brought or used on-site. Sunblock and insect repellants that are used on-site should consist of 100% natural ingredients, unless previously vetted by the project chemist. A list of acceptable sunscreens and insect repellents are provided in Table 1.
- For washroom breaks, field personnel will leave the exclusion zone and then remove gloves and overalls. Field personnel should wash as normal with extra time for rinsing with water after soap use. When finished washing, the use of a mechanical dryer is preferred and the use of paper towel for drying is to be avoided (if possible).

Food Considerations

- No food or drink shall be brought on-site, with the exception of bottled water and hydration drinks (i.e., Gatorade® and Powerade®), which will only be allowed to be brought and consumed within the staging area.

Visitors

- Visitors to the investigation area are asked to remain outside of the exclusion zone during sampling activities.

6.0 TIERED APPROACH TO ASSIST WITH FIELD DECISIONS

In evaluating whether products contain PFAS and are suitable for use in the field, the tiered approach presented in Table 2, *Tiered Approach*, will be used to assist with field decisions. Any member of the field team should contact the PM, or Project Chemists with questions.

Table 1. Summary of Prohibited and Acceptable Items for PFAS Sampling

Prohibited Items	Acceptable Items
Field Equipment	
Teflon® containing materials	High-density polyethylene (HDPE) and Low density polyethylene (LDPE) materials
Fluoropolymers (e.g. Polyvinylidene fluoride (PVDF) Kynar®, Polychlorotrifluoroethylene (PCTFE) Neoflon®, Ethylene-tetrafluoroethylene (ETFE) Tefzel®, Fluorinated ethylene propylene (FEP) Teflon®FEP and Hostaflon® FEP)	HDPE, polypropylene, silicone, stainless steel, natural rubber, nylon, uncoated metal springs, polyethylene, LDPE
LDPE sample containers	HDPE sample containers and acetate liners
Teflon® tubing	Silicon or HDPE tubing
Waterproof field books not manufactured by Rite in the Rain	Rite in the Rain products or loose leaf paper (non-waterproof)
Plastic clipboards, binders, or spiral hard cover notebooks	Aluminum field clipboards or with Masonite
	Sharpies®, ballpoint pens
Adhesive paper products (e.g. Post-it notes)	
Chemical (blue) ice packs	Regular ice
Excel Purity Paste TFW Multipurpose Thread Sealant Vibra-Tite Thread Sealant	Gasoils NT Non-Polytetrafluoroethylene (PTFE) Thread Sealant Bentonite
Equipment with Viton Components (need to be evaluated on a case by case basis, Viton contains PTFE, but may be acceptable if used in gaskets or O-rings that are sealed away and will not come into contact with sample or sampling equipment.)	
Field Clothing and PPE	
New clothing or water resistant, waterproof, or stain-treated clothing, clothing containing Gore-Tex™	Well-laundered clothing, defined as clothing that has been washed 6 or more times after purchase, made of synthetic or natural fibers (preferable cotton)
Clothing laundered using fabric softener	No fabric softener
Boots containing Gore-Tex™	Boots made with polyurethane and PVC, well-worn or untreated leather boots, leather boots with boot covers
Tyvek®	Reflective safety vests, Cotton Clothing, synthetic under clothing, body braces

Prohibited Items	Acceptable Items
No cosmetics, moisturizers, hand cream, or other related products as part of personal cleaning/showering routine on the morning of sampling, unless the products are applied to body parts that will be covered by clothing.	**Sunscreens** - Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, Baby sunscreens that are "free" or "natural". Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30, Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Stick SPF 50, Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, Coppertone Sport High Performance AccuSPray Sunscreen SPF 30, Coppertone Sunscreen Stick Kids SPF 55, L'Oréal Silky Sheer Face Lotion 50, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 50, Meijer Sunscreen Continuous spray Broad Spectrum SPF 30, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30, and 50, Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70, Neutrogena Beach Defense Water+Sun barrier Lotion SPF 70, Neutrogena Beach Defenses Water+Sun Barrier Lotion SPF 70, Neutrogena Pure and Free Baby Sunscreen Broad Spectrum SPF 60+, Neutrogena UltraSheer Dry-Touch Sunscreen Broad Spectrum SPF 30 **Insect Repellents** - Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, Deep Woods Off, Sawyer Permethrin **Sunscreen and insect repellant -** Avon Skin So Soft Bug Guard Plus – SPF 30 Lotion
Sample Containers	
LDPE or glass containers	HDPE or polypropylene
Teflon®-lined caps	Lined or unlined HDPE or polypropylene caps
Rain Events	
Waterproof or resistant rain gear	Polyurethane, vinyl, wax or rubber-coated rain gear. Gazebo tent that is only touched or moved prior to and following sampling activities
Equipment Decontamination	
Decon 90	Alconox®, Citranox® and/or Liquinox®
Water from an on-site well	Potable water from municipal drinking water supply (needs screening), Triple Rinse with ultra-pure deionized water
Food Considerations	
All food and drink, with exceptions noted on the right	Bottled water and hydration drinks (i.e. Gatorade® and Powerade®) to be brought and consumed only in the staging area

Table 2. Tiered Approach

Tier and Description	Action
Tier 1: Products that *will come into direct contact* with field samples include, but are not limited to, drilling grease, sampling equipment, sample containers, and well construction materials	These products will undergo the greatest scrutiny and requires chemist's input to help evaluate the materials as a possible source of contamination[A] and as possible sampling or storage materials or both
Tier 2: Products that *will not come into direct contact* with samples, but could be *reasonably expected to contain PFAS*, such as waterproof or nonstick products	Project team/affected person can review the Safety Data Sheet (SDS)[B] and if it shows PFAS, product should not be used. If product SDS does not indicate PFAS, confirm with chemist before use
Tier 3: Products that *will not come into direct contact* with samples and are *not expected to contain PFAS*, such as ballpoint pens, zipper bags, and body braces	Project team/affected person can review SDS and if no PFAS, then appropriate to use

[A] Tier 1 products will undergo the closest scrutiny. It may be necessary to have Tier 1 products analyzed for PFAS to confirm that a specific batch or lot number does not contain PFAS. Alternate products will need to be evaluated/used if PFAS are identified in the product.

[B] SDS Check: To evaluate product SDS and/or manufacturing specs, check if the product contains anything with "fluoro" in the name or the acronyms TPE, FEP, ETFE, and/or PFA. If fluorinated compounds are not listed in the manufacturing specs and/or on the SDSs, product can be used.

Appendix B

Field Forms

FIELD ACTIVITY DAILY LOG

Project Name: ______________________ **Project Number:** ______________

Technician Name: ______________________ **Date:** ______________

Personnel Onsite: ____

Weather Conditions:

Description of Daily Activities and Events:

Time	**Observation/Comment**

List of Samples Collected:

Deviation from Plans:

Visitors on Site:

Important Telephone Calls / Photos Taken:

Technician Signature:

Technician Name (print)**:**

QA/QC'd by: **QA/QC Date:**

ATTACHMENT 1 TO SOP 13
DAILY PFAS PROTOCOL CHECKLIST

Site Name: ______________________

Project Number: ______________________

Field Manager: ______________________

Weather (temp./precipitation):

Date and Time:

Field Clothing and PPE (as applicable):

☐ Field crew in compliance with Tables 1 and 2, SOP-01

☐ Field crew has not used fabric softener on clothing

☐ Field crew has not used cosmetics, moisturizers, hand cream, or other related products or exposed body parts this morning

☐ Field crew has not applied unacceptable sunscreen or insect repellant

Field Equipment:

☐ No Teflon® containing materials on-site

☐ All sample materials made from stainless steel, HDPE, acetate, silicon, or polypropylene

☐ No waterproof field books on-site other than Rite-in-the-Rain® Products

☐ No plastic clipboards, binders, or spiral hard cover notebooks on-site

☐ No adhesives (Post-it® Notes) on-site

☐ Coolers filled with regular ice only. No chemical (blue) ice packs in possession

Sample Containers:

☐ All sample containers made of HDPE or polypropylene. Samples are not stored in containers made of LDPE

☐ Caps are lined or unlined and made of HDPE or polypropylene

Wet Weather (as applicable):

☐ For personnel in direct contact with samples and/or sampling equipment, wet weather gear made of Vinyl, polyurethane, PVC, latex or rubber-coated materials only

Equipment Decontamination:

☐ "PFAS-free" water on-site for decontamination of sample equipment

☐ Alconox and Liquinox to be used as decontamination materials

Food Considerations:

☐ No food or drink on-site with exception of bottled water and/or hydration drinks (i.e., Gatorade and Powerade) that is available for consumption only in the staging area

If any applicable boxes cannot be checked, the Field Manager 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 investigation area or removal of worker offsite until in compliance. Repeated failure to comply with PFAS sample protocols will result in the permanent removal of worker(s) from the investigation area.

Describe the noncompliance issues (include personnel not in compliance) and action/outcome of noncompliance:

Field Manager Signature:

{Field_Manager_Signature}

Field Manager Name (print):

{Field_Manager}

Groundwater Gauging Form

Site Name:
Date:
Project Number:
Field Staff:

Well ID	Time	Depth to Groundwater (btoc,ft)	Depth to Bottom (btoc, ft)	Notes/Remarks

Notes:

Technician Signature:

QA/QC'd By:

QA/QC Date:

GROUNDWATER SAMPLING RECORD

wsp

Project Name:		**Project Number:**	
Sample Technician:		**Date:**	
Well ID:		**Well Diameter (inches):**	
Initial Depth to Water:		**Screen Interval (feet):**	
Total Depth of Well:		**1 Casing Volume (gal):**	
Method of Purging:		**3 Casing Volumes (gal):**	
Measuring Point (toc, tor, etc.):		**Pump Intake Depth (feet):**	

Time	Cum. Volume (gal.)	Flow Rate (mL/min)	Water Level (ft)	Temp. (°C)	pH (units)	Specific Electrical Conductance (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Comments/Observations During Purging (color, sediment, odor, etc.)
Stabilization Criteria			±0.02 ft	±0.5°C	±0.1	±3%	±10%	±10%	±10% and <10 NTU	
Final Values:										

Stability Reached (Y/N): If No, Provide Explanation

Sample ID:		**Method of Sampling:**	
Sample Depth:		**PID (ppm):**	
Sample Date:		**Sample Container Type(s):**	
Sample Collection Time:		**Sample Container Preservative(s):**	
QA/QC Sample:		**Analysis/Method(s):**	
QA/QC Sample Type:		**Initial Depth to Water:**	
Duplicate Collected:		**Depth to Water After Sampling:**	
Duplicate ID:			

Instruments (Manufacturer, Model, and Serial No.):

Calculations:

Saturated well casing volume: $V = \Pi(R^{2})H*7.48\ \text{gal/ft}^{3}$

V=Volume (gal/ft)
Π = 3.14
R = well radius (ft) = (well diameter (in)/12 (in/ft))/2)
H = height of water column (ft)

Technician Signature:

Notes:

Technician Name (print):

QA/QC'd by: **QA/QC Date:**

Sample Control Log

Project Name:

Date:

Project Number:

Field Staff:

Sample ID	Date	Time	Duplicate ID	MS / MSD	Notes
Quantity			Quantity	Quantity	

Notes:

WATER QUALITY SAMPLING INSTRUMENT CALIBRATION FORM

Site Name: **Calibration Start Time:** **Calibration End Time:**

Project Number: **Sample Technician:** **Date:**

Morning (AM) Calibration

Time (24hr)	Temperature (°C)	pH (SU)	Turbidity (NTUs)	Specific Electrical Conductance (mS/cm)	D.O. (mg/L)	ORP/Eh (mV)	Barometric Pressure (mm Hg)	Comments

Afternoon (PM) Calibration

Time (24hr)	Temperature (°C)	pH (SU)	Turbidity (NTUs)	Specific Electrical Conductance (mS/cm)	D.O. (mg/L)	ORP/Eh (mV)	Barometric Pressure (mm Hg)	Comments

Calibration Materials Record:

pH Calibration Standards

Standard	Cal. Standard Lot #	Expiration Date
pH (4)		
pH (7)		
pH (10)		

Specific Electrical Conductance, Salinity, Dissolved Oxygen (DO) and Oxidation Reduction Potential (ORP) Calibration Standards

Standard	Cal. Standard Lot #	Expiration Date
Spec. Conductance		
D.O.		
ORP		

Turbidity Standards

Standard	Cal. Standard Lot #	Expiration Date
10		
100		

Instruments (Manufacturer, Model, and Serial No.):

	Manufacturer/Model	**Serial No**
Water Quality Meter:		
Turbidity Meter:		

Calibrated Within Acceptance Criteria (Y/N):

If No, Provide Explanation:

Notes:

{Notes}

Technician Signature:

{Signature}

Technician Name (print)**:** {Technician}

QA/QC'd by: **QA/QC Date:**

Attachment B

EPA Pore Water Sampling Procedure

U.S. Environmental Protection Agency
Region 4, Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Pore Water Sampling**

Effective Date: December 16, 2016

Number: SESDPROC-513-R3

Author

Name: Mel Parsons
Title: Life Scientist
Signature: Mel Parsons Date: 12/14/16

Approval

Name: John Deatrick
Title: Chief, Field Services Branch
Signature: John Deatrick Date: 12/14/16

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 12/14/16

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-513-R3, Pore Water Sampling, replaces SESDPROC-513-R2. **General:** Corrected any typographical, grammatical, and/or editorial errors. **Title Page:** Changed the Field Quality Manager from Bobby Lewis to Hunter Johnson. Updated cover page to represent SESD reorganization. John Deatrick was not listed as the Chief of the Field Services Branch	December 16, 2016
SESDPROC-513-R2, Pore Water Sampling, replaces SESDPROC-513-R1.	February 28, 2013
SESDPROC-513-R1, Pore Water Sampling, replaces SESDPROC-513-R0.	January 29, 2013
SESDPROC-513-R0, Pore Water Sampling, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

The purpose of this operating procedure is to describe the procedures, methods and considerations to be used when obtaining a sediment pore water sample.

1.2 Scope/Application

This document describes procedures generic to all pore water sampling methods to be used by field personnel when collecting and handling samples in the field. On the occasion that Science and Ecosystem Support Division (SESD) personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a pore water sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version.

M.H.E. Products. 2003. PushPoint Sampler (US Pat. # 6,470,967) Operators Manual and Applications Guide, Version 2.01. East Tawas, MI. http://www.mheproducts.com

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version.

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version.

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version.

SESD Operating Procedure for Surface Water Sampling, SESDPROC-201, Most Recent Version.

SESD Operating Procedure for Pump Operation, SESDPROC-203, Most Recent Version.

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version.

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version.

SESD Operating Procedure for Groundwater Sampling, SESDPROC-301, Most Recent Version.

SESD Operating Procedure for Potable Water Supply Sampling, SESDPROC-305, Most Recent Version.

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version.

USEPA. ASBLOQAM. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4, Science and Ecosystem Support Division, Athens, GA. Most Recent Version.

USEPA. SHEMP. Safety, Health and Environmental Management Program Procedures and Policy Manual. Science and Ecosystem Support Division, Region 4, Athens, GA. Most Recent Version.

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version.

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting pore water samples. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual (most recent version) and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting pore water samples:

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done in a bound logbook. Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as bills of lading, will be retained by the project leader and stored in a secure place.

1.5.3 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in SESD Operating Procedure for Control of Records, SESDPROC-002 (most recent version). Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation, in accordance with SESD Operating Procedure for Logbooks, SESDPROC-010 (most recent version), and SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005 (most recent version).

2 Sampling Methodology

2.1 General

The pore water sampling techniques and equipment described in this procedure are designed to minimize effects on the chemical and physical integrity of the sample. If the procedures in this section are followed, a representative sample of the pore water should be obtained.

2.2 Collection Considerations

The physical location of the investigator when collecting a sample may dictate the equipment to be used. Wading is the preferred method for reaching the sampling location, particularly if the stream has a noticeable current (i.e., is not impounded). However, wading may disrupt bottom sediments causing biased results; therefore, the sampler should enter the area downstream of the sampling location and collect sample facing upstream. If the stream is too deep to wade, the pore water sample may be collected from a platform such as a boat or by SCUBA diving. If sampling from a boat or in water deeper than the length of the sampler, extensions may be utilized. The device is suitable for use only in fine-grained material (no gravel or cobble).

2.3 Summary of Procedure

Sediment pore water is collected using a pore water extracting device (Figure 1). The most common type used is the PushPoint™ sampler (M.H.E. Products 2003), made out of stainless steel tubing. The sampling end of the pore water device is inserted into the sediment to the desired depth, and pore water is extracted using a syringe or peristaltic pump. Other similar devices may be used providing that the integrity of the sample is maintained and no ambient surface water is allowed in contact with the sample.

2.4 Sampling Equipment

A PushPoint™ or similar sampler typically consists of a pointed tubular stainless steel tube with a screened zone at one end and a sampling port at the other. The pointed end with the screened zone consists of a series of very fine interlaced machined slots to allow pore water to enter the sampler. A removable guard rod adds rigidity to the sampler during sediment insertion. The length of the screened zone will depend on the site specific study design. Depending on the data quality objectives (DQO) of the study, filters may be placed over the screened zone if additional screening is needed. Pore water is collected through the opposite end of the device by connecting flexible tubing and using a syringe or peristaltic pump to extract the sample. Teflon® tubing is the preferred tubing to be used for collecting pore water samples. However, other tubing may be used, depending upon the DQOs for the specific application.

There are many modifications that can be incorporated into the procedure to satisfy data quality objectives for a specific application. The procedures discussed in the following sections provide guidance on the basic operation of pore water sampling devices and issues to consider when collecting pore water.

An alternative system is available in SESD inventory for use in soft sediments in water deeper than wading depth. A well screen and short riser approximately ¾" in diameter has external threads to fasten to the bottom of a custom flange and internal threads to accept a tubing compression adapter. The accompanying rimmed flange has a coupling with both top and bottom threads. The well screen is screwed into the bottom of the flange coupling and Teflon® tubing is attached to the tubing compression adapter which is threaded into the well screen. The tubing is then inserted through the pipe or well casing which is then screwed into the upper coupling threads. The entire assembly can be deployed in water up to ten feet of depth from a well anchored boat.

2.5 Pore Water Sampler Deployment Considerations

It is critical in the collection of pore water to avoid surface water intrusion. Water will flow in a path of least resistance. If space is created around the sides of the sampling end of the pore water device during deployment, surface water may flow down the outside of the device to the screened area and into the intended sample. Therefore, the pore water device should be used with a sampling flange (Figure 2), especially when collecting pore water near the sediment-surface water interface. If pore water is collected from deep in the sediments, a flange may not be necessary. When inserted though the sampling platform, or flange, the body of the pore water device should form a water tight seal to eliminate surface water intrusion during sample collection. Flanges should include a cutting ring to enhance sealing. Flange systems can be augmented by flexible plastic sheeting of appropriate material. The sheeting can be weighted to conform to the stream bottom by sediments obtained from other areas of the stream or banks away from the sampling location.

The flange can be made of any material that will not cross contaminate the intended sample. If both inorganic and organic analyses are required, the flange should be made of inert material such as stainless steel or Teflon®. The size of the flange depends on the volume of pore water to be collected. If large volumes of pore water are to be collected, use a large flange size. A useful estimate can be made for planning by taking the entire required water volume, tripling it to assume 33% porosity, and then calculating the dimensions of a sphere or cylinder of this volume. The flange should cover at least this estimated volume. If it is not practical to use a large flange, then multiple devices may be deployed and smaller volumes can be collected from several devices for a composite sample. If multiple devices are deployed, they should be spaced an appropriate distance apart so they will not interfere with one another.

For irregular surfaces a flange can be improvised from polyethylene sheeting weighted by shovelled nearby stream sediments. Several of the flanges in SESD inventory have a threaded nut and washer to facilitate sealing the flange to a polyethylene sheet for this purpose.

In general, the volume of pore water that can be collected at a given location is limited. Collecting large volumes of pore water will ultimately result in the collection of water from the overlying water body. Often, minimum required volumes must be negotiated with the laboratory to limit the volumes withdrawn.

Where significant differences in parameters such as pH or conductivity exist between the surface water and pore water, a check can be made at the end of sampling to assess whether surface water intrusion has occurred by measuring the pore water parameters at the beginning and conclusion of sampling.

2.6 Pore Water Collection

The flange is first placed at the desired sampling point with the push-point removed to allow water to escape from under the flange. The flange rim should be carefully worked into the sediment until the flange is flush with the sediment surface. The pore water device should then be inserted through the compression adapter on the flange and into the sediment as carefully as possible (Figure 2). When the sampler is inserted to the desired depth, the compression adapter should be tightened. The push-point's guard rod can then be withdrawn. Do not reinsert the guard rod into the sampler for any reason until the sampler has been cleaned (sediment particles rolled between the two metal surfaces will lock the parts together and permanently damage the sampler.)

When deploying the pore water device, care must be taken not to disturb the sampling area. If the sampler is wading in the water body, the sampler should lean out and insert the pore water device as far as possible away from where the sampler is standing to reduce potential effects of the sampler on the integrity of the pore water sample. Depth of penetration of the pore water device into the sediment depends on the objectives of the specific investigation.

After the pore water device has been successfully deployed, attach the sample tubing to the sampling port of the pore water device. Short pieces of Silastic® tubing can be used to splice Teflon® sample tubing to a push-point sampler, taking care to butt the tubing to the sampler at the center of the splice. Then attach the other end of the tubing to a sample withdrawing device, such as a syringe or a peristaltic pump (according to SESD Operating Procedure for Pump Operation, SESDPROC-203). Before collecting a pore water sample, be sure to purge out all air and surface water from the pore water device and sample tubing with the appropriate amount of pore water. If utilizing a syringe for collection, a three-way valve with a side syringe must be utilized for the surface water purge in order not to cross contaminate the sampling syringe.

2.6.1 Peristaltic Pump/Vacuum Jug Collection

The peristaltic pump/vacuum jug can be used for sample collection of organic or inorganic samples because it allows for the sample to be collected without coming in contact with the pump head tubing, maintaining the integrity of the sample. This is accomplished by placing a Teflon® transfer cap assembly onto the neck of a pre-cleaned standard 1-liter amber glass container (Figure 3). Teflon® tubing (¼-inch O.D.) connects the container to both the pump and the sample source. The pump creates a vacuum in the container, thereby drawing the sample into the container without it coming into contact with the pump head tubing.

Because the sample is exposed to a vacuum and is agitated as it enters the vacuum jug, this method cannot be used for collection of samples for volatile organic compounds. An alternative method for collecting volatile organics involves filling the Teflon® tubing with sample by running the pump for a short period of time. Once the tubing is full of water, the tubing is removed from the pore water sampler and, then pinched off at the pump in order to maintain the vacuum and disconnected from the pump head tubing. The water is then allowed to carefully drain, by gravity, into the sample vials. Alternatively, without disconnecting the tubing from the pump head, the contained sample can be pushed out of the tubing, into the sample vials, by reversing the peristaltic pump at very low speed. Great care must still be taken with this method in order not to agitate the sample during the transfer process or transfer water that has been in contact with the Silastic® tubing into the vials.

Because pore water is typically collected from an anaerobic environment, it is preferable, especially when collecting samples for nutrient analysis, to maintain the integrity of the sample by minimizing exposure to air. This can be accomplished by purging the sample container with an inert gas such as nitrogen or argon prior to sampling. In addition, if analyzing for nutrients or metals, the container can be pre-preserved in order to minimize exposure of the sample to ambient conditions.

An alternative, when collecting samples for metals, nutrients or other sample analysis not affected by the Silastic® tubing and exposure to air is not a concern, is to collect the sample directly from the discharge of the pump head tubing after an adequate purge has been demonstrated. When collecting samples in this manner, there are several considerations to be aware of. The pump head tubing (Silastic®, etc.) must be changed after each sample and a rinsate blank must be collected from a representative piece of the pump head tubing (only one blank per investigation). Also, precautions must be taken to ensure that the end of the discharge tubing is not allowed to touch the ground or other surface to ensure the integrity of the sample collected in this manner.

2.6.2 Syringe

An alternative to using the pump and vacuum container is to use a syringe as the mechanism to draw the pore water through the sampling device. The tubing from the sampling port of the pore water device can be directly attached to a syringe with a three-way valve and a side syringe and the pore water sample can be manually withdrawn from the sediment. The valve is first switched to the side syringe, which is used for purging air and any ambient surface water in the system prior to sampling. The volume to be purged is determined by the length and diameter of the sampling device and attached tubing. Once the sampler has been purged, the valve is switched to the sampling syringe and the sample is drawn into the syringe. The syringe can be used as the final sample container or the pore water can be transferred to another container, depending on project objectives and analytical requirements.

2.7 Quality Control

If possible, a control or background sample should be collected from a location not affected by the possible contaminants of concern and submitted with the other samples. In streams or other bodies of moving water, the control sample should be collected upstream of the sampled area. For impounded bodies of water, particularly small lakes or ponds, it may be difficult or inappropriate to obtain an unbiased control from the same body of water from which the samples are collected. In these cases, it may be appropriate to collect a background sample from a similar impoundment located near the sampled body of water if there is a reasonable certainty that the background location has not been impacted. Equipment blanks should be collected if equipment is field cleaned and reused on-site or, if necessary, to document that low-level contaminants were not introduced by pumps, bailers or other sampling equipment.

2.8 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect pore water samples shall be cleaned as outlined in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205 (most recent version) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206 (most recent version) and repaired, if necessary, before being stored at the conclusion of field studies. Cleaning procedures utilized in the field or field repairs shall be thoroughly documented in field records.

3 Special Sampling Considerations

3.1 Volatile Organic Compounds (VOC)

Pore water samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two week holding time, whereas, unpreserved samples have only a seven day holding time. During most sampling events, preserved vials are used due to their extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the surface water sample contains a high concentration of dissolved calcium carbonate, there may be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles. This will render the sample unacceptable. In this case, unpreserved vials should be used and arrangements must be confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

Samples for VOC analysis must be collected using either stainless steel or Teflon® equipment. Samples should be collected with as little agitation or disturbance as possible. The vial 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. After the cap is securely tightened, the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be refilled. Care should be taken not to flush any preservative out of the vial during topping off. If, after attempting to refill and cap the vial, bubbles are still present, a new vial should be obtained and the sample re-collected.

3.2 Dissolved Metals Sample Collection

If a dissolved metals pore water sample is to be collected, an in-line filtration should be used. The use of disposable, high-capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus is preferred. The high-capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration.

Potential differences could result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter "dissolved" trace element concentrations; these include filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidally-associated trace elements, and concentration of organic matter. Therefore, consistency is critical in the comparison of short-term and long-term results. Further guidance on filtration may be obtained from Section 4.7.3 of the SESD Groundwater Sampling Procedure (SESDPROC-301).

3.3 Special Precautions for Pore Water Sampling

- A clean pair of new, non-powdered, disposable latex gloves will be worn each time a different location is sampled and the gloves should be donned prior to handling sampling equipment and sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- All background or control samples shall be collected and placed in separate ice chests or shipping containers. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Samplers must use new, verified, certified clean disposable equipment, or pre-cleaned non-disposable equipment. Non-disposable equipment should be pre-cleaned according to procedures contained in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205), for collection of samples for trace metals or organic compound analyses.

3.4 Sample Handling and Preservation Requirements

1. Pore water will typically be collected from sediments using a peristaltic pump and placed directly into the sampling containers. In some cases a syringe may be used to collect the sediment pore water and then transfer the sample into the appropriate container.
2. During sample collection, if transferring the sample from a collection device, make sure that the device does not come in contact with the sample containers.
3. Place the sample into appropriate, labeled containers. Samples collected for VOC analysis must not have any headspace (see Section 3.1).
4. All samples requiring preservation must be preserved as soon as practically possible, soon after sample collection. If pre-preserved VOA vials are used, these will be preserved with concentrated hydrochloric acid prior to departure for the field investigation. For all other chemical preservatives, SESD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples, except for the samples collected for VOC analysis. If it is determined that a sample is not acceptably preserved, additional preservative should be added to achieve adequate preservation. Preservation requirements for surface water samples are found in the USEPA Analytical Support Branch *Laboratory Operations and Quality Assurance Manual (*USEPA ASBLOQAM).

Figure 1. Pore Water Sampling Device

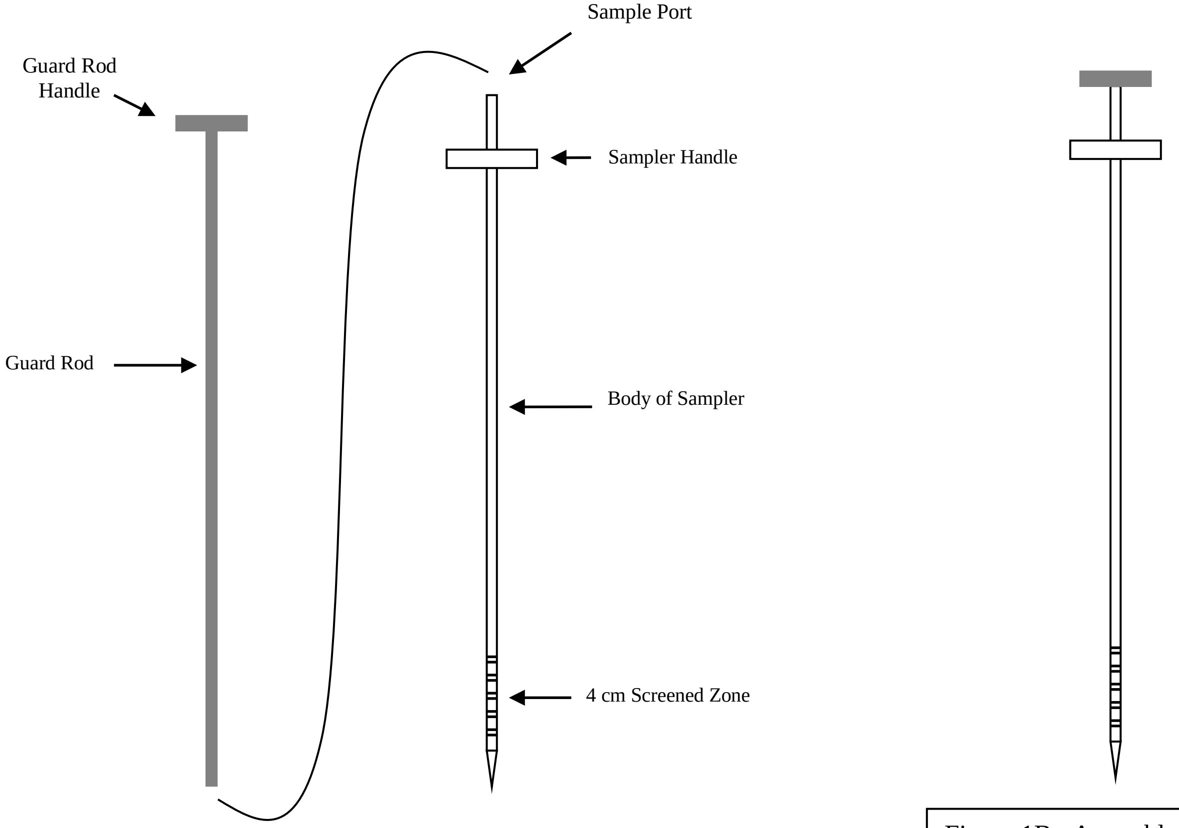
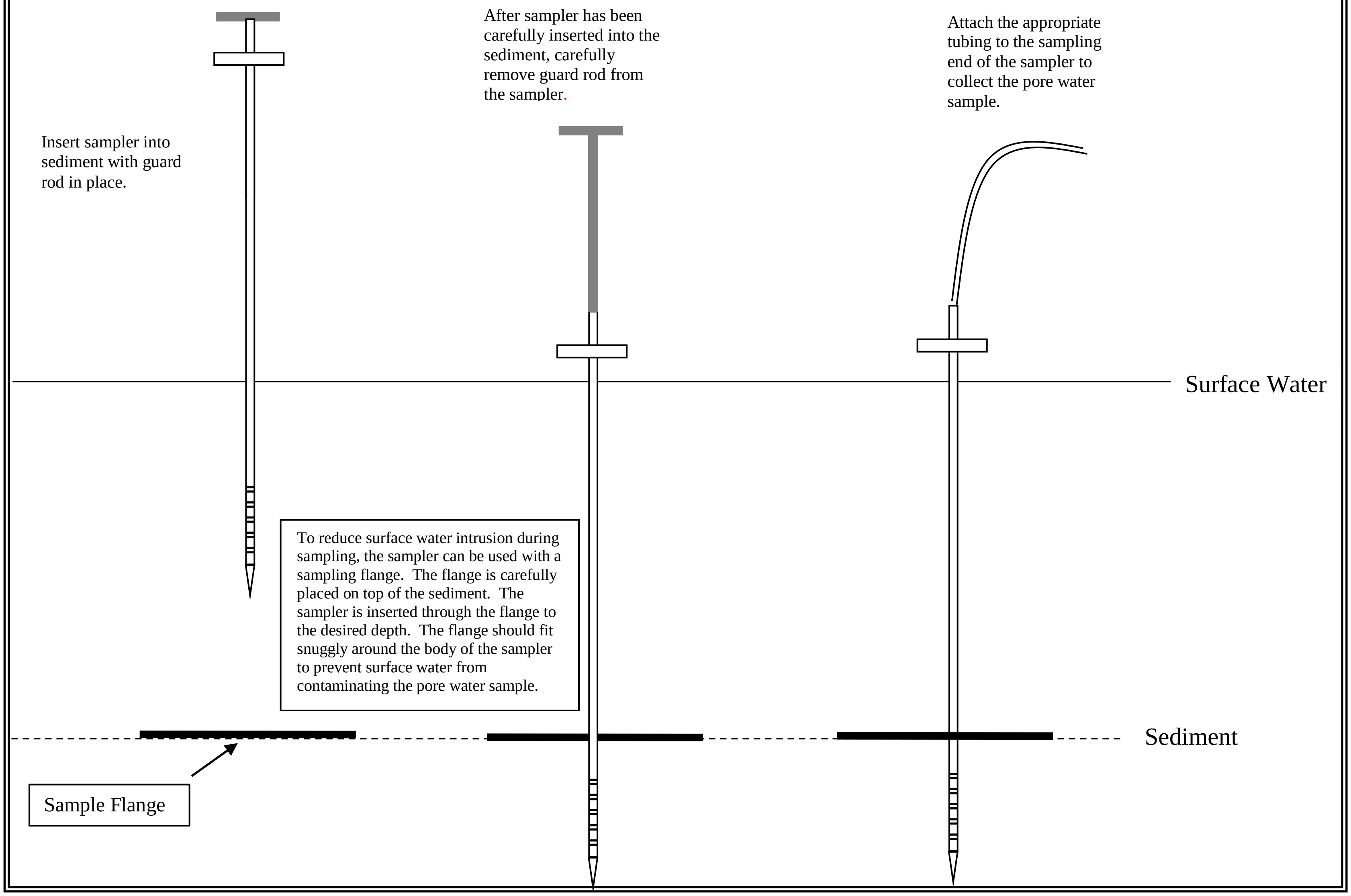


Figure 1A. Disassembled Device

Figure 1B. Assembled Device

Actual length and width of device will vary, depending on sampling needs and site conditions.
Note: cm = centimeter

Figure 2. Pore Water Sampler Deployment Using a Sampling Flange



Insert sampler into sediment with guard rod in place.

After sampler has been carefully inserted into the sediment, carefully remove guard rod from the sampler.

Attach the appropriate tubing to the sampling end of the sampler to collect the pore water sample.

To reduce surface water intrusion during sampling, the sampler can be used with a sampling flange. The flange is carefully placed on top of the sediment. The sampler is inserted through the flange to the desired depth. The flange should fit snuggly around the body of the sampler to prevent surface water from contaminating the pore water sample.

Figure 3. Pore Water Sampler Deployment Using a Peristaltic Pump to Sample