Field Activities
Standard Operating Procedures

for the

West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Voluntary Remediation Program
UECA-LUST Program
CERCLA (Superfund) and Federal Facilities Program

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January 2025

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Field Activities Standard Operating Procedures for the West Virginia Department of Environmental Protection Division of Land Restoration Office of Environmental Remediation

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General Decontamination Procedures for Non-Disposable Field Sampling Equipment

SOP OER-0100

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ruth Porter	1.0	7/1/2010	Reformatted, added SOP ID #, and renumbered. Supersedes Revision 0.0	Editorial
			Additional detail provided for decontamination procedures.	Technical
Dave Long	2.0	9/21/2016	Revised decontamination procedures. Reformatted.	Editorial, Technical
Ross Brittain	3.0	11/10/2020	Revised decontamination procedures as necessary, edited typographical and grammatical errors.	Editorial, Technical
Ross Brittain	4.0	1/13/2025	Revised decontamination procedures to account for PFAS sampling.	Technical

GENERAL DECONTAMINATION PROCEDURES FOR NON-DISPOSABLE FIELD SAMPLING EQUIPMENT

SOP OER-0100

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List of Acronyms and Abbreviations

HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDW	Investigation Derived Wasted
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PFAS	Per- and Polyfluoroalkyl Substances
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
WVDEP	West Virginia Department of Environmental Protection

Disclaimer: Any mention in this SOP of any products or services does not constitute or imply the endorsement, recommendation or favoring by WVDEP or any of its employees or contractors acting on its behalf.

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide a description of the methods used for non-disposable field equipment decontamination. Field equipment decontamination serves many purposes, including, but not necessarily limited to:

- Preventing, minimizing, or limiting cross-contamination of samples
- Preventing cross-contamination of sampling locations
- Ensuring collection of representative samples
- Ensuring proper operation of field equipment
- Ensuring accuracy of field measurements
- Reducing potential exposure hazards for field personnel
- Preventing contamination of uncontaminated areas

This SOP also provides general guidelines for developing decontamination procedures for sampling equipment to be used for Office of Environmental Remediation (OER) projects within the West Virginia Department of Environmental Protection (WVDEP). This SOP does not address personnel decontamination.

These are standard (i.e. typically applicable) operating procedures which may be varied or changed as needed, dependent upon site conditions, equipment limitation, and/or limitations imposed by the procedure. The actual procedures employed at a site should be fully documented.

2.0 SUMMARY OF METHOD

All non-disposable sampling equipment (including, but not limited to: augers, GeoProbe^{TM} drive rods, trowels, spatulas, hand augers, shovels, stainless steel mixing bowls, split spoon sampler, GeoProbe^{TM} sampling spoon, etc.) will be thoroughly cleaned. Decontamination of all sampling equipment will be accomplished prior to and between sampling locations. The decontamination procedure is briefly summarized below.

Sampling equipment to be used at the site will be divided into one of two categories:

1. Equipment that does not contact the sample
2. Equipment that does contact the sample

Procedures for Non-Sample Contacting Equipment

a) Physically remove gross contamination.

b) Clean with portable power washer, steam cleaning machine or dedicated pressurized sprayer *or* hand wash with brush using detergent solution.

c) Rinse with control water, such as tap water that has not been recycled.

Procedures for Sample Contacting Equipment

a) Physically remove gross contamination.

b) Wash with non-phosphate detergent and brush made of inert material. [Note: For equipment that cannot be disassembled for cleaning (e.g., tubing), circulate decontamination liquid through the equipment.]

c) Rinse with tap water.

d) Rinse with inorganic desorbing agent (applicable only when analyzing for inorganics).

e) Rinse with tap water.

f) Rinse with organic desorbing agent rinse (applicable only when analyzing for organics).

g) Rinse with deionized water.

h) Let equipment air dry.

i) Wrap equipment in inert material (e.g., aluminum foil or plastic wrap) for transport, to prevent contact with potentially contaminated materials.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Sample collection and analysis of decontamination waste may be required before beginning proper disposal of decontamination liquids and solids generated at a site. The amount of sample to be collected and the proper sample container type (i.e., glass, plastic), chemical preservation, and storage requirements should be determined prior to initiation of site activities. As part of the development of the project specific Site Assessment Work Plan (SAWP) or Sampling and Analysis Plan (SAP; hereafter, both SAWP and SAP are collectively referred to as SAWP), decontamination waste sampling procedures should be determined and then incorporated into the SAWP. Parameters to be sampled will be dependent upon the matrix being sampled and the requirements of the disposal facility.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The use of an untreated potable water supply is not an acceptable substitute for tap water. The use of deionized water commonly available from commercial vendors should generally be acceptable for decontamination of sampling equipment. If there is a concern that the water is not analyte free, then it can be verified by laboratory analysis. If acids or solvents are utilized in decontamination, they raise health and safety as well as waste disposal concerns. Care must be used when working with acids and organic solvents.

5.0 EQUIPMENT APPARATUS

Decontamination equipment, materials, and supplies are generally selected based on availability. Other considerations include the ease of decontaminating or disposing of the equipment. The following are some of the materials and equipment that are potentially needed for decontamination activities:

- Non-phosphate detergent (PFAS-free if sampling media for PFAS compounds)
- Organic and inorganic decontamination reagents, if required by site-specific SAWP
- Tap water (may not be appropriate if sampling for PFAS given the likelihood of cross-contamination, low detection levels and presence of PFAS in many public water systems)
- Deionized water
- Brushes (various assortment of sizes)
- Drop cloth/plastic sheeting made of inert (PFAS-free if sampling media for PFAS compounds) materials appropriate for the contaminants of concern
- Paper towels
- Wash and rinse containers (buckets)
- Portable power washer, steam cleaning machine or pressurized sprayers that have been appropriately pre-cleaned based on media and Contaminants of Potential Concern to be sampled
- Solvent sprayers
- Aluminum foil/plastic wrap
- Trowel
- Trash bags (trash bags may contain PFAS compounds and should be kept away from the sampling area/equipment if sampling for PFAS)
- Trash containers
- DOT approved 55-gallon drums
- Safety glasses
- Gloves
- Eyewash
- First aid kit

6.0 REAGENTS

Depending upon the project, a solvent rinse using organic or inorganic desorbing agent may be required. This shall be specified in the site-specific SAWP. In cases where the use of solvents is planned, the analytical laboratory performing the analysis shall be consulted prior to sampling to ensure that decontamination procedures do not affect the subsequent analysis. It is recommended that all solvent rinses be made from an appropriate grade of chemical, such as pesticide or purge-and-trap grade quality.

7.0 PROCEDURES

These procedures are intended as general procedures to be followed for decontamination of field sampling equipment. The site-specific SAWP should be referred to for any given project in order to establish what portions of these procedures are applicable to the project. It is always recommended that procedures be established in the site-specific SAWP to minimize the potential for contamination. Such procedures may include the following:

- Work practices that minimize contact with potential contaminants
- All food and beverages stored and consumed in designated areas far from the sample locations to minimize potential transfer to food (to prevent ingestion exposures) or to the sample (especially for PFAS sampling since many food wrappers and containers have PFAS coatings)
- Covering monitoring and sampling equipment with (PFAS-free, where applicable) plastic or other protective material
- Avoiding laying equipment down in areas of obvious or suspected contamination
- Use of disposable sampling equipment

7.1 Decontamination Methods

Various decontamination methods will physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both. In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

7.1.1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- Mechanical cleaning methods are brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.
- Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines

cleaning efficiency. This method generates a large amount of waste and is unlikely to be utilized on OER projects.

- Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste and is unlikely to be utilized on OER projects.

7.1.2 Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure. The following non-abrasive methods are available:

High-Pressure Water:	This method consists of a high-pressure pump, an operator controlled directional nozzle, and a high-pressure hose.
Low-Pressure Water:	This system produces a pressurized water jet with operating pressures less than 240 atm which relates to a flow rate less than 20 liters per minute. Because of the low pressure, this method is applicable for hand-held sampling equipment.

7.1.3 Disinfection/Rinse/Hand Removal Methods

Disinfection/ Sterilization:	Disinfectants are a practical means of inactivating infectious agents; sterilization methods involve heating the equipment which is impractical for large equipment. It is unlikely that these methods would be utilized on OER projects.
Rinsing:	In cases of gross soil/sediment contamination on hand-held sampling equipment, a tap water rinse/wash may first be performed to remove clumps of dirt in order to make the detergent wash more effective.
Hand Removal:	In cases of gross soil/sediment contamination on hand-held sampling equipment, dirt may be removed by hand (gloved) or using a trowel or similar device to remove clumps of dirt in order to make the detergent wash more effective.

7.2 Field Sampling Equipment Cleaning Procedures

If trace analysis for organics or metals is to be performed, then a solvent rinse for trace organics and an acid rinse for trace metals would be appropriate. If no trace analysis is planned, the solvent and acid rinses may be eliminated from the decontamination sequence specified below.

a) In cases of gross contamination, follow the most appropriate physical removal procedures specified in section 7.1.

b) Using a brush, wash equipment with soap (non-phosphate and PFAS-free) and water.

c) Rinse the equipment with tap water. Note that deionized water should be used instead of tap water if sampling for PFAS and the tap water has detectable PFAS in it. If contaminants are clearly present, wash the equipment again and rinse again with tap water. Repeat until contaminants are no longer clearly present.

d) Rinse with deionized water. A triple rinse with two rinses of tap water followed by a final rinse with deionized water is recommended. (If solvent or acid rinses are not necessary, then proceed to step i.)

e) If applicable, rinse with an inorganic desorbing agent if the samples will be analyzed for inorganics.

f) Rinse with deionized water.

g) Use an organic desorbing agent rinse, as appropriate, if the sample will be analyzed for organics.

h) Final rinse with deionized water.

i) Decontaminated equipment shall be dried or allowed to air dry on plastic sheeting in an area free of potential contaminants. When sampling for PFAS, the plastic sheeting must be HDPE or replaced with metal or certified PFAS-free material.

j) Wrap equipment in inert material (e.g., aluminum foil or plastic wrap) for transport. When sampling for PFAS, plastic wrap must be HDPE or certified PFAS-free material (note that aluminum foil is often lined with PFAS). Store decontaminated equipment in an area free of potential contaminants when it is not in use.

8.0 CALCULATIONS

There are no calculations associated with decontamination procedures. This section is not applicable to this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Decontamination of field sampling equipment is necessary when dedicated or non-disposable sampling equipment is utilized at a site. An equipment rinsate blank should be collected as part of the quality control associated with the field decontamination on non-disposable, dedicated sampling equipment. This sample will provide information on the effectiveness of the decontamination process in the field. Equipment rinsate blanks are samples obtained by running deionized water over the decontaminated sampling equipment after cleaning to test for residual contamination. The equipment rinsate water is collected in sample containers and handled exactly as any other samples from the site. One equipment rinsate blank should be collected per each day of field work or at least one for every 20 samples per decontamination method, whichever frequency is greater. An equipment rinsate blank is used to assess cross-contamination brought about by improper decontamination procedures.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered to when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training with 8 Hour refreshers as appropriate. Some level of personal protective equipment (PPE) is generally required for all sampling and decontamination activities. Note that PPE should be PFAS-free when sampling for PFAS at the site. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the site health and safety plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Note that handling of IDW containing PFAS compounds may require special attention to detail since PFAS regulations frequently change. Also note that tap water may be a source of PFAS in IDW. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA QA/G-6, US EPA, Office of Environmental Information, April 2007.

Sampling Equipment Decontamination, SOP# 2006, US EPA, Environmental Response Team, August 11, 1994.

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, August 2005, Update – April, 2011.

ASTM D5088-15a, *Standard Practice for Decontamination of Field Equipment Used at Waste Sites*, ASTM International, West Conshohocken, PA, 2015, www.astm.org.

Sampling Precautions and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS), Interstate Technology Regulatory Council (ITRC), 2023. https://pfas-1.itrcweb.org/wp-content/uploads/2023/10/Sampling_and_Lab_PFAS_Fact-Sheet_Sept2023_final.pdf.

US EPA, 2015, *Field Equipment Cleaning and Decontamination*; SESD PROC-205-R3, U.S. Environmental Protection Agency Region 4, Athens, GA, 18 pp.

PID/FID Field Screening

SOP OER-0101

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ruth Porter	0.0	8/2/2010	New SOP	Technical
Dave Long	1.0	9/21/2016	Revised PID Screening Procedures. Reformatted.	Editorial, Technical
Ross Brittain	2.0	11/10/2020	Revised Summary of Method and edited the document for grammatical errors.	Editorial, Technical
Ross Brittain	3.0	1/13/2025	Revised Screening Procedures to include Collocated Borings	Technical

PID/FID FIELD SCREENING

SOP OER-0101

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List of Acronyms and Abbreviations

eV	electronvolt
FID	Flame Ionization Detector
GC	Gas Chromatograph
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
ID	Identification
IDW	Investigation Derived Wasted
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PFAS	Per- and Polyfluoroalkyl Substances
PID	Photoionization Detector
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
UV	Ultraviolet light
VOC	Volatile Organic Compounds
WVDEP	West Virginia Department of Environmental Protection
XRF	X-Ray Fluorescence

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1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to describe the procedure for using a photoionization detector (PID) or flame ionization detector (FID) used for Office of Environmental Remediation (OER) projects within the West Virginia Department of Environmental Protection (WVDEP). The PID is a portable vapor/gas detector employing the principle of photoionization to detect a variety of chemical compounds. It is of particular use in identifying organic compounds, but can identify certain inorganic compounds such as chlorine, bromine, silicon, and sulfur. This procedure is a non-specific method applicable to field screening for organic compounds in surface and subsurface soils. The FID is also a portable vapor/gas detector that operates by burning samples in a hydrogen flame to ionize the gases.

2.0 SUMMARY OF METHOD

The PID is a useful field screening tool. A PID is capable of detecting and measuring real-time concentrations of many organic vapors and some inorganic vapors. The PID is unable to respond to certain low molecular weight hydrocarbons, such as methane and ethane. The PID works by employing the principle of photoionization. It will respond to most vapors that have an ionization potential less than or equal to that supplied by the ionization source. The ionization source is an ultraviolet (UV) lamp.

Photoionization occurs when an atom or molecule absorbs a photon of sufficient energy to release an electron and form a positive ion. This will occur when the ionization potential of the molecule in electron volts (eV) is less than the energy of the photon. The released electron and newly created positive ion are propelled toward electrodes, which produces a current that is proportional to the concentration of volatile organic compounds (VOCs) in the air sample. Several ionization sources are available for the PID, each having a different eV lamp and a different ionization potential. The selection of the appropriate ionization source is essential in obtaining useful data. Though it can be calibrated to a particular compound, the instrument cannot distinguish between detectable compounds in a mixture of gases. Therefore, the PID can only indicate an integrated response to the mixture; the primary use of the PID is as a semi-quantitative instrument for screening purposes.

By comparison, FID technology has the advantage of responding to all hydrocarbon gases including methane and has a wide measuring range. FIDs work by combusting samples to ionize the gases and generate an electrical current. The magnitude of the current is proportional to the concentration of organic vapors (e.g., hydrocarbons). In general, FIDs respond better to carbon chain length than functional groups. The disadvantage of FIDs is that they do not identify the type of hydrocarbons, should not be used in areas where there is a chance of explosion, and they respond poorly to highly halogenated hydrocarbon gases, ammonia, hydrogen sulfide, formaldehyde, amines, methanol and aromatic compounds. FIDs are less affected by humidity than are PIDs, but they can have problems in high humidity conditions by preventing the flame from igniting. Like PIDs, an FID is only used as a semi-quantitative instrument for screening purposes. Specific details for sampling at any location should be found in the Sampling and

Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

PIDs and FIDS are nonspecific total vapor detectors; therefore, they cannot be used to identify unknown substances. The PID does not respond to certain low molecular weight hydrocarbons, such as methane and ethane. The PID does not detect a compound if the probe has a lower energy than the compound's ionization potential. Certain toxic gases and vapors, such as carbon tetrachloride and hydrogen cyanide, have high ionization potentials and cannot be detected with a PID. Strong winds and high humidity will affect measurement readings. A PID may become unusable under foggy or humid conditions. The lamp window must be periodically cleaned to ensure ionization of the compounds by the probe. Pulling liquids or soil particulates into the probe will result in poor readings and can damage the instrument. Thus, a dust shield is recommended while using any probe. FIDs should not be used in areas where there is a chance of explosion since they have a flame that could ignite the explosive materials. While FIDs are less affected by humidity than PIDs, high humidity conditions may prevent the flame from igniting. FIDs respond poorly to highly halogenated hydrocarbon gases, ammonia, hydrogen sulfide, formaldehyde, amines, methanol and aromatic compounds.

5.0 EQUIPMENT APPARATUS

The following are some of the materials and equipment that are potentially needed for soil screening activities using the PID. Refer to the site SAWP to determine specific needs for any given project.

- PID/FID
- Calibration equipment and gases (isobutylene)
- Quart or gallon zip-locking baggies (Note that some brands of baggies can produce elevated PID readings after sitting in the sun for a brief period. The baggies should be pre-screened with a PID to determine if they may be the source of vapors when screening soils. Note also that baggies may contain PFAS and some PFAS are volatile. Use certified PFAS-free baggies if sampling PFAS.)
- Field logbook, field data sheets and samples labels
- Pails, tubs, or buckets (certified PFAS-free if sampling PFAS)
- Plastic sheeting (certified PFAS-free if sampling PFAS)
- Sampling gloves
- Methanol
- Light source cleaning compound

- Mild, non-phosphate soap

6.0 REAGENTS

The following reagents may be needed when using a PID/FID for field screening purposes:

- Isobutylene standards for calibration
- Methanol for cleaning ionization chamber (GC grade)
- Mild soap solution for cleaning unit surfaces
- Specific gas standards when calibrating to a specific compound (as applicable)
- Light source cleaning compound (PID), or jet cleaning compound or replacements (FID)

7.0 PROCEDURES

The following procedures are applicable for field screening of organic compounds utilizing a PID/FID:

7.1 Standard Screening

a) Conduct a fresh air calibration and multi-sensor span calibration on the instrument daily in accordance with manufacturer specifications before any headspace readings are performed. Re-calibrate the instrument throughout the day as needed.

b) Place the portion of soil sample to be screened from no more than 12-inch intervals inside a clean zip-locking baggie and then seal the baggie. Fill the baggie at least 1/3 full (no more than ½ full) if sufficient sample is available and be sure to use the same size baggie and same relative proportion of soil for each sample in order to be consistent with the amount of headspace for appropriate comparisons.

c) After the baggie has been sealed, knead the soil sample to thoroughly mix the soil within the baggie and maximize potential volatilization.

d) Allow the baggie to set for no more than ten minutes prior to taking a reading. *Note: If the ambient temperature is below 60° F, headspace analysis shall be conducted in a heated environment (i.e., inside a building or vehicle).*

e) Carefully open a corner of the zip-locking baggie and insert the probe tip of the PID/FID, being careful not to fully open the baggie to minimize loss of vapors. Once the probe tip has been inserted use a clip or clean fingers to pinch and seal the baggie against the probe to prevent loss of vapors. *Note: Care shall be taken to ensure that neither water droplets nor soil particulates enter the probe tip.*

f) The highest meter response shall be recorded as the volatile organic vapor concentration. This usually occurs within a few seconds. Some samples may continue to climb by small increments over time and never stabilize, potentially due to releases from the baggie instead of the soil sample. For this reason, there should be a pre-determined set time limit used for each screening sample at a site, such as recording the highest PID/FID reading within 30 seconds or 60 seconds, but for no less than ten seconds.

g) After withdrawing the probe, allow sufficient time for the PID/FID readings to return to zero before screening the next sample.

h) All headspace analysis shall be completed at an equivalent time period between 8-10 minutes for specific samples.

i) Record the PID/FID readings in the field logbook along with other sampling information such as:

  - Sample ID
  - Location
  - Depth of sample
  - Soil type description
  - Equipment used
  - Apparent moisture content (i.e., dry, moist, wet)
  - Color
  - Staining
  - Odor
  - Any other pertinent information (e.g., date, time and name of sampler)

7.2 Direct-Push Core Liner

Another option for screening soils collected via direct-push methods (e.g., Geoprobe^{TM}) is to use the method in *ASTM D4547-15 X3.1.2 Direct Subsurface Soil Sampling Technique Using a Cutting Tool* to collect the soil cores leaving them within the acetate liner and drilling holes through the liner to expose a portion of the soils (Sorini et al. 2009), but with a slight modification to the screening protocol. Note that Geoprobe^{TM} core liners are PFAS-free (https://geoprobe.com/articles/geoprobe-pvc-liners-tested-nondetect-52-pfas-compounds) but other liner brands may not be PFAS-free. Be sure to use PFAS-free core liners when sampling for PFAS to prevent cross-contamination.

a. The core liner is brought to the surface and placed in a metal rack for sub-sampling. Care should be taken to ensure that the air around and over the core liner is still, such as the use of shielding or being inside a structure or vehicle.
b. A cutting tool (e.g., drill bit) powered by a portable drill is used to cut circular screening holes in the liner at 12-inch intervals. The diameter of the circle is the dimension required for easy insertion of the hand-operated coring device to be inserted into the hole for sample collection (e.g., En Core®) and/or the PID/FID probe tip. Any portion of the liner that is not completely filled with soil should not be screened or sampled. Additionally, a small amount of cuttings may be generated, but will typically accumulate away from the soil core.
c. As each hole is cut, the exposed soil should be dug out with a stainless-steel tool to remove any potential cuttings and smeared soils to create a hole about 1-inch deep.

d. The tip of the PID/FID should be inserted into the hole immediately after it is dug, being careful not to touch the probe tip to any exposed soils. A vapor reading should be taken with the PID/FID and the highest value within ~15 seconds should be recorded.
e. The 12-inch section with the highest PID/FID reading will then be sampled for laboratory analysis by drilling another hole next to the screening hole and collecting samples using Method 5035 and placing them on ice at < 6°C without freezing. Be sure to expose a fresh area of the soil core before collecting the sample to make sure that smeared soils were not collected.
f. Once the VOC soil samples have been collected, the liner may be cut horizontally and removed to proceed with XRF screening, if applicable, soil core logging and sample collection in accordance with the SAWP. OER recognizes that this method may be more likely to select the inappropriate 12-inch sample interval or generate false negatives during the field screening procedures, but it should reduce the amount of IDW generated and the chances of false negatives should be minimal.

7.3 Collocated Borings

A third option is to collocate borings where an initial boring is used only for field screening and logging of subsurface conditions.

a. Collect a screening boring and screen the entire length of the boring in no more than 12-inch intervals to determine the sample depths for lab analysis based on PID/FID readings using standard screening methods above.
b. Collect a second boring to the desired sample depths at a location immediately adjacent to the first boring (less than 18" apart, preferably within 12") and collect the necessary samples from this second, undisturbed core.
c. Expose a fresh area of both soil cores to prevent collection of smeared soils.

Note: Soil samples collected for field soil screening may not be used for laboratory analysis. Separate soil samples must be collected according to the soil sampling protocols above and/or outlined in the site-specific SAWP.

8.0 CALCULATIONS

No calculations are applicable to this SOP. The PID/FID is a direct reading instrument.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

There are no specific quality assurance activities which apply to these procedures. However, the following general QA/QC procedures do apply:

- All data must be documented on field data sheets and/or in field logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the SAWP.

- Equipment calibration activities must be documented and must occur prior to beginning sampling operations. Performance checks on the PID/FID should occur throughout the course of a day, and recalibration should be performed as needed.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered to when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. Note that PPE should be PFAS-free when sampling for PFAS at the site. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Note that handling of IDW containing PFAS compounds may require special attention to detail since PFAS regulations frequently change. Also note that tap water may be a source of PFAS in IDW. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

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XRF Field Screening

SOP OER-0102

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ruth Porter	0.0	8/3/2010	New SOP	Technical
Ross Brittain	1.0	11/10/2020	Edited grammatical mistakes and clarified sampling procedures.	Editorial, Technical
Ross Brittain	1.1	2/28/2022	Edited to correct the sieve size	Editorial
Ross Brittain	1.2	1/13/2025	Edited to account for drying the soil samples	Technical

XRF FIELD SCREENING

SOP OER-0102

Table of Contents

List of Acronyms and Abbreviations

HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDW	Investigation Derived Wasted
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
WVDEP	West Virginia Department of Environmental Protection
XRF	X-Ray Fluorescence

Disclaimer: Any mention in this SOP of any products or services does not constitute or imply the endorsement, recommendation or favoring by WVDEP or any of its employees or contractors acting on its behalf.

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) is applicable to field screening of a variety of metals in surface and subsurface soils used for Office of Environmental Remediation (OER) projects within the West Virginia Department of Environmental Protection (WVDEP). This is a field screening method used for profiling an area, locating sources of contamination, determining the horizontal and vertical extent of contamination, collecting preliminary data that may be used to design a sampling plan and/or verifying that remedial activities have been successful.

X-Ray Fluorescence Spectroscopy (XRF) is a nondestructive qualitative and quantitative analytical technique used to determine the elemental composition of samples. Primary X-rays are emitted from a sealed radioisotope source and are utilized to irradiate samples. In the samples, radiation knocks out an electron from the innermost shell of an atom. The atom is excited and releases its surplus energy almost instantly by filling the vacancy created with an electron from one of the higher energy shells. This rearrangement of electrons is associated with emission of X-rays characteristic of the given atom and represents an emission of fluorescent X-rays. Energies of the characteristic, fluorescent X-rays are converted within the detector into electric pulses, the amplitudes of which are linearly proportional to the energy. An electronic analyzer measures the pulse amplitudes which are the basis of a qualitative X-ray analysis. The number of equivalent counts at a given energy is representative of element concentration in a sample basis for quantitative analysis.

2.0 SUMMARY OF METHOD

Testing of samples may be done in-situ, in plastic bags with minimal preparation, or in plastic bags or the XRF cup with more extensive sample preparation. If the primary objective of the sampling event is to determine whether an element is present, then in-situ or bagged samples with little preparation would be the quickest and simplest way to proceed. If measuring accuracy of the concentration of metal(s) present is the primary objective, then additional preparation of the sample is recommended. Precision and accuracy between samples is best achieved with prepared homogenous samples. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Generally, the instrument precision is the least significant source of error in XRF analysis. User or application related error is the most significant source of error. Following are some of the components of user or application related errors.

4.1 Sample Placement

This is a potential source of error since the X-ray signal decreases as the distance from the radioactive source increases. This type of error can be minimized by maintaining the same sample distance from the source. This SOP allows for the use of a thin plastic wrap (like Saran Wrap) that can be placed between the soil and the analyzer window to keep the window clean. This has little, if any, effect on the distance from the sample to the radioactive source; therefore, it does not cause a potential source of error due to sample placement issues. However, for a few elements (namely Chromium, Vanadium, and Barium) testing through thin plastic may result in lower readings (~ 20%) for these elements.

4.2 Representative Nature of Samples

Heterogeneous samples can be a major source of error. This error can be minimized by either homogenizing a large volume of sample prior to analyzing an aliquot, or by analyzing several samples (in-situ) at each sampling point and then averaging the results.

4.3 Chemical Matrix Effects

Chemical matrix effects result from differences in concentrations of interfering elements. These effects appear as either spectral interferences (peak overlaps) or as X-ray absorption/enhancement phenomena. Both effects are common in soils contaminated with heavy metals. For example, Fe (iron) tends to absorb Cu (copper), reducing the intensity of Cu measured by the detector. Measuring As (arsenic) concentrations also has known interference issues in the presence of high concentrations of lead due to spectral peak overlap, but many of the newer XRF models have built correction factors for As in the presence of Pb (lead) to help account for this interference, although they are imperfect corrections.

4.4 Physical Matrix Effects

Physical matrix effects are the result of variations in the physical character of the sample. They may include such parameters as particle size, uniformity, homogeneity and surface condition.

4.5 Moisture Content

The overall error from moisture may be a minor source of error when the moisture range is small (5-10%) or may be a major source of error when measuring on the surface of soils that are saturated with water (Endriss et al. 2024). Analyses conducted to accurately determine metal concentrations in soil should be done with soils that have been homogenized and dried.

5.0 EQUIPMENT APPARATUS

The following are some of the materials and equipment that are potentially needed for soil screening activities using the XRF. Refer to the site SAWP to determine specific needs for any given project.

- XRF
- Batteries and chargers
- Standardization clip
- Sieves
- Plastic bags
- Clear thin plastic sandwich “baggies”
- Clear polyvinylidene chloride (plastic) wrap
- Mortar and pestle
- Sample test stand, if desired
- Logbook
- Field data sheets and samples labels
- Pails, tubs, or buckets (certified PFAS-free if sampling PFAS)
- Plastic sheeting
- Sampling gloves

6.0 REAGENTS

Standardization of the XRF is performed utilizing the metal standardization clip; therefore, reagents are not generally used for site screening using the XRF. Reagents associated with decontamination of sampling equipment may be applicable if samples are not analyzed “in-situ”. Refer to SOP OER-0100 for general decontamination procedures for non-disposable sampling equipment.

7.0 PROCEDURES

7.1 General Procedures

a) Install a fully charged battery in the instrument, or fully charge the instrument as applicable.

b) Follow manufacturer’s instructions to turn on the XRF unit.

c) Choose the soil test mode and perform a standardization/calibration test, as applicable.

d) As necessary, prepare the instrument for analyzing samples by following the manufacturer’s instructions.

7.2 In-Situ Analysis

These procedures are applicable for analysis of surface soils and can be used for vertical profiling of acetate sleeves retrieved by direct push technology.

a) Complete the procedures outlined in the General Procedures Section.

b) Clear the area selected for analysis of any surface debris or vegetation. Level the area so the XRF sample window will contact the area evenly. If desired, a clear thin polyvinylidene chloride plastic wrap (like Saran Wrap) can be placed between the soil and the analyzer window to keep the window clean. (*Note: Except for a few elements (namely Chromium, Vanadium, and Barium) testing through the thin plastic has little effect on the test results. Results for chromium, vanadium, and barium may be 20 to 30% lower.*)

c) Hold the XRF against the sample. Make sure the sample is as flush against the analyzing window as is possible. Conduct the test according to the manufacturer's instructions.

d) Collect as many samples as needed for the project.

7.3 Bagged Soil Sample Testing

a) A soil sample is collected in a clear thin plastic bag (i.e. a "baggie"). It is recommended that at least 100 grams of soil are placed in the baggie, and when possible, the soils should be dried beforehand for greater accuracy. A thickness of at least 0.5 inches of soil in the bag is recommended when conducting the test.

b) When placing soil in the baggie, remove vegetation, debris, and rocks from the soil to the extent practical. Mix the soil in the baggie to homogenize it. If greater accuracy is desired, dry soil may be passed through a #10 (~2 mm) sieve to better homogenize it. A mortar and pestle may be used to break the soil into smaller particles to ease its passage through the sieve and to provide better accuracy. If wet soil is encountered, using a sieve is not an option in the field unless a method to dry the soil can be found, such as electric drying ovens. Note that analyses with wet soils are biased low and results should be used with caution. Under no circumstances should wood-fired ovens or smokers be used to dry the soils.

c) Hold the XRF to the sample. Make sure the sample is as flush against the analyzing window as is possible. Conduct the test according to the manufacturer's instructions.

8.0 CALCULATIONS

No calculations are applicable to this SOP. The XRF is a direct reading instrument.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

The analysis of soils by XRF should be considered as a screening tool. Data derived from the instrument should be used with discretion. The following general QA/QC procedures apply:

- All data must be documented on field data sheets, in field logbooks, and/or downloaded to a computer.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the SAWP.
- Equipment calibration activities must be documented and must occur prior to beginning sampling operations. Performance checks on the XRF should be performed throughout the course of a day, and re-standardization of the instrument should be performed as needed.
- Confirmation samples should be collected at a rate established in the SAWP and sent to a laboratory for analysis. Typically, confirmation samples will be 10% of the total samples to meet OER requirements but may be a lower percentage on sites with numerous samples to save money. In order to properly perform a comparative analysis of the field screening method with the lab data, it is important to send the soil to the lab that was actually field screened due to the potential problems noted in Section 4.0 of this SOP.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

Confirmation samples are recommended at a minimum rate of 10%. Ideally, the sample that was analyzed by XRF should be the same sample that is sent for laboratory analysis. When confirming an in-situ analysis, collect a sample from a six-inch-by-six-inch area and a depth of at least one-half-inch for both an XRF measurement and confirmation analysis.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the hazards associated with soil sampling and the use of the XRF for environmental analysis:

- Exposure to unknown contaminants.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE.
- Slips, trips, and fall hazards.
- The XRF has an x-ray radiation source and potentially additional sources of radiation. The XRF should not be pointed at anyone or any body part, whether energized or de-energized. A radiation dosimeter or radiation meter may be necessary to provide adequate safety for personnel using the XRF.
- Ensure that the proper batteries are placed in the instrument. There is a danger of explosion if improper substitution of batteries is made.
- Biohazards, such as snakes, biting insects and poison ivy.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

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Groundwater Well Sampling Procedures

SOP OER-0110

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ruth Porter	1.0	7/1/2010	Reformatted, added SOP ID #, and renumbered. Supersedes Revision 0.0. Additional detail provided.	Editorial Technical
Dave Long	2.0	9/21/2016	Revised procedures. Reformatted	Editorial, Technical
Ross Brittain	3.0	11/10/2020	Edited grammatical issues, clarified details and changed it to XRF instruments in general.	Editorial, Technical
Ross Brittain	4.0	1/13/2025	Edited to account for PFAS sampling methodology	Technical

GROUNDWATER WELL SAMPLING PROCEDURES

SOP OER-0110

Table of Contents

List of Acronyms and Abbreviations

DQO	Data Quality Objectives
FID	Flame Ionization Detector
FOM	Field Operations Manager
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
ID	Identification
IDW	Investigation Derived Wasted
NTU	Nephelometric Turbidity Unit
OER	Office of Environmental Remediation
ORP	Oxidation Reduction Potential
OSHA	Occupational Safety and Health Administration
PDBS	Passive Diffusion Bag Sampler
PFAS	Per- and Polyfluoroalkyl Substances
PID	Photoionization Detector
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
TOC	Top of Casing
USEPA	United States Environmental Protection Agency
WVDEP	West Virginia Department of Environmental Protection
VOC	Volatile Organic Compounds

Disclaimer: Any mention in this SOP of any products or services does not constitute or imply the endorsement, recommendation or favoring by WVDEP or any of its employees or contractors acting on its behalf.

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide general reference information on sampling of groundwater wells for projects in the Office of Environmental Remediation (OER) within the West Virginia Department of Environmental Protection (WVDEP). Groundwater samples provide data on groundwater quality and give an indication of the nature and extent of any groundwater contamination. Groundwater sampling procedures are generally split into two tasks, purging and sampling. Purging is the process of removing water from the monitoring well and sand pack prior to sampling and replacing it with adjacent groundwater from within the formation. This ensures that a more representative sample of the actual aquifer condition is collected. Every effort must be made to ensure that the sample is representative of the particular zone of water being sampled. These procedures are designed to be used in conjunction with analyses for the most common types of ground water contaminants (i.e., volatiles, semi-volatiles, and metals). These procedures may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. The procedures utilized at a site should be documented and included in the site investigation report.

2.0 SUMMARY OF METHOD

In order to obtain a representative groundwater sample for chemical analysis, it is important to either purge water from the monitoring well or take steps to ensure that only water meeting the data quality objectives (DQO's) and work plan objectives is removed from the well during sampling. Purging is generally performed by removing a pre-determined number of well volumes (well-volume purging), or by removing groundwater until water quality parameters have stabilized. Purging is conducted to remove stagnant water in the well casing and/or immediately adjacent to the well screen before collecting the sample. This may be achieved in a variety of ways. Commonly used methods include but are not limited to the use of bailers and pumps. When utilizing pumps, low flow (or low stress) purging/sampling is recommended. Low flow purging/sampling is also highly recommended when sampling for volatile organic compounds (VOC's) and metals. Due to agitation, the tendency to mix formation water with stagnant water above the well screen, and the tendency to stir up fines in the bottom of the well, purging and sampling with a bailer should only be conducted as a last resort. Data is collected under the OER programs to delineate the extent of contamination from sites and to formulate remedial actions utilizing risk-based standards; therefore, a high level of data accuracy and validation is required for these programs. As such, groundwater data collected for volatile organic compounds (VOC's) and metals analysis utilizing bailers for purging and sampling may not be accepted in these programs. Note that passive sampling, minimal purge and no-purge methods do not attempt to purge the stagnant water in the well prior to sampling.

The primary method of sampling groundwater is to use low-flow sampling. However, low-flow sampling may not be possible or appropriate in low-yielding wells, in which case the well volume should be purged before sampling. When purging, monitoring wells should be purged, at a minimum, the equivalent of three times the well volume of standing water or they should continue to be purged until parameters outlined in Section 7 of this SOP are. For well-volume purging, the volume of water present in each well shall be computed based on the length of water column and well casing diameter. Once purging is completed, sampling may proceed. Care should be taken when choosing the sampling device as some will affect the integrity of the sample, depending on the analytical parameters of interest. If information about the contaminant levels in a well is known, then sampling should be performed in a progression from the least to most contaminated well. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The type of sample container, the preservative, holding time, and filtering requirements are all dependent upon the type of analysis to be performed upon the sample. This information should be clearly set forth in the SAWP for the site. The sampler should consult the SAWP for all pertinent information relating to the proper sample preservation, type of containers, handling, and storage procedures for their project. A pair of clean, new, non-powdered disposable gloves shall be worn each time a different location is sampled to prevent cross-contamination. Samples should be collected directly from the sampling device (i.e. bailer or pump) into appropriate laboratory cleaned containers without making contact with the sampling device. Samples shall be appropriately preserved, labeled, and placed in a cooler to be maintained at ≤6ºC, but without freezing the sample, in accordance with the SAWP and *QAPrP* requirements. The samples should be shipped with adequate packing and cooling to ensure that they arrive at the laboratory intact and still ≤6ºC without freezing. Refer to Table 2 of the OER *QAPrP* for information on sample containers, preservation, and holding times for common contaminants.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 General

The goal is to obtain a representative sample of the groundwater. Proper field sampling techniques need to be utilized in order to ensure that a representative sample is collected, and the sampler does not compromise the sample through their actions. Analysis can be compromised by field personnel in three primary ways: by taking an unrepresentative sample, by incorrectly handling the sample, or by improperly labeling the sample. There are a variety of ways to introduce contaminants into a sample; that is why it is very important to follow sampling protocols.

4.2 Purging

Purging is generally conducted with the use of a pump or a bailer. Purging can introduce problems such as stirring up the water with corresponding increases in turbidity and conductivity along with total concentrations for metals. Another specific problem during purging is that the agitation of the water may lead to loss of VOCs and a low-biased sample. Two commonly recognized purging methods include the low-stress approach (utilized during low-flow sampling) and the well-volume approach. Low-stress purging prevents too much agitation during the purging process while the well-volume approach ensures that the water has not been removed too quickly such that the sampled water in the well has not properly equilibrated.

5.0 EQUIPMENT APPARATUS

The following are some of the materials and equipment that are potentially needed for groundwater well sampling activities:

- Water level indicator
- Photoionization detector (PID) and/or Flame Ionization Detector (FID)
- Logbook
- Calculator
- Field data sheets and sample labels
- Chain of custody records and seals
- Sample and shipping containers (certified PFAS-free containers, liners and caps if sampling PFAS)
- Preservatives, as applicable
- Pails, tubs, or buckets (certified PFAS-free if sampling PFAS)
- Plastic sheeting (certified PFAS-free if sampling PFAS)
- Packing materials and Ziploc® plastic bags (other brands of baggies can be used but must be certified PFAS-free if sampling PFAS)
- Decontamination solutions (i.e., tap water, non-phosphate soap, deionized water)
- Brushes
- Clean, decontaminated or new unused bailers
- Nylon line, enough to dedicate to each well (certified PFAS-free or cotton strings if sampling PFAS)
- In-line filters, 0.45 microns (µm), typically for sampling dissolved metals
- Water quality meter (e.g., YSI)
- 55-gallon drums for storage of purged groundwater
- Paper towels
- Personal protective equipment (PPE) (certified PFAS-free if sampling PFAS)
- Pump
- Clean and unused polyethylene tubing (certified PFAS-free if sampling PFAS)
- High-density polyethylene, polypropylene, silicone, or other tubing material approved for PFAS sampling.

6.0 REAGENTS

Reagents may be utilized for preservation of samples and for decontamination of sampling equipment. Refer to the SOP for the decontamination procedures and required reagents. Refer to the site-specific SAWP for the preservatives required for the specified analysis to be performed.

7.0 PROCEDURES

7.1 General Procedures

The following general procedures are applicable to all well sampling events.

a) Place plastic sheeting on the ground in the vicinity of the well to ensure that sampling equipment does not contact the ground surface.

b) Remove the well cap and check for volatile organics in the headspace using a PID/FID, if applicable. If concentrations are detected in the headspace above the action levels established in the Site Health and Safety Plan, appropriate personal protective equipment will be required.

c) If water (e.g. from precipitation) is present inside the well vault, ensure that the water level is significantly below the top of casing before removing the well cap/plug. If the water level is at or above the well casing elevation, decant the water until it is significantly below the well cap elevation.

d) Water-level measurement will be made using an electronic water level meter capable of measuring water levels to the nearest 0.01 foot.

e) Typically, all depth measurements should be made from the top (the highest point) of the inner well casing (top-of-casing, TOC), also known as the well riser; this point may also be marked on the outside of the well riser to ensure continuity of measurements and should be checked for before assuming a reference point. The reference point location should be described in the field logbook and should be used in all subsequent sampling efforts. Check for well damage at each well that could indicate a shift in the reference point. Lower the water-level measurement tape and gauge the depth to water and total depth of the well. Care should be taken to assure that the water-level measurement device hangs freely in the monitoring well and is not adhering to the wall of the well casing. Take replicate measurements (at least 3) in each well to ensure accuracy. Record water level data in the field logbook. The water level meter should be left in the well during low-flow purging and sampling.

f) As necessary (depending on the purging/sampling approach), determine the well volume using one of the formulas in Section 8.0 of this SOP. If more than 24 hours have passed since water levels were measured, re-gauge and record the static water level prior to purging.

7.2 Peristaltic Pump (Low Flow Sampling)

(Note that USEPA does not recommend using peristaltic pumps for VOC samples.)

a. Utilizing a water-level meter, find the depth to water. If water is above the screen interval, the tubing should be set at the middle of the screen; however, if the water level is below the top of the screen, the tubing should be set in the middle of the water column.

b. Lower tubing to the appropriate depth. If tubing coils, brass or stainless-steel weights can be added to the bottom of the tubing, capped by a small piece of silicon tubing. At the surface, tubing should connect to silicon tubing, which is placed within the peristaltic apparatus. Additional tubing is connected to the outflow side of the apparatus, which is then joined to the intake of the flow-thru cell. The flow-thru cell's output should connect directly into a waste-water receptacle.

c. Record the location of the tubing intake (feet below TOC) so that future sampling will occur at the same depth interval.

d. Start the pump at the lowest possible flow setting. Increase the pump rate gradually until a continuous flow is achieved from the discharge tubing. The discharge rate of the pump can be determined by using a graduated cylinder and a stopwatch. Record the flow rate in milliliters per minute. Pumping rates should be kept at minimal flow to ensure minimal drawdown in the monitoring well. The flow rate should be maintained between 100 mL/min and 500 mL/min (0.03-0.13 gal/min), or between 100 mL/min and 300 mL/min (0.03-0.08 gal/min) for VOC sampling, throughout the purging and sampling activities. Flow rates achieved during the purging period should also be maintained throughout the sampling period.

e. When a stable purge rate has been established (i.e., pumping rate is equal to or less than well recharge rate), begin recording water quality readings at a frequency of every three to five minutes. Note that total drawdown should not exceed 4 inches.

f. Continue to purge the well until water quality parameters have stabilized within the following stabilization criteria over three consecutive readings. Generally, the water quality parameters should stabilize within an hour or approximately three well volumes. Any issues with parameter stabilization (e.g., pumping rate exceeding the recharge rate or excessive time) should be addressed on a case-by-case basis between the FOM, site Project Manager and the WVDEP Project Manager. Options to address the parameter stabilization issue should include changing purge methods (e.g., water extraction method) or sampling methods (e.g., Passive Diffusion Bags), as applicable. Record the purging and sampling data in the field logbook.

Parameter	Criteria
Water level drawdown	<0.3 feet
pH	+/- 0.1 standard units
Conductivity	+/- 3% of readings
Temperature	+/- 3% of readings
Dissolved Oxygen	+/- 0.3 mg/L or 3% of readings, whichever is greater
Turbidity	+/- 10% of readings for values greater than 1 nephelometric turbidity unit (NTU)
Eh/ORP	+/- 10 millivolts

g. Once the water quality parameters have stabilized, collect the ground water sample by detaching the tubing from the flow-through cell. Under no circumstances should the ground water sample be collected from the flow-through cell discharge stream. Collect the samples in the following order, as applicable for the site:

  - i. Volatile organic compounds (Ensure that volatiles are immediately capped and have no headspace by inverting the vial, tapping gently and waiting at least 10 seconds. If an air bubble appears, unscrew the cap and pop the bubble or refill with more sample and re-seal the vial. Do not collect a sample with air trapped in the vial.)
  - ii. Semi-volatile organic compounds
  - iii. Nitroaromatics
  - iv. Herbicides/pesticides
  - v. Metals (see section h below)
  - vi. All other parameters, including PFAS

h. Samples for total metals analysis, if applicable, should be collected prior to sampling for dissolved metals. To collect samples for dissolved metals analysis, a 0.45µm filter should be added to the discharge line. Samples for dissolved metals analysis should be collected after 500 mL of water has passed through the in-line filter. Discard the filter following collection of samples for dissolved metals.

i. Preserve and filter according to the requirements set forth in the site-specific SAWP. Label the sample containers using indelible pen, attach a chain-of-custody seal to each container lid, place the containers in plastic bags, and place them on ice in a cooler. Record sample collection date and time. Handle and store samples in accordance with the approved *QAPrP* and/or SAWP.

j. Remove the water level meter (if not already removed) and then the pump from the monitoring well. Decontaminate the pump and dispose of the tubing if it is non-dedicated to the well. Protect equipment from contamination by storing on plastic sheeting.

k. Close and lock the well.

l. Record the following information in the field logbook:

  - Sample ID
  - Location
  - Purging and sampling data
  - Color
  - Odor
  - Field screening instrument readings, if applicable
  - Any other pertinent information (e.g., date, time and sampler)

7.3 **Submersible Pump (Low Flow Sampling)** *(Recommended pump type for low flow sampling for VOCs)*

a) Connect the pump tubing to the flow-through cell and connect the multi-parameter probe to the cell. Connect the discharge from the flow-through cell to a purge water drum (or temporarily to a bucket that will subsequently be placed into a drum) for later IDW disposal. Keep the flow-through cell out of direct sunlight.

b) Lower the pump slowly in the well to minimize the disturbance of the water column.

  - Do not let the pump, tubing, electrical cords, and support cable touch the ground as you are lowering the pump into place.
  - Secure the pump at the desired depth using the support cable. The entire pump and tubing assembly should be supported by a stainless steel or Teflon coated cable. It is not advisable to use the tubing to support the pump.
  - Place the pump intake as close to the middle of the screened interval for wells with water levels above the top of the screen. For wells with water levels below the top of the screen, the pump should be set near the top of the water column and slowly lowered, being careful not to expose the screen to air, until the pump is placed in the middle (or just below the middle) of the water column.
  - The pump or water level probe should not be allowed to hit the bottom of the well before or during sampling because it will disturb sediment. It should be noted that at least three feet of water is needed to implement low flow sampling.

c) Record the location of the pump intake (feet below TOC) so that future sampling will occur at the same depth interval.

d) Start the pump at the lowest possible flow setting. Increase the pump rate gradually until a continuous flow is achieved from the discharge tubing. The discharge rate of the pump can be determined by using a graduated cylinder and a stopwatch. Record the flow rate in gallons per minute. Pumping rates should be kept at minimal flow to ensure minimal drawdown in the monitoring well. The flow rate should be maintained between 100 mL/min and 500 mL/min (0.03-0.13 gal/min), or between 100 mL/min and 300 mL/min (0.03-0.08 gal/min) for VOC sampling, throughout the purging and sampling activities. Flow rates achieved during the purging period should also be maintained throughout the sampling period.

e) When a stable purge rate has been established (i.e., pumping rate is equal to or less than well recharge rate), begin recording water quality readings at a frequency of every three to five minutes. Note that total drawdown should not exceed 4 inches.

f) Continue to purge the well until the water quality parameters have stabilized within the following stabilization criteria over three consecutive readings. Generally, the water quality parameters should stabilize within an hour or approximately three well volumes. Any issues with parameter stabilization (e.g., pumping rate exceeding the recharge rate or excessive time) should be addressed on a case-by-case basis between the FOM, site Project Manager and the WVDEP Project Manager. Options to address the parameter stabilization issue should include changing purge methods (e.g., water extraction method) or sampling methods (e.g., Passive Diffusion Bags), as applicable. Record the purging and sampling data in the field logbook.

Parameter	Criteria
Water level drawdown	<0.3 feet
pH	+/- 0.1 standard units
Conductivity	+/- 3% of readings
Temperature	+/- 3% of readings
Dissolved Oxygen	+/- 0.3 mg/L or 3% of readings, whichever is greater
Turbidity	+/- 10% of readings for values greater than 1 nephelometric turbidity unit (NTU)
Eh/ORP	+/- 10 millivolts

g) Once the water quality parameters have stabilized, collect the ground water sample by detaching the tubing from the flow-through cell. Under no circumstances should the ground water sample be collected from the flow-through cell discharge stream. Collect the samples in the following order, as applicable for the site:

   i. Volatile organic compounds (Ensure that volatiles are immediately capped and have no headspace by inverting the vial, tapping gently and waiting at least 10 seconds. If an air bubble appears, unscrew the cap and pop the bubble or refill with more sample and re-seal the vial. Do not collect a sample with air trapped in the vial.)
   ii. Semi-volatile organic compounds
   iii. Nitroaromatics
   iv. Herbicides/pesticides
   v. Metals (see section h below)
   vi. All other parameters, including PFAS

h) Samples for total metals analysis should be collected prior to sampling for dissolved metals. To collect samples for dissolved metals analysis, a 0.45µm filter should be added to the discharge line. Samples for dissolved metals analysis should be collected after 500 mL of water has passed through the in-line filter. Discard the filter following collection of samples for dissolved metals.

i) Preserve and filter according to the requirements set forth in the site-specific SAWP. Label the sample containers using indelible pen, attach a chain-of-custody seal to each container lid, place the containers in plastic bags, and place them on ice in a cooler. Record sample collection date and time. Handle and store samples in accordance with the approved *QAPrP* and/or SAWP.

j) Remove the water level meter (if not already removed) and then the pump from the monitoring well. Decontaminate the pump and dispose of the tubing if it is non-dedicated to the well. Protect equipment from contamination by storing on plastic sheeting.

k) Close and lock the well.

l) Record the following information in the field logbook:

- Sample ID
- Location
- Purging and sampling data
- Color
- Odor
- Field screening instrument readings, if applicable
- Any other pertinent information (e.g., date, time and sampler)

7.4 Bailer Method

[As noted above, bailers are not recommended for most purging/sampling situations, other than in low-permeability formations (see below). If bailers are to be used, justification must be provided in the SAWP.]

a) Purge the well by manually bailing until a minimum of three well volumes have been removed and water quality parameters have stabilized within the following stabilization criteria over three consecutive readings. Record the purging and sampling data in the field logbook.

Parameter	Criteria
pH	+/- 0.1 standard units
Conductivity	+/- 3% of readings
Temperature	+/- 3% of readings
Dissolved Oxygen	+/- 0.3 mg/L or 3% of readings, whichever is greater
Turbidity	+/- 10% of readings for values greater than 1 nephelometric turbidity unit (NTU)
Eh/ORP	+/- 10 millivolts

b) Lower bailer slowly and gently into well, do not drop or splash bailer into the water column. Stop lowering at desired point adjacent to well screen. Withdraw a sample from the well, transfer the sample from the bailer directly into sample containers. Preserve and filter according to the requirements set forth in the site-specific SAWP.

c) Collect the samples in the following order, as applicable for the site:

   i. Volatile organic compounds (Ensure that volatiles are immediately capped and have no headspace by inverting the vial, tapping gently and waiting at least 10 seconds. If an air bubble appears, unscrew the cap and pop the bubble or refill with more sample and re-seal the vial. Do not collect a sample with air trapped in the vial.)

   ii. Semi-volatile organic compounds

   iii. Nitroaromatics

   iv. Herbicides/pesticides

    v. Metals (see section d below)
    vi. All other parameters, including PFAS

d) To collect samples for dissolved metals analysis, a 0.45µm filter should be attached to a syringe (or other device to force water through the filter). Samples for dissolved metals analysis should be collected after 500 mL of water has passed through the filter. Discard the filter following collection of samples for dissolved metals.

e) Label appropriate sampling containers with sampling details and custody information.

f) Replace the well cap and lock the cover.

g) Record the following information in the field logbook:

    - Sample ID
    - Location
    - Purging and sampling data
    - Color
    - Odor
    - Field screening instrument readings (i.e., water quality, PID)
    - Any other pertinent information (e.g., date, time and sampler)

7.5 Sampling Wells in Low-Permeability Formations

Wells located in low-permeability formations (i.e., slow-recovery wells, wells that can be purged to dryness, etc.) require alternate sampling procedures than the methods listed above. One approach, for a well screened below the water table, is to remove the stagnant water in the casing to just above the top of the screened interval, to prevent the exposure of the gravel pack or formation to atmospheric conditions. The pumping rate should be as low as possible to minimize disturbance as much as possible in the well. A sample should then be secured from the water within the screened interval. Another approach is to use a dedicated pump located within the screened interval and purge only the pump and tubing volume before collecting the sample (“passive sampling”). Another type of passive sampling uses a passive diffusion bag sampler (PDBS) which is deployed in the screened interval of the monitoring well for a period recommended by the manufacturer. Analytes of interest passively diffuse into deionized water contained within the sampler as the well equilibrates. It should be noted that only certain VOCs will diffuse into the PDBS. The PDBS is retrieved from the well and the sample is poured into appropriate sample containers. Other no-purge samplers include equilibrated grab samplers such as the HYDRASleeve™ and the Snap Sampler®. These samplers are deployed in the screened interval of the monitoring well and the well is allowed to equilibrate. Use of these passive sampling and no-purge sampling techniques will require development of a method-specific SOP to be included in the SAWP.

7.6 PFAS Considerations

Sampling groundwater for PFAS should follow the general procedures detailed above but with the following adjustments to prevent cross contamination from the numerous sources of PFAS in the environment and everyday life.

A. All sampling components must be PFAS-free.

B. Glass components should not be used for collecting aqueous PFAS samples because several PFAS are known to adsorb to the glassware when in contact with the glass for extended periods of time.

C. Similarly, LDPE and PTFE containers should not be used due to either adsorption of PFAS onto or leaching of PFAS from the container materials.

D. Per the OER QAPrP, PFAS sampling containers must be 500 mL certified PFAS-free HDPE bottles sealed using a HDPE or polyethylene cap with no liner.

E. Due to the abundance of PFAS in food packaging, all food and beverage should be kept in a designated location far away (>50 feet) from the wells to be sampled, and after eating, the workers hands must be washed with PFAS-free soap for decontamination before returning to sampling activities.

F. Avoid use of cosmetics, moisturizers, hand cream, perfume, deodorant/antiperspirant, sunscreen, insect repellent or similar products that have not been determined to be PFAS-free on the day of sampling.

G. Sampling materials should not come into contact with carpeting or upholstery in buildings or vehicles before, during or after the sampling process.

H. Ensure that the well does not have any known sources of potential cross-contamination, such as Teflon fittings or PFAS-containing grout. If the well does contain such materials, then another well may need to be installed for collecting PFAS samples.

I. Do not use chemical ice packs to cool the samples.

J. Do not use foil as a layer between stacked sample bottles.

K. PFAS sampling of groundwater can be done using either EPA Method 537.1 for drinking water or Method 1633. Method 1633 has more analytes and is therefore the preferred method to use.

L. At least one round of groundwater PFAS samples should be analyzed for Adsorbable Organic Fluorine (AOF), Total Organic Fluorine (TOF) or Total Oxidizable Precursor (TOP) analysis to assess how much of the potential PFAS compounds are accounted for using either Method 537.1 or Method 1633.

M. Clothing

   1. *Permitted*:

      - 100% cotton preferred, but synthetic, polyurethane, PVC, rubber, neoprene, powderless nitrile gloves, uncoated Tyvek® clothing, and wax-coated fabrics are acceptable

- Clothing should be previously laundered (preferably at least six times) without fabric softeners
- Boots can be either polyurethane, PVC or PFAS-free boot covers

2. *Banned*:

- New or unwashed clothing, or clothing washed with fabric softeners
- Clothing treated with fabric protection, water-resistant, stain-resistant or insect-resistant chemicals
- Any clothing or boots made of Gore-Tex^{TM} or other known PFAS-containing or water-resistant materials.

N. PPE

1. *Permitted*:

- Powderless nitrile gloves (sampling personnel must wash their hands with PFAS-free soap and water before putting on any gloves.)
- HDPE hard hats, or hard hat covers/liners made of cotton or other natural fabrics
- Safety glasses made with HDPE
- Life jackets made of polyethylene foam and nylon shell fabric
- Waders made of Neoprene or other PFAS-free materials
- PFAS-free sunscreen (examples include Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 50, Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, and Neutrogena® Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30)
- PFAS-free insect repellent (examples include OFF® Deep Woods and Sawyer® Permethrin)

2. *Banned*:

- Gore-Tex^{TM} gloves, waders or safety equipment, or any other PPE made with PFAS-containing materials
- Note that further research is needed on the potential use of Latex and leather gloves.

O. Field Materials

1. *Permitted*:

- Aluminum, polypropylene or Masonite clipboards
- Rite in the Rain® notebooks
- Loose paper (non-waterproof and non-recycled)
- Ballpoint pens and pencils

2. *Banned*:

- All PFAS-coated materials
- Post-It® Notes and other adhesive paper products

- Sharpie markers (there is not a consensus on PFAS in Sharpie markers, but they should not be used unless that are certified PFAS-free)
- Coated paper towels
- Aluminum foil should not be used since it is often coated with PFAS, but if a certified PFAS-free foil can be found then it can be used

P. Decontamination

1. *Permitted*:
    - Alconox®, Liquinox® or Citranox®
    - Dry decontaminated equipment using cotton cloth or untreated paper towels, or air dry on a PFAS-free surface
    - Polyethylene or PVC brush to remove particulates
2. *Banned*:
    - Decon 90®
    - Dawn dish detergent
    - PFAS-treated paper products

When in doubt, assume that the product contains PFAS and should not be used!

8.0 CALCULATIONS

Volume estimates per foot for common inside diameter tubing is presented in the following table:

Tubing Inside Diameter (inches)	Tubing Volume (gallon per foot)
1/4	0.0003
3/8	0.0057
1/2	0.010

If it is necessary to calculate the volume of the well, utilize the following equation:

$$V = kh\pi r^2$$

Where:
$V =$ Volume (gallons)
$\pi =$ 3.14
$r =$ radius of the well (feet)
$h =$ water column height (feet)
$k =$ conversion factor (7.48 gal/ft^3)

Or if the variables are known:

$$V = k\{r^2_{ic}h + [(r^2_{b}h - r^2_{oc}h) * ne]\}$$

Where:
$V =$ Volume (gallons)
$r_{ic} =$ radius inside diameter of casing (feet)

r_b = radius of borehole (feet)
r_{oc} = radius outside diameter of casing (feet)
h = water column height (feet)
k = conversion factor (7.48 gal/ft^3)
ne = effective porosity of filter pack material (~ 35%)

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on field data sheets and/or within the field logbook.
- All instrumentation should be operated and calibrated in accordance with the manufacturer's instructions unless specified otherwise in the site-specific SAWP.
- The collection of an equipment rinsate blank is required to evaluate potential for cross-contamination from the purging and/or sampling equipment.
- The collection of duplicate samples will be required as set forth in the SAWP and/or *QAPrP*.
- Trip blanks are required for each cooler with samples for volatile organic compounds analysis.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the hazards associated with well sampling:

- Exposure to unknown contaminants in the well headspace and in the groundwater.
- Lifting injuries associated with moving equipment, coolers with samples, and retrieving pumps and bailers.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE.
- Slips, trips, and fall hazards.
- Potential electrical shocks associated with use of submersible pumps.

- Biohazards, such as snakes, biting insects, and poison ivy.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA QA/G-6, US EPA, Office of Environmental Information, April 2007.

Ground Water Well Sampling, SOP# 2007, US EPA, Environmental Response Team, January 26, 1995.

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, August 2005, Updated – April, 2011.

Standard Operating Procedure for Ground Water Sampling, The Office of Environmental Measurement and Evaluation, EPA New England - Region 1, January 9, 2003.

ASTM D4448-01 (Reapproved 2013), Standard Guide for Sampling Ground-Water Monitoring Wells, ASTM International, West Conshohocken, PA, 2013, www.astm.org.

Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, Ground Water Forum Issue Paper, EPA 542-S-02-001, EPA Technology Innovative Office, Office of Solid Waste and Emergency Response, May, 2002.

Per- and Polyfluoroalkyl Substances (PFAS) Sampling Guidelines for Non-Drinking Water, California State Water Quality Control Board, September 2020. https://www.waterboards.ca.gov/pfas/docs/sept_2020_pfas_sampling_guidelines.pdf.

Sampling Precautions and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS), Interstate Technology Regulatory Council (ITRC), 2023. https://pfas-1.itrcweb.org/wp-content/uploads/2023/10/Sampling_and_Lab_PFAS_Fact-Sheet_Sept2023_final.pdf.

ITRC (Interstate Technology & Regulatory Council). 2005. *Technology Overview of Passive Sampler Technologies.* DSP-4. Washington, D.C.: Interstate Technology & Regulatory Council, Authoring Team. www.itrcweb.org.

Soil Sampling

SOP OER-0120

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ruth Porter	1.0	7/1/2010	Reformatted, added SOP ID #, and renumbered. Supersedes Revision 0.0.	Editorial
			Combined previous soil sampling SOP for surface and subsurface sampling, added sampling information	Technical
Dave Long	2.0	9/21/2016	Revised procedures. Reformatted.	Editorial, Technical
Ross Brittain	3.0	11/10/2020	Edited grammatical issues and updated procedures.	Editorial, Technical
Ross Brittain	4.0	1/14/2025	Edited to account for PFAS sampling methodology	Technical

SOIL SAMPLING

SOP OER-0120

Table of Contents

List of Acronyms and Abbreviations

bgs	below ground surface
FID	Flame Ionization Detector
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HLC	Henry's Law Constant
IDW	Investigation Derived Wasted
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PFAS	Per- and Polyfluoroalkyl Substances
PID	Photoionization Detector
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compounds
WVDEP	West Virginia Department of Environmental Protection
VOC	Volatile Organic Compounds
XRF	X-Ray Fluorescence

Disclaimer: Any mention in this SOP of any products or services does not constitute or imply the endorsement, recommendation or favoring by WVDEP or any of its employees or contractors acting on its behalf.

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to describe the procedures for the collection of surface and subsurface soil samples using equipment such as a continuous flight auger, a split spoon, backhoe, hand auger, shovel, trowel, and/or scoop for projects in the Office of Environmental Remediation (OER) within the West Virginia Department of Environmental Protection (WVDEP). Refer to SOP OER-0121 for soil sample collection procedures using direct push (i.e. Geoprobe^{TM}). Analysis of soil samples may determine whether concentrations of specific pollutants exceed established action levels, or if the concentrations of pollutants present a risk to public health or the environment. These procedures may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure, as long as the changes would not significantly impact the representativeness of the results. The procedures utilized at a site should be documented and included in the site investigation report. Refer to SOP OER-0122 for procedures for soil sampling of volatiles utilizing Method 5035. Refer to SOP OER-0101 and OER-0102 for procedures for field screening of soil with a photoionization detector (PID)/flame ionization detector (FID) and an X-Ray fluorescence (XRF) detector, respectively.

2.0 SUMMARY OF METHOD

Soil samples may be collected using a variety of methods and equipment depending on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type. Surface and near-surface soils may be easily sampled using a spade, trowel, and scoop. Sampling at greater depths may be performed using a hand auger, continuous flight auger, a split-spoon, or a backhoe. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is generally not performed or recommended, except for Method 5035. However, samples should be cooled and protected from sunlight to minimize any potential reaction. The type of sample container, the preservative (if any), and holding times are all dependent upon the type of analysis to be performed upon the sample. Refer to Table 2 of the relevant WVDEP-OER *QAPrP* for information on sample containers, preservation and holding times for common contaminants. This information should be clearly set forth in the SAWP for the site. The sampler should consult the SAWP for all pertinent information relating to the proper sample preservation, type of containers, handling, and storage procedures for their project. A pair of clean, new, non-powdered disposable gloves shall be worn each time a different location is sampled to prevent cross-contamination. Samples should be collected directly from the sampling device into appropriate laboratory cleaned containers. Samples shall be appropriately preserved (if applicable), labeled, and placed in a cooler to be maintained at ≤6ºC, but without freezing the sample, and custody seals attached to the cooler in accordance with the SAWP and *QAPrP* requirements. The samples should be shipped with adequate packing and cooling to ensure that they arrive at the laboratory intact and still ≤6ºC without freezing. Consider placing each sample container in a zip-lock bag to prevent ice/water in the cooler from dislodging the label and custody seal. (Sample vials and jars for each sample from Method 5035 sampling may be placed in the same zip-lock bag.)

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary potential problems associated with soil sampling: cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. Strictly following decontamination procedures of the non-dedicated sampling equipment, as outlined in SOP OER-0100 *General Decontamination Procedures for Non-Disposable Field Sampling Equipment* can prevent or reduce the chance of cross-contamination problems. Improper sample collection can involve disturbance of the matrix resulting in compaction of the sample, significant volatile loss for VOC sample collection or inadequate homogenization of the samples where required, resulting in variable, non-representative results. When sampling with a hand auger, non-cohesive sands may collapse in the borehole prior to reaching the sampling depth; also, in tight clays, the greater the depth attempted, the more difficult it is to recover a sample due to increased friction and torquing of the hand auger extensions.

5.0 EQUIPMENT APPARATUS

The following are some of the materials and equipment that are potentially needed for soil sampling activities. Refer to the SAWP to determine specific needs for any given project.

- Photoionization detector (PID) and/or flame ionization detector (FID)
- Logbook
- Field data sheets and samples labels
- Chain of custody records and seals
- Sample and shipping containers (certified PFAS-free if sampling PFAS)
- Preservatives, as applicable
- Pails, tubs, or buckets (certified PFAS-free if sampling PFAS)
- Plastic sheeting (certified PFAS-free if sampling PFAS)
- Packing materials and Ziploc® plastic bags (other brands of baggies can be used but must be certified PFAS-free if sampling PFAS)
- Decontamination solutions (i.e., tap water, non-phosphate soap, distilled water)
- Brushes
- Stakes and flagging
- Sampling gloves (unpowdered nitrile if sampling for PFAS)
- Shovel (uncoated if sampling for PFAS)
- Spatula, scoops, and/or trowels (certified PFAS-free if sampling PFAS)
- Continuous flight (screw) auger
- Bucket auger
- Post hole auger
- Split spoons
- Drilling rig equipment (points, drive head, drop hammer, puller jack and grip, extension rods, T-handle, thin wall tube sampler, etc.)

- Backhoe
- Drums for storage of investigation derived waste
- Personal protective equipment (PPE) (certified PFAS-free if sampling PFAS)

6.0 REAGENTS

Chemical preservation of solids is not generally recommended except for sampling for VOC analysis; therefore, reagents will likely be utilized only for decontamination of sampling equipment. Refer to the SOP for the decontamination procedures and required reagents. Refer to the SOP for Method 5035 for VOC soil sample collection. Refer to the site-specific SAWP for the preservatives, if any, required for other specified analyses to be performed.

7.0 PROCEDURES

7.1 General Procedures

a) Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies required.

b) Obtain necessary sampling and monitoring equipment. Ensure that it has been decontaminated since its last use and ensure that the equipment is in good working condition.

c) Use stakes and/or flagging to identify and mark all sampling locations.

d) Ensure that WV811 and all local utilities have been called to perform a utility marking of the site.

7.2 Surface Soil Samples

The West Virginia Department of Environmental Protection Office of Environmental Remediation defines surface soil as the soil located from a depth of 0.0 to 2.0 ft. below ground surface (bgs). Collection of surface soil samples can be accomplished with tools such as spades, shovels, trowels, and scoops.

a) Clear any surface debris (e.g., concrete/asphalt, vegetation, roots, gravel/rocks, and twigs) from the sampling location.

b) Use a scoop, hand-auger, trowel, or shovel to collect a portion of surface soil. Plastic devices cannot be used to collect samples for SVOC analysis. Perform field screening as appropriate (see SOP OER-0101 *PID/FID Field Screening*). (Note: Soil samples collected for field soil screening may not be used for laboratory analysis.) Whenever a vertical or near-vertical surface is sampled, such as when shovels or similar devices are used for surface or subsurface sampling, the surface should be dressed (scraped) to remove smeared soil and to expose a fresh surface for sampling. If Method 5035 is required for volatiles, these samples must be collected first by submerging the VOC sample device (e.g., Terra Core™ or En Core® directly into a fresh face of the remaining soil contained in the sampling device and collect the sample, placing the soil in the appropriate sample jar for volatile organic analysis. Note, however, that if the soil is non-cohesive and crumbles when removed from the ground surface, consideration should be given to obtaining the soil plug for Method 5035 analysis directly from a newly exposed ground surface. Samples collected for SVOC analysis that includes lighter compounds such as naphthalene and acenaphthene must be collected by completely filling the sample jar and leaving no headspace rather than homogenizing first, due to the volatility of the lighter SVOCs. The volatility of target SVOC analytes will determine if the SVOC soil samples should be homogenized. In general, soils with potential contaminants whose vapor pressure > 0.1 mg Hg or Henry's Law Constant (HLC) > 0.0001 atm*m^3/mol should not be homogenized, but it may be good practice to not homogenize any soils being analyzed for SVOCs. For all other analysis, the soil may be homogenized in a stainless-steel bowl prior to placing the soil in the appropriate sample containers. (Note: Remove rocks, pebbles, and organic material from the soil sample prior to placing the soil in the sample containers).

c) Close the sample containers and affix labels (if not already present) and immediately place on ice.

d) Measure the depth of the samples using a ruler and record it in the field logbook.

e) Once the sampling is completed, dispose of disposable sampling equipment and 5035 plastic syringes. Decontaminate any non-disposable sampling equipment prior to the collection of the next sample.

f) Record the following information in the field logbook:

- Sample ID
- Location
- Depth of sample
- Soil type description
- Equipment used
- Apparent moisture content (i.e., dry, moist, wet)
- Color
- Odor
- Field screening instrument readings, if applicable
- Any other pertinent information (e.g., date, time and sampler)

7.3 Sampling Subsurface Soil with Hand Augers and Thin Wall Tube Samplers

This system consists of an auger (typically, 4-inch stainless steel auger buckets with cutting heads are used) and/or a thin-wall tube sampler, a series of extensions, and a "T" handle. The auger is used to bore a hole to a desired sampling depth and is then withdrawn. Perform field screening as appropriate and as referenced in Section 7.2.2 above. Samples for Method 5035 analysis will be collected first, immediately and directly from the auger. Samples collected for SVOC analysis may also need to be collected prior to homogenization (see Step k below) and should not be collected with plastic equipment. Samples for other analysis may then be collected once the material is removed from the auger and homogenized. If a core sample is to be collected, the auger tip is then replaced with a thin wall tube sampler. The system is then lowered down the borehole and driven into the soil to the completion depth. The system is withdrawn, and the core is collected from the thin wall tube sampler.

The following procedure is used for collecting soil samples with the auger:

a) Clear the area to be sampled of any surface debris (e.g., twigs, rocks, etc.).

b) Attach the auger bit to a drill rod extension and attach the "T" handle to the drill rod.

c) Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole or into a 55-gallon drum. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. Consider using a second, clean auger bucket for sampling once the sampling depth is attained.

d) After reaching the desired depth, slowly and carefully remove the auger from the hole.

e) If soil has sloughed from the sides of the auger hole, discard the top 1” of soil in the auger. When sampling directly from the auger, collect the sample after the auger is removed from the hole (note special considerations for Method 5035 sampling above and proceed to Step k).

f) Remove auger tip from the extension rods and replace with a pre-cleaned thin wall tube sampler. Install the proper cutting tip.

g) Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Do not scrape the borehole sides. Avoid hammering the rods as the vibrations may cause the boring walls to collapse.

h) Remove the tube sampler and unscrew the drill rods.

i) Remove the cutting tip and the core from the device.

j) Discard the top 1” of the core as this may represent material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container.

k) Perform field screening as appropriate. If Method 5035 is required for volatiles, collect this sample first, submerging the VOC sample device (e.g., Terra Core^{TM} or En Core®) directly into the soil contained in the sampling device and placing the soil in the appropriate sample jar for volatile organic analysis. Samples collected for SVOC analysis that includes lighter compounds such as naphthalene and acenaphthene must be collected by completely filling the sample jar and leaving no headspace rather than homogenizing first, due to the volatility of the lighter SVOCs. The volatility of target SVOC analytes will determine if the SVOC soil samples should be homogenized. In general, soils with potential contaminants whose vapor pressure > 0.1 mg Hg or Henry's Law Constant (HLC) > 0.0001 atm*m^3/mol should not be homogenized, but it may be good practice to not homogenize any soils being analyzed for SVOCs. For all other analyses, the soil may be homogenized in a stainless-steel bowl prior to placing the soil in the appropriate sample containers.

l) Once the sampling is completed, dispose of disposable sampling equipment and plastic 5035 plastic syringes. Decontaminate any non-disposable sampling equipment prior to the collection of the next sample.

m) Record the following information in the field logbook:

- Sample ID
- Location
- Depth of sample
- Soil type description
- Equipment used
- Apparent moisture content (i.e., dry, moist, wet)
- Color
- Odor
- Field screening instrument readings, if applicable
- Any other pertinent information (e.g., date, time and sampler)

n) Abandon the boring as necessary in accordance with applicable state regulations.

7.4 Sampling Surface and Subsurface Soils Using Test Pit/Trench Excavation

The following procedures are used for collecting soil samples from test pits or trenches:

a) Backhoes may be used in the collection of surface and shallow subsurface soil samples. The trenches created by excavation with a backhoe offer the capability of collecting samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. Using the backhoe, excavate a trench approximately three feet wide to the desired sampling depth. Place excavated soils on plastic sheets (certified PFAS-free if sampling PFAS). (Note: Trenches greater than five feet deep must be sloped or protected by a shoring system, and personnel not operating the backhoe must follow safety protocols as required by OSHA regulations.)

b) A shovel may be used to remove a one to two-inch layer of soil from the vertical face of the pit where sampling is to be done. Remember to dress (scrape) the vertical face if sampling is conducted directly from the trench/pit sidewall, to remove smeared soil from the backhoe bucket and expose fresh soil for screening and sampling. Field screening may be completed in accordance with SOP OER-0101, as there is plenty of soil available for screening and sampling with test pits and trenches.

c) Samples may also be taken directly from the approximate center of the soil mass in the backhoe bucket using a shovel, trowel, scoop, or coring device after field screening. Field screening may be completed in accordance with SOP OER-0101. For Method 5035 sampling the VOC samples must be collected first by submerging the VOC sample device (e.g., Terra Core^{TM}) directly into the soil in the backhoe bucket adjacent to the field screening location and collect the sample, placing the soil in the appropriate sample jar for volatile organic analysis. Samples collected for SVOC analysis that includes lighter compounds such as naphthalene and acenaphthene must be collected by completely filling the sample jar and leaving no headspace rather than homogenizing first, due to the volatility of the lighter SVOCs. The volatility of target SVOC analytes will determine if the SVOC soil samples should be homogenized. In general, soils with potential contaminants whose vapor pressure > 0.1 mg Hg or Henry's Law Constant (HLC) > 0.0001 atm*m^3/mol should not be homogenized, but it may be good practice to not homogenize any soils being analyzed for SVOCs. For all other analyses, the soil may be homogenized in a stainless-steel bowl prior to placing the soil in the appropriate sample containers.

d) Once the sampling is completed, dispose of disposable sampling equipment and plastic 5035 plastic syringes. Decontaminate any non-disposable sampling equipment prior to the collection of the next sample.

e) Record the following information in the field logbook:

- Sample ID
- Location and depth of sample
- Soil type description
- Equipment used
- Apparent moisture content (i.e., dry, moist, wet)
- Color
- Odor
- Field screening instrument readings, if applicable
- Any other pertinent information (e.g., date, time and sampler)

f) Abandon the pit in accordance with applicable state regulations.

7.5 PFAS Considerations

Sampling soils for PFAS should follow the general procedures detailed above but with the following adjustments to prevent cross contamination from the numerous sources of PFAS in the environment and everyday life.

a) All sampling components must be PFAS-free. This includes shovels, trowels and scoops that must not be coated.

b) Glass components should not be used for collecting PFAS samples because several PFAS are known to adsorb to the glassware when in contact with the glass for extended periods of time.

c) Similarly, LDPE and PTFE containers should not be used due to either adsorption of PFAS onto or leaching of PFAS from the container materials.

d) Per the relevant WVDEP-OER *QAPrP*, PFAS sampling containers must be 500 mL certified PFAS-free HDPE bottles sealed using a HDPE or polyethylene cap with no liner.

e) Due to the abundance of PFAS in food packaging, all food and beverage should be kept in a designated location far away (>50 feet) from the wells to be sampled, and after eating, the workers hands must be washed with PFAS-free soap for decontamination before returning to sampling activities.

f) Avoid use of cosmetics, moisturizers, hand cream, perfume, deodorant/antiperspirant, sunscreen, insect repellent or similar products that have not been determined to be PFAS-free on the day of sampling.

g) Sampling materials should not come into contact with carpeting or upholstery in buildings or vehicles before, during or after the sampling process.

h) Do not use chemical ice packs to cool the samples.

i) Do not use foil as a layer between stacked sample bottles.

j) PFAS sampling of soils currently can only be done using EPA Method 1633.

k) At least one soil sample, preferably in a known/likely PFAS source area, should be analyzed for Total Organic Fluorine (TOF) or Total Oxidizable Precursor (TOP) analysis to assess how much of the potential PFAS compounds are accounted for using Method 1633.

l) Clothing

   1. *Permitted*:

      - 100% cotton preferred, but synthetic, polyurethane, PVC, rubber, neoprene, powderless nitrile gloves, uncoated Tyvek® clothing, wax-coated fabrics are acceptable
      - Clothing should be previously laundered (preferably at least six times) without fabric softeners
      - Boots can be either polyurethane, PVC or PFAS-free boot covers

   2. *Banned*:

      - New or unwashed clothing, or clothing washed with fabric softeners
      - Clothing treated with fabric protection, water-resistant, stain-resistant or insect-resistant chemicals
      - Any clothing or boots made of Gore-Tex™ or other known PFAS-containing or water-resistant materials.

m) PPE

   1. *Permitted*:

- Powderless nitrile gloves (Sampling personnel must wash their hands with PFAS-free soap and water before putting on any gloves.)
- HDPE hard hats, or hard hat covers/liners made of cotton or other natural fabrics
- Safety glasses made with HDPE
- Life jackets made of polyethylene foam and nylon shell fabric
- Waders made of Neoprene or other PFAS-free materials
- PFAS-free sunscreen (examples include Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 50, Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, and Neutrogena® Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30)
- PFAS-free insect repellent (examples include OFF® Deep Woods and Sawyer® Permethrin)

2. *Banned*:

   - Gore-Tex™ gloves, waders or safety equipment, or any other PPE made with PFAS-containing materials
   - Note that further research is needed on the potential use of Latex and leather gloves.

n) Field Materials

1. *Permitted*:

   - Aluminum, polypropylene or Masonite clipboards
   - Rite in the Rain® notebooks
   - Loose paper (non-waterproof and non-recycled)
   - Ballpoint pens and pencils

2. *Banned*:

   - All PFAS-coated materials
   - Post-It® Notes and other adhesive paper products
   - Sharpie markers (there is not a consensus on PFAS in Sharpie markers, but they should not be used unless that are certified PFAS-free)
   - Coated paper towels
   - Aluminum foil should not be used since it is often coated with PFAS, but if a certified PFAS-free foil can be found then it can be used

o) Decontamination

1. *Permitted*:

   - Alconox®, Liquinox® or Citranox®
   - Dry decontaminated equipment using cotton cloth or untreated paper towels, or air dry on a PFAS-free surface
   - Polyethylene or PVC brush to remove particulates

2. *Banned*:
    - Decon 90®
    - Dawn dish detergent
    - PFAS treated paper products

When in doubt, assume that the product contains PFAS and should not be used!

8.0 CALCULATIONS

No calculations are applicable to this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

The following general quality assurance and quality control (QA/QC) procedures apply:

- All data must be documented on field data sheets and/or within the field logbook.
- All instrumentation should be operated and calibrated in accordance with the manufacturer's instructions unless specified otherwise in the site-specific SAWP.
- The collection of an equipment rinsate blank is recommended to evaluate potential for cross-contamination.
- The collection of duplicate samples will likely be required for the project. Refer to the site-specific SAWP and/or *QAPrP* for further information on collection of duplicate samples.
- Trip blanks are required for each cooler with samples for volatile organic compounds analysis.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. Before beginning any field work, be sure that all sampling locations are clear of overheard and buried utilities. The following is a summary of just some of the hazards associated with these soil sampling procedures:

- Exposure to unknown contaminants.
- Lifting and carrying injuries.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE.
- Slips, trips, and fall hazards.
- Injury from moving equipment.
- Striking underground utilities in borings or test pits.
- Loud noises.
- Biohazards, such as snakes, biting insects and poison ivy.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA QA/G-6, US EPA, Office of Environmental Information, April 2007.

Soil Sampling, SOP# 2012, US EPA, Environmental Response Team, February 18, 2000.

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, August 2005, Update – April 2011.

Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods, Second Edition, EPA-600/4-84-076, U.S. Environmental Protection Agency, 1984.

Sampling Precautions and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS), Interstate Technology Regulatory Council (ITRC), 2023. https://pfas-1.itrcweb.org/wp-content/uploads/2023/10/Sampling_and_Lab_PFAS_Fact-Sheet_Sept2023_final.pdf.

US EPA Region 4, 2014, *Operating Procedure – Soil Sampling*; SESD PROC-300-R1, U.S. Environmental Protection Agency Region 4, Athens, GA, 24 pp.

Soil Sampling Using Direct-Push Drilling

SOP OER-0121

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ruth Porter	0.0	7/1/2010	New SOP	Technical
Ross Brittain	1.0	11/10/2020	Edit grammatical issues and clarify processes.	Editorial, Technical
Ross Brittain	2.0	1/14/2025	Edit to account for PFAS sampling methodology	Technical

SOIL SAMPLING USING DIRECT-PUSH DRILLING

SOP OER-0121

Table of Contents

List of Acronyms and Abbreviations

bgs	below ground surface
FID	Flame Ionization Detector
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HLC	Henry's Law Constant
ID	Identification
IDW	Investigation Derived Wasted
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PFAS	Per- and Polyfluoroalkyl Substances
PID	Photoionization Detector
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compounds
WVDEP	West Virginia Department of Environmental Protection
VOC	Volatile Organic Compounds
XRF	X-Ray Fluorescence

Disclaimer: Any mention in this SOP of any products or services does not constitute or imply the endorsement, recommendation or favoring by WVDEP or any of its employees or contractors acting on its behalf.

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide general reference information on soil sampling using direct push (i.e. Geoprobe^{TM}) technology for projects in the Office of Environmental Remediation (OER) within the West Virginia Department of Environmental Protection (WVDEP). Surface and subsurface soil sampling supplies information on subsurface lithology as well as providing data for use in evaluating the vertical and horizontal extent of contaminant impact.

These procedures are designed to be used in conjunction with analyses for the most common types of soil contaminants (i.e., volatile, semi-volatiles, and metals). These procedures may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure, as long as the changes would not significantly impact the representativeness of the results. The procedures utilized at a site should be documented and included in the site report. Refer to SOP OER-0122 for procedures for soil sampling of volatiles utilizing Method 5035. Refer to SOP OER-0101 for procedures for field screening of soil with a photoionization detector (PID) or flame ionization detector (FID) and OER-0102 for procedures for field screening soil with an X-Ray fluorescence (XRF) detector.

2.0 SUMMARY OF METHOD

Direct-push soil sampling devices are used to collect soil samples at specific depths below ground surface (bgs). Direct-push machines are hydraulically powered and are generally mounted on a customized four-wheel drive or tracked vehicle. The base of the sampling device is positioned on the ground over the sampling location and the vehicle is hydraulically raised on the base. As the weight of the vehicle is transferred to the probe, the probe is pushed into the ground. A built-in hammer mechanism allows the probe to be driven through dense materials. Maximum depth penetration under favorable circumstances may be greater than 100 feet.

Soil samples are collected using specially designed sample tubes. The sample tube is pushed and/or vibrated to a specified depth. In the simplest sampler, the piston-activated system, the interior plug of the sample tube is removed by inserting small diameter threaded rods. The sample tube is then driven an additional foot to collect the samples. The probe sections and sample tube are then withdrawn, and the sample is extruded from the tube. Latch-activated systems are similar to those that use piston-activation mechanisms, but they can collect samples more rapidly. Sampling rates can also be increased by using dual-tube samplers. The dual-tube sampling system is recommended for continuous sampling as the outer casing prevents sloughing and cross-contamination from other depths. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is not generally recommended, except for Method 5035. However, samples should be cooled and protected from sunlight to minimize any potential reaction. The type of sample container, the preservative (if any), and holding times are all dependent upon the type of analysis to be performed on the sample. This information should be clearly set forth in the SAWP for the site. The sampler should consult the SAWP and *QAPrP* for all pertinent information relating to the proper sample preservation, type of containers, handling, and storage procedures for their project. Samples should be collected directly from the sampling device into appropriate laboratory cleaned containers. Samples shall be appropriately preserved (if applicable), labeled, and placed in a cooler to be maintained at ≤6ºC, but without freezing the sample in accordance with the SAWP requirements. The samples should be shipped with adequate packing and cooling to ensure that they arrive at the laboratory intact and still ≤6ºC without freezing.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

A preliminary site survey should be performed in order to identify areas to be avoided with the Geoprobe^{TM} and to determine if the Geoprobe^{TM} will be able to access the desired sampling locations. All underground utilities should be located and marked. These areas where underground and aboveground utilities are located should be avoided during sampling.

Decontamination of sampling tubes, probe rods, adaptors, non-expendable points and other equipment that contact the soil is necessary to prevent cross-contamination of samples. During sampling, the bottom portion and outside of the sampling tubes can be contaminated with soil from other depth intervals. Care must be taken to prevent soil which does not represent the sampled interval form being carefully wiped from the outside surface of the sampling tube and the bottom 3 inches of the sample should be discarded before extruding the sample.

Obtaining sufficient volume of soil for analysis of multiple parameters from one sample location may present a problem. Most direct-push soil sampling systems recover a limited volume of soil, and it is not possible to reenter the same hole and collect additional soil. When multiple analyses are to be performed on soil samples by this method, the relative importance of the analyses should be established. Identifying the order of importance will ensure that the limited sample volume will be used for the most crucial analyses. In some instances, it may be appropriate to push another boring very near the initial boring (within 18”) in order to have sufficient soil for all analysis. However, this should be clearly documented in the field notes and in the subsequent report for the site.

5.0 EQUIPMENT APPARATUS

The following are some of the materials and equipment that are potentially needed for soil sampling activities. Refer to the site SAWP to determine specific needs for any given project.

- Photoionization detector (PID) and/or flame ionization detector (FID)
- Logbook
- Field data sheets and samples labels
- Chain of custody records and seals
- Sample and shipping containers (certified PFAS-free if sampling PFAS)
- Preservatives, as applicable

- Pails, tubs, or buckets (certified PFAS-free if sampling PFAS)
- Plastic sheeting (certified PFAS-free is sampling PFAS)
- Packing materials and Ziploc® plastic bags (other brands of baggies can be used but must be certified PFAS-free if sampling PFAS)
- Decontamination solutions (i.e., tap water, non-phosphate soap, distilled water)
- Brushes
- Stakes and flagging
- Sampling gloves (unpowdered nitrile if sampling for PFAS)
- Personal protective equipment (PPE) (certified PFAS-free if sampling PFAS)
- Drums for storage of investigation derived waste
- Direct-push system and associated equipment [i.e., rods, extractor, drive and pull caps, expandable point holders, drive points, piston rods and stops, sample tubes, vinyl end caps (note that the sample tubes must be acetate liners when sampling PFAS)]

6.0 REAGENTS

Chemical preservation of solids is not generally recommended, except for samples for VOC analysis; therefore, reagents will likely be utilized primarily for decontamination of sampling equipment. Refer to the SOP for the decontamination procedures and required reagents. Refer to the site-specific SAWP for the preservatives, if any, required for the specified analysis to be performed.

7.0 PROCEDURES

7.1 Hollow Stem

These procedures relate to the sampling activities associated with collecting a soil sample from a Geoprobe™ and are not intended to address in detail the actual operation of the Geoprobe™. The operator should follow the SOP requirements established by the manufacturer for the Geoprobe™ model being utilized at the site. Other direct-push systems with generally similar operating procedures are also available for soil sampling. Ensure that WV811 and all local utilities have been called to perform a utility marking of the site prior to beginning work.

a) A decontaminated Geoprobe ™ sampling spoon with an acetate or clear PVC liner is prepared at the surface and driven into the ground.

b) The sample spoon is closed on the end with a drive point and advanced to the top of the desired sample interval.

c) A pin is removed from the top of the sampler and the drive point is lifted out, thereby opening the bottom of the sampler, allowing soil to enter the sample spoon when the spoon is advanced.

d) The hydraulic hammer advances the Geoprobe™ sampling spoon to fill the acetate liner inside the sampler.

e) The sample spoon is then retrieved from the hole and the liner extruded from the sampling spoon.

f) Immediately upon retrieval, field screening using one of the accepted methods below and Method 5035 sampling should be the first tasks performed to reduce the loss of volatiles from the sample as much as possible (Hewitt and Lukash 1996, Sorini et al. 2009). Note that field screening directly from an exposed soil core is unacceptable due to the dilution of vapors in ambient air and potential loss of volatiles from the samples. There are three options for field screening:

   i. The first option is to cut the core into 12-inch sections and immediately collect VOC samples using Method 5035 (be sure to expose a fresh area of the soil core to prevent collection of smeared soils), place the samples in laboratory-supplied vials, as necessary, and store them on ice at < 6°C without freezing. After collecting samples from each 12-inch section, screen the remaining soils using PID/FID Field Screening SOP OER-0101. Once the field screening has identified the 12-inch section from which samples should be collected to send to the laboratory for analyses, the samples collected using Method 5035 from those 12-inch sections should be packed for shipping to the lab. All other 12-inch section samples collected using Method-5035 should be disposed of as IDW. After determining the appropriate VOC samples, the rest of the soil core logging and sample collection may proceed in accordance with the SAWP. This method of collecting all potential VOC samples before field screening ensures that the samples are the most representative of VOC soil concentrations at the site by minimizing the loss of vapors, but OER recognizes that this method will also generate a larger amount of IDW for disposal, depending on the use of preservatives (En Core® vs. Terra Core™ samplers).

   ii. The second option is to collocate borings where an initial boring is used only for field screening and logging of subsurface conditions. Once the sample depths for lab analysis have been determined based on PID/FID readings, staining and soil characteristics of the screening boring using SOP OER-0101, a second boring is completed to the desired sample depths at a location immediately adjacent to the first boring and samples are collected from this second, undisturbed core using Method 5035. Be sure to expose a fresh area of both soil cores to prevent collection of smeared soils. Once the VOC soil samples have been collected, XRF screening, if applicable, soil core logging and sample collection may proceed in accordance with the SAWP. OER recognizes that this method will require more use of the drill equipment and generate more cuttings as IDW.

   iii. The third option is to use the method in *ASTM D4547-15 X3.1.2 Direct Subsurface Soil Sampling Technique Using a Cutting Tool* to collect the soil cores leaving them within the acetate liner and drilling holes through the liner to expose a portion of the soils (Sorini et al. 2009), but with a slight modification to the screening protocol. The core liner is brought to the surface and placed in a metal rack for sub-sampling. Care should be taken to ensure that the air around and over the core liner is still, such as the use of shielding or being inside a structure or vehicle. A cutting tool powered by a portable drill is used to cut circular screening holes in the liner at 12-inch intervals. The diameter of the circle is the dimension required for easy insertion of the hand-operated coring device to be inserted into the hole for sample collection (e.g., En Core®) and/or the PID/FID probe tip. Any portion of the liner that is not completely filled with soil should not be screened or sampled. Additionally, a small amount of cuttings may be generated, but will typically accumulate away from the soil core. As each hole is cut, the exposed soil should be dug out with a stainless-steel tool to remove any potential cuttings and smeared soils to create a hole about 1-inch deep. The tip of the PID/FID should be inserted into the hole immediately after it is dug, being careful not to touch the probe tip to any exposed soils. A vapor reading should be taken with the PID/FID and the highest value within ~15 seconds should be recorded. The 12-inch section with the highest PID/FID reading will then be sampled for laboratory analysis by drilling another hole next to the screening hole and collecting samples using Method 5035 and placing them on ice at < 6°C without freezing. Be sure to expose a fresh area of the soil core before collecting the sample to make sure that smeared soils were not collected. Once the VOC soil samples have been collected, the liner may be cut horizontally and removed to proceed with XRF screening, if applicable, soil core logging and sample collection in accordance with the SAWP. OER recognizes that this method may be more likely to select the inappropriate 12-inch sample interval or generate false negatives during the field screening procedures, but it should reduce the amount of IDW generated and the chances of false negatives should be minimal.

(Note that for risk assessment purposes, the field screening results should be used to determine the location of a sample from each boring for the surface soils (top 0-2 ft. bgs), unless surface soil samples were collected using another method, and subsurface soils in the zone of potential excavation activities (2-10 ft. bgs). Additional samples deeper than 10 ft. bgs may be necessary to locate potential sources of contamination leaching to groundwater.)

g) If volatiles are being sampled, use the Encore® or Terra Core™ samplers (Method 5035) to collect a soil sample directly from the soil core as outlined in section 7.f above. Refer to the SOP for Method 5035, as needed. Samples that will be analyzed for VOCs should be directly placed into the appropriate sample container without homogenizing or mixing and immediately placed on ice. As appropriate, refer to the SOP for sampling method SW-846 5035. Samples collected for

SVOC analysis that includes lighter compounds such as naphthalene and acenaphthene must be collected by completely filling the sample jar and leaving no headspace rather than homogenizing first, due to the volatility of the lighter SVOCs. The volatility of target SVOC analytes will determine if the SVOC soil samples should be homogenized. In general, soils with potential contaminants whose vapor pressure > 0.1 mg Hg or Henry's Law Constant (HLC) > 0.0001 atm*m^3/mol should not be homogenized, but it may be good practice to not homogenize any soils being analyzed for SVOCs. All other non-volatile analytes may be placed in a stainless-steel bowl and thoroughly homogenized. Fill the appropriate sample containers with the remaining homogenized sample.

h) Record the following information in the field logbook:

  - Sample ID
  - Location
  - Depth of sample
  - Soil type description
  - Equipment used
  - Apparent moisture content (i.e., dry, moist, wet)
  - Color
  - Odor
  - Field screening instrument readings, if applicable
  - Any other pertinent information (e.g., date, time and sampler)

i) Abandon the boring, as needed, in accordance with applicable state regulations.

j) Decontaminate all sections of the drilling rig touching the soil prior to moving to the next sample.

7.2 Sampling Subsurface Soil with a Split Spoon (Barrel) Sampler

Split spoon sampling is generally used to collect soil cores of 18 or 24 inches in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. For standard split spoon sampling, a drill rig is used to advance a borehole to the target depth. The drill string is then removed, and a standard split spoon is attached to a string of drill rod. The spoon is then lowered to the bottom of the borehole, and a safety hammer is used to drive the split spoon into the soil. After the spoon is filled, it is retrieved to the surface, where it is removed from the drill string and opened for sample collection. Continuous split spoon samplers are also common. These are generally larger in diameter and longer in length than standard split spoons. The continuous split spoon is advanced into the soil column inside a hollow stem auger. After the auger string has been advanced into the soil column a distance equal to the length of the continuous sampler being used it is returned to the surface. The sampler is removed from inside the auger and opened for sampling. When split spoon sampling is performed for geotechnical purposes, all work should be performed in accordance with ASTM D1586/D1586M-18, "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils".

The following procedures are used for collecting soil samples with a split spoon:

a) Verify that the split spoon sampler and all sections of the drilling rig contacting the soil have been decontaminated.

b) Assemble the sampler by aligning both sides of the barrel and then screwing the drive shoe on the bottom and the head piece on top.

c) Depending on the type of split spoon being used, the sampler is driven into the soil by the drilling rig, allowing the sample to be collected in the spoon.

d) As the spoon is being retrieved from the drill string, record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth.

e) Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. Field screening (directly from the spoon) and Method 5035 sampling should be the first tasks performed after opening the spoon to reduce as much as possible the loss of volatiles from the sample. For screening, poke a small hole to the middle of the soil core and take readings with the PID/FID. Samples collected for SVOC analysis that includes lighter compounds such as naphthalene and acenaphthene must be collected by completely filling the sample jar and leaving no headspace rather than homogenizing first, due to the volatility of the lighter SVOCs. The volatility of target SVOC analytes will determine if the SVOC soil samples should be homogenized. In general, soils with potential contaminants whose vapor pressure > 0.1 mg Hg or Henry's Law Constant (HLC) > 0.0001 atm*m^3/mol should not be homogenized, but it may be good practice to not homogenize any soils being analyzed for SVOCs. For all other analysis, the soil may be homogenized in a stainless-steel bowl prior to placing the soil in the appropriate sample containers. If a split sample is desired, a cleaned, stainless-steel knife should be used to divide the tube contents in half, longitudinally. The standard split spoon sampler is typically available in 2- and 3.5-inch diameters. A continuous split spoon sampler may be necessary to obtain the required sample volume depending upon the analysis required.

f) The amount of soil recovery, blow counts (N-value for Standard Penetration Test), soil type/description, field screening results, sample interval, and depth of any groundwater encountered (first encounter and after boring completion) should all be recorded on the boring log.

g) Once the sampling is completed, dispose of disposable sampling equipment and plastic 5035 plastic syringes. Decontaminate any non-disposable sampling equipment prior to the collection of the next sample.

h) Record the following information in the field logbook:

- Sample ID
- Location
- Depth of sample
- Soil type description
- Equipment used
- Apparent moisture content (i.e., dry, moist, wet)
- Color
- Odor
- Field screening instrument readings, if applicable
- Blow counts
- Any other pertinent information (e.g., date, time and sampler)

i) Abandon the boring as necessary in accordance with applicable state regulations.
j) Decontaminate all sections of the drilling rig touching the soil prior to moving to the next sample.

7.3 PFAS Considerations

Sampling soils for PFAS should follow the general procedures detailed above but with the following adjustments to prevent cross contamination from the numerous sources of PFAS in the environment and everyday life.

a) All sampling components must be PFAS-free.

b) The sample tube must be an acetate liner.

c) Glass components should not be used for collecting PFAS samples because several PFAS are known to adsorb to the glassware when in contact with the glass for extended periods of time.

d) Similarly, LDPE and PTFE containers should not be used due to either adsorption of PFAS onto or leaching of PFAS from the container materials.

e) Per the OER *QAPrP*, PFAS sampling containers must be 500 mL certified PFAS-free HDPE bottles sealed using a HDPE or polyethylene cap with no liner.

f) Due to the abundance of PFAS in food packaging, all food and beverage should be kept in a designated location far away (>50 feet) from the wells to be sampled, and after eating, the workers hands must be washed with PFAS-free soap for decontamination before returning to sampling activities.

g) Avoid use of cosmetics, moisturizers, hand cream, perfume, deodorant/antiperspirant, sunscreen, insect repellent or similar products that have not been determined to be PFAS-free on the day of sampling.

h) Sampling materials should not come into contact with carpeting or upholstery in buildings or vehicles before, during or after the sampling process.

i) Do not use chemical ice packs to cool the samples.

j) Do not use foil as a layer between stacked sample bottles.

k) PFAS sampling of soils currently can only be done using EPA Method 1633.

l) At least one soil sample, preferably in a known/likely PFAS source area, should be analyzed for Total Organic Fluorine (TOF) or Total Oxidizable Precursor (TOP) analysis to assess how much of the potential PFAS compounds are accounted for using Method 1633.

m) Clothing

3. *Permitted*:
   - 100% cotton preferred, but synthetic, polyurethane, PVC, rubber, neoprene, powderless nitrile gloves, uncoated Tyvek® clothing, wax-coated fabrics are acceptable
   - Clothing should be previously laundered (preferably at least six times) without fabric softeners
   - Boots can be either polyurethane, PVC or PFAS-free boot covers
4. *Banned*:
   - New or unwashed clothing, or clothing washed with fabric softeners
   - Clothing treated with fabric protection, water-resistant, stain-resistant or insect-resistant chemicals
   - Any clothing or boots made of Gore-Tex™ or other known PFAS-containing or water-resistant materials.

n) PPE

3. *Permitted*:
   - Powderless nitrile gloves (Sampling personnel must wash their hands with PFAS-free soap and water before putting on any gloves.)
   - HDPE hard hats, or hard hat covers/liners made of cotton or other natural fabrics
   - Safety glasses made with HDPE
   - Life jackets made of polyethylene foam and nylon shell fabric, although likely unnecessary with Direct-Push sampling
   - Waders made of Neoprene or other PFAS-free materials, although likely unnecessary with Direct-Push sampling
   - PFAS-free sunscreen (examples include Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 50, Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, and Neutrogena® Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30)
   - PFAS-free insect repellent (examples include OFF® Deep Woods and Sawyer® Permethrin)
4. *Banned*:

  - Gore-Tex™ gloves, waders or safety equipment, or any other PPE made with PFAS-containing materials
  - Note that further research is needed on the potential use of Latex and leather gloves.

o) Field Materials

3. *Permitted*:
    - Aluminum, polypropylene or Masonite clipboards
    - Rite in the Rain® notebooks
    - Loose paper (non-waterproof and non-recycled)
    - Ballpoint pens and pencils
4. *Banned*:
    - All PFAS-coated materials
    - Post-It® Notes and other adhesive paper products
    - Sharpie markers (there is not a consensus on PFAS in Sharpie markers, but they should not be used unless that are certified PFAS-free)
    - Coated paper towels
    - Aluminum foil should not be used since it is often coated with PFAS, but if a certified PFAS-free foil can be found then it can be used

p) Decontamination

3. *Permitted*:
    - Alconox®, Liquinox® or Citranox®
    - Dry decontaminated equipment using cotton cloth or untreated paper towels, or air dry on a PFAS-free surface
    - Polyethylene or PVC brush to remove particulates
4. *Banned*:
    - Decon 90®
    - Dawn dish detergent
    - PFAS treated paper products

When in doubt, assume that the product contains PFAS and should not be used!

8.0 CALCULATIONS

No calculations are applicable to this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

The following general quality assurance/quality control (QA/QC) procedures apply:

- All data must be documented on field data sheets and/or within the field logbook.

- All instrumentation should be operated and calibrated in accordance with the manufacturer's instructions unless specified otherwise in the site-specific SAWP.
- The collection of an equipment rinsate blank is recommended to evaluate potential for cross-contamination.
- The collection of duplicate samples will likely be required for the project. Refer to the site-specific SAWP and/or *QAPrP* for further information on collection of duplicate samples.
- Trip blanks are required for each cooler with samples for volatile organic compounds analysis.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the hazards associated with soil sampling using direct push technology:

- Exposure to unknown contaminants.
- Lifting and carrying injuries.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE.
- Slips, trips, and fall hazards.
- Injury from moving equipment.
- Underground utilities.
- Loud noises.
- Biohazards, such as snakes, insect bites and poison ivy.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA QA/G-6, US EPA, Office of Environmental Information, April 2007.

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Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, August 2005.

Hewitt, A.D, and N.J.E. Lukash. 1996. Obtaining and Transferring Soils for In-Vial Analysis of Volatile Organic Compounds. U.S. Army Corps of Engineers. Special Report 96-5.

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Sorini, S.S., J.F. Schabron, J.F. Rovani, and M.M. Sanderson. 2009. Soil Samplers: New Techniques for Subsurface Sampling for Volatile Organic Compounds. U.S. Department of Energy. WRI-09-R030.

US EPA Region 4, 2014, *Operating Procedure – Soil Sampling*; SESD PROC-300-R1, U.S. Environmental Protection Agency Region 4, Athens, GA, 24 pp.

US EPA, Contaminated Site Clean-up Information/Characterization and Monitoring/Direct-Push Technologies/Soil and Soil Gas Samplers, Available online at https://clu-in.org/characterization/technologies/soilandsoilgassamp.cfm; US Environmental Protection Agency, Washington, DC.

Soil Sampling Method 5035

SOP OER-0122

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ruth Porter	1.0	7/1/2010	Reformatted, added SOP ID #, and renumbered. Supersedes Revision 0.0. Additional detail provided.	Editorial Technical
Ross Brittain	2.0	11/10/2020	Reformatted and updated the content	Editorial, Technical

SOIL SAMPLING METHOD 5035

SOP OER-0122

Table of Contents

List of Acronyms and Abbreviations

DQO	Data Quality Objective
FID	Flame Ionization Detector
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HLC	Henry's Law Constant
ID	Identification
IDW	Investigation Derived Wasted
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PID	Photoionization Detector
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compounds
WVDEP	West Virginia Department of Environmental Protection
VOA	Volatile Organics Analysis
VOC	Volatile Organic Compounds

Disclaimer: Any mention in this SOP of any products or services does not constitute or imply the endorsement, recommendation or favoring by WVDEP or any of its employees or contractors acting on its behalf.

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide general reference information on sample collection procedures utilizing Method 5035. The use of Method 5035 for the collection of volatiles samples is required for Office of Environmental Remediation (OER) programs within the West Virginia Department of Environmental Protection (WVDEP). The procedures in this SOP may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. The procedures utilized at a site should be documented and included in the site investigation report.

2.0 SUMMARY OF METHOD

Method 5035 was adopted because of studies showing that sampling according to the previous methods resulted in significant losses of selected volatile organic compounds (VOCs). Method 5035 incorporates chemical preservatives and sample storage techniques to limit volatilization and biodegradation of VOCs. There are two collection options for Method 5035: an airtight coring device such as the Encore® sampler or preserved vials (Terra Core™). The collection method determination should be based on holding time, laboratory-processing considerations, soil type (calcareous soils have special considerations when using the preserved vial option), and shipping considerations. Samples for VOC analysis are not homogenized. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples collected with the Encore® Sampler do not require preservation other than being cooled to ≤6ºC, but without freezing the sample. These samples should be extracted by the laboratory within 48 hours of the samples being collected. Samples collected by the Terra Core™ Method undergo chemical preservation. Three 40 mL vials are utilized in the Terra Core™ sampling method. Two of the vials have sodium bisulfate and the third has methanol as the preservative. After soil collection and preservation, the Terra Core™ samples should also be cooled to ≤6ºC, but without freezing the sample. Terra Core™ samples should be extracted by the laboratory within 14 days of the samples being collected.

The type of sample container, the preservative (if any), and holding times should be clearly set forth in the Sampling and Analysis Plan or Site Assessment Work Plan (SAWP) for the site. The sampler should consult the SAWP for all pertinent information relating to the proper sample preservation, type of containers, handling, and storage procedures for their project. Samples should be collected directly from the sampling device into appropriate laboratory cleaned containers. Samples shall be appropriately preserved (if applicable), labeled, and placed in a cooler to be maintained at ≤6ºC, but without freezing the sample in accordance with the SAWP requirements. The samples should be shipped with adequate packing and cooling to ensure that they arrive at the laboratory intact and still ≤6ºC without freezing.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Holding times for samples collected with the Encore® sampling equipment is 48-hours. This creates the need for overnight shipment and/or hand delivery to the laboratory. It also requires immediate attention to the samples by the analytical laboratory.

When using the Terra Core™ Sampling method, calcareous soil samples may react upon contact with sodium bisulfate solution in the pre-preserved sample vial, causing VOC loss through effervescence and potential failure of the VOA vial septum through pressure buildup. Additionally, when soil samples are highly calcareous in nature, the sodium bisulfate preservative solution may not be strong enough to reduce the pH of the aqueous solution to below 2.0, potentially rendering the preservative useless.

5.0 EQUIPMENT APPARATUS

The following are some of the materials and equipment that are potentially needed for soil sampling activities. Refer to the site SAWP to determine specific needs for any given project.

- Encore® Sampler
- Terra Core™ sampler
- Sample containers (Encore® air-tight container or Terra Core™ which will consist of 40- mL vials with appropriate preservative and stirring bar), plus additional minimum 2 oz. glass jar to collect sample for dry weight determination
- Photoionization detector (PID) or flame ionization detector (FID)
- Logbook
- Field data sheets and samples labels
- Chain of custody records and seals
- Sample and shipping containers
- Preservatives, as applicable
- Packing materials
- Decontamination solutions (i.e., tap water, non-phosphate soap, distilled water)
- Brushes
- Sampling gloves
- Plastic bags
- Containers for investigation derived waste
- Personal protective equipment (PPE)

6.0 REAGENTS

The Terra Core™ vials should come pre-prepared from the laboratory with the proper chemical preservatives (sodium bisulfate and methanol). Reagents for the decontamination of non-disposable sampling equipment used to collect the soil samples will be required. Refer to the SOP for the decontamination procedures and required reagents.

7.0 PROCEDURES

7.1 Encore® Sample Collection Method

a) Clear any surface debris (e.g., vegetation, rocks, twigs) from the sampling location.

b) Before taking the sample, hold the coring body and push plunger rod down until the small o-ring rests against tabs. This will ensure that the plunger moves freely.

c) Depress locking lever on Encore® T-Handle. Place coring body, plunger end first, into open end of T-Handle, aligning the (2) slots on the coring body with the (2) locking pins in the T-Handle. Twist coring body clockwise to lock pins in slots. Check to ensure sampler is locked in place. Sampler is ready for use.

d) Turn T-Handle with T-up and coring body down. This positions the plunger bottom flush with the bottom of the coring body (ensure that the plunger bottom is in position). Using T-Handle, push sampler into soil until the coring body is completely full. When full, the small o-ring will be centered in T-Handle viewing hole. Remove sampler from soil. Wipe excess soil from the coring body exterior.

e) Cap the coring body while it is still on the T-handle. Push the cap over flat area of ridge. Push and twist the cap to lock the arm in place. Cap must be seated to seal the sampler.

f) Remove the capped sampler by depressing locking lever on T-Handle while twisting and pulling sampler from T-Handle. Lock the plunger by rotating the extended plunger rod fully counterclockwise until the wings rest firmly against the tabs.

g) Place the capped sampler back into the Encore® sample zipper bag and label. Seal the bag and put on ice. Samples collected with the Encore® method should be analyzed within 48 hours or preserved by the laboratory within 48 hours. Collect sample for dry-weight determination in 2-oz. glass jar. This container should be air-tight (septum lid) but should not contain any preservative. Place this sample in the cooler with the Encore® samples.

h) Record the following information in the field logbook:

- Sample ID
- Location
- Depth of sample
- Soil type description
- Equipment used
- Apparent moisture content (i.e., dry, moist, wet)
- Color
- Odor
- Field screening instrument readings, if applicable
- Any other pertinent information (e.g., date, time and sampler)

7.2 TerraCore™ Sampling Method

a) A determination of whether the sample will be considered high (>200 µg/Kg) or low (0.5-200 µg/Kg) concentration should be performed. This may be based on DQOs, expected concentrations, or regulatory limits. If the expected concentrations cannot be estimated prior to sampling, and/or DQOs or other considerations indicate the need for both concentration levels, both low and high concentration aliquots should be collected. Refer to the Table below for appropriate sample containers for high/low sample concentrations.

Sample Container and Preservative Requirements for Samples Collected by the TerraCore™ Method

Concentration of Volatiles **Solid Type**	**<200 ug/kg**	**>200 ug/kg**	**Unknown Concentrations**
Non-Reactive	3-40 mL vials with 5 mL of organic free reagent water, 1 gram of $NaHSO_4$ and a magnetic stirring bar weighed to the nearest 0.01gram[1]	3-40 mL vials with 5 mL of methanol weighed to the nearest 0.01gram[1]	3-40 mL vials with 5 mL of organic free reagent water, 1 gram of $NaHSO_4$ and a magnetic stirring bar weighed to the nearest 0.01gram[1] AND 3-40 mL vials with 5 mL of methanol weight checked to the nearest 0.01gram[1]
Reactive	3-40 mL vials with 5 mL of organic free reagent water weighed to the nearest 0.01gram[1]	3-40 mL vials with 5 mL of methanol weighed to the nearest 0.01gram[1]	3-40 mL vials with 5 mL of organic free reagent water weighed to the nearest 0.01gram[1] AND 3-40 mL vials with 5 mL of methanol weighed to the nearest 0.01gram[1]
Unknown	3-40 mL vials with 5 mL of organic free reagent water, 1 gram of $NaHSO_4$ and a magnetic stirring bar weighed to the nearest 0.01gram[1] AND 3-40 mL vials with 5 mL of organic free reagent water weighed to the nearest 0.01gram[1]	3-40 mL vials with 5 mL of methanol weighed to the nearest 0.01gram[1]	3-40 mL vials with 5 mL of organic free reagent water, 1 gram of $NaHSO_4$ and a magnetic stirring bar weighed to the nearest 0.01gram[1] AND 3-40 mL vials with 5 mL of organic free reagent water weighed to the nearest 0.01gram[1] AND 3-40 mL vials with 5 mL of methanol weighed to the nearest 0.01gram[1]

[1] The vials will be pre-weighed by the laboratory to the nearest 0.01gram. If the required weight check is performed in the field, a variance of up to 0.2 grams is allowed. If the required weight check is performed in the laboratory, a variance of up to 0.01 gram is allowed. Weight checks should be performed within 24 hours of use.

b) Prior to adding solid to any vial, the individual vial should be checked to ensure that the weight of the vial and preservative have been written on the vial by the laboratory.

c) Clear any surface debris (e.g., vegetation, rocks, twigs) from the sampling location.

d) Have ready a 40-mL glass volatile organic analysis (VOA) vial containing the appropriate preservative. With the plunger seated in the handle, push the Terra Core™ into freshly exposed soil until the sample chamber is filled. A filled chamber will deliver approximately 5 grams of soil.

e) Wipe all soil or debris from the outside of the Terra Core™ sampler. The soil plug should be flush with the mouth of the sampler. Remove any excess soil that extends beyond the mouth of the sampler.

f) Rotate the plunger that was seated in the handle top 90° until it is aligned with the slots in the body. Place the mouth of the sampler into the 40-mL VOA vial containing the appropriate preservative and extrude the sample by pushing the plunger down, holding the VOA at a 45-degree angle so that when the soil plug falls into the preservative, none splashes out of the container. Quickly place the lid back on the 40-mL VOA vial. Repeat steps d-f for additional sample vials as necessary.

Note: When capping the 40-mL VOA vial, be sure to remove any soil or debris from the threads of the vial.

g) Place the containers in a plastic bag and seal. Store sample on ice at approximately <6°C but without freezing. Collect sample for dry-weight determination in 2-oz. glass jar. This container should be air-tight (septum lid) but should not contain any preservative. Place this sample in the cooler with the Terra Core™ sample vials. Deliver the cooler to the laboratory.

h) Record the following information in the field logbook:

- Sample ID
- Location
- Depth of sample
- Soil type description
- Equipment used
- Apparent moisture content (i.e., dry, moist, wet)
- Color
- Odor
- Field screening instrument readings, if applicable
- Any other pertinent information (e.g., date, time and sampler)

8.0 CALCULATIONS

No calculations are applicable to this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

The following general quality assurance/quality control (QA/QC) procedures apply:

- All data must be documented on field data sheets and/or within the field logbook.
- All instrumentation should be operated and calibrated in accordance with the manufacturer's instructions unless specified otherwise in the site-specific SAWP.
- The collection of duplicate samples will likely be required for the project. Refer to the site-specific SAWP and/or *QAPrP* for further information on collection of duplicate samples.
- Trip blanks are required for each cooler with samples for volatile organic compounds analysis.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the potential hazards associated with this SOP.

- Exposure to unknown contaminants.
- Exposure to chemical reagents and preservatives.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE.
- Slips, trips, and fall hazards.
- Biohazards, such as snakes, biting insects and poison ivy.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA QA/G-6, US EPA, Office of Environmental Information, April 2007.

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, August 2005.

Test Methods for Evaluation of Solid and Hazardous Wastes, SW 846 Method 5035, US Environmental Protection Agency, Washington, DC 1998.

US EPA Region 4, 2014, *Operating Procedure – Soil Sampling*; SESD PROC-300-R1, U.S. Environmental Protection Agency Region 4, Athens, GA, 24 pp.

Soil Gas Sampling

SOP OER-0130

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ross Brittain	0.0	1/10/2021	Created new SOP and SOP ID#	Editorial, Technical
Ross Brittain	1.0	1/14/2025	Edit to clarify modeling clay use and length of sample time	Editorial

SOIL GAS SAMPLING

SOP OER-0130

Table of Contents

List of Acronyms and Abbreviations

AC	Alternating Current
°C/°F	Degrees Celsius/Degrees Fahrenheit
FID	Flame Ionization Detector
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
GPS	Global Positioning System
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	High Density Polyethylene
HEPA	High Efficiency Particulate Air
HPLC	High Performance Liquid Chromatography
IDW	Investigation Derived Wasted
L	Liter
NPT	National Pipe Thread
OD	Outer Diameter
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PID	Photoionization Detector
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compound
VOC	Volatile Organic Compound
USEPA	United States Environmental Protection Agency
WVDEP	West Virginia Department of Environmental Protection

1.0 SCOPE AND APPLICATION

Vapor intrusion of volatile organic compounds (VOCs), some semi-volatile organic compounds (SVOCs) and some vapor-phase metals (e.g., mercury) is often a leading risk pathway for contaminated sites, especially those with petroleum and/or halogenated compounds. Methods for identifying and tracing the movement of underground vapor-phase contaminants is critical to protecting human health. The purpose of this standard operating procedure (SOP) is to outline the methods used to install soil gas wells and sub-slab probes, as well as collecting soil gas using Tedlar bags and/or Summa canisters. Alternate methods of collecting samples, such as sorbent tubes, may be proposed for the site and the West Virginia Department of Environmental Protection (WVDEP) will review the merits of such alternatives for potential approval. These procedures may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. Refer to the site-specific Sampling and Analysis Plan or Site Assessment Work Plan (SAWP) for details on the procedures to be used at the site. The procedures utilized at a site should be documented and included in the site investigation report.

2.0 SUMMARY OF METHOD

2.1 Soil Gas Wells

A hole is driven into the ground using manual (e.g., slam bar) or power driven mechanical (e.g., Geoprobe) methods. A probe made from inert materials (e.g., stainless steel, copper, brass, PVC, or HDPE) is connected to ¼-inch outer diameter (OD) tubing inserted into the hole. Once the probe is inserted, silica sand should be poured into the hole so that the probe is covered by no less than six inches of silica sand. The remaining annular space in the hole shall be filled with expandable clay (such as bentonite chips) and wetted so that a seal is created between the sand-packed probe and the ambient air. The interstitial gases may be pulled through the probe using an air sampling pump where the sample may be stored in a Tedlar bag. Summa canisters do not require an air sampling pump, but rather are sampled by soil gas equilibration with the evacuated Summa canister. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

2.2 Sub-Slab Probes

Sub-slab probes can be installed by assembling a probe following the procedures outlined in this SOP, or installing a vapor probe kit (e.g., VaporPin®) using the manufacturer's SOP to ease the installation procedures. Using a ⅜" diameter drill bit and an electric hammer drill or rotary hammer, an inner or pilot hole is drilled into the concrete slab to a depth ~2 inches below the slab. An outer hole is drilled to a depth of ~1⅜ inches using a 1-inch diameter drill bit and the pilot hole as the center. The 1-inch drill bit is then replaced by the ⅜-inch drill bit and the pilot hole is drilled through the slab and several inches into the subsurface soils. After drilling is complete, a probe made from inert materials (e.g., stainless steel, copper, or brass) is assembled, inserted into the pre-drilled hole, flush-mounted with the surrounding slab so it will not interfere with traffic and cemented into place. Tubing is then attached to the probe assembly and to a sample container/system. Specific details for sampling at any location should be found in the SAWP.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.1 Tedlar Bags

Soil gas samples can be collected in 1.0 liter (L) Tedlar bags, which should be stored in the dark (e.g., opaque containers) and protected from damage during transit to the laboratory. Sample bags should be kept at ambient temperatures and out of direct sunlight and analyzed within 48 hours of sample collection.

3.2 Summa Canisters

Summa canisters have up to a 6.0 L capacity and are certified clean by gas chromatography/mass spectrometry (GC/MS) before collecting samples in the field. Canisters are stored and shipped in travel cases and should be analyzed within 30 days of sample collection. The canister should be fitted with a regulator valve properly calibrated by the laboratory to allow a maximum flow rate of 200 milliliters per minute (mL/min).

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 General

Physical and chemical characteristics of the soils and soil moisture can affect the concentrations of VOCs in soil gas. Highly charged soil particles, such as clays, can cause VOCs to be tightly adsorbed to the soils, and highly soluble compounds can dissolve in soil water or associate with organic matter in the soil and reduce the concentrations in the interstitial pore spaces. Fine textured soil may also impede the movement of soil vapors or reduce the sample volume available. High or perched water tables and impermeable subsurface layers may also interfere with the movement and sampling of soil gas. Soil Conservation Service soil surveys and other existing knowledge of site geology should be consulted prior to planning a soil gas survey. Importantly, it has been found that lighter SVOCs, particularly Naphthalene, may have significant sample losses in cool conditions (Hayes et al. 2005) and differences in soil temperatures in the upper profile can lead to variations in soil gas concentrations by a factor of two for all VOCs (Luo et al. 2009, USEPA 2010, Hers et al. 2014, Johnson and Deeb 2014). Accordingly, WVDEP recommends that soil gas be sampled when the ambient temperature is at least 21°C (70°F), especially when sampling for Naphthalene.

WVDEP may require additional samples be collected at a time when ambient temperature is at least 21°C to verify the data if soil vapor is collected during periods of relatively low soil and ambient air temperatures, especially when initial sample concentrations are greater than one-half of benchmark values.

4.2 Soil Probe Clogging

Clogging of the soil gas probes is a common problem, best identified by using an in-line gauge or by listening for the sound that the pump is laboring. Clogging can usually be remedied by using a wire cable to clear the probe.

4.3 Underground Utilities

An underground utility search must be completed prior to selecting the sample locations by calling Miss Utility West Virginia at 811, or using the West Virginia 811 App. Additionally, the local utility companies can be contacted and requested to mark the locations of their underground lines. Each sample location should also be screened with a metal detector or magnetometer to verify that no metallic pipes, drums or other objects are present. Installation of sub-slab sample probes should also take place after first locating water, sanitary sewer, gas, electric or other potential buried hazards under the foundation/floor. The biggest and most constant threat to personnel safety is the existence of rebar in the concrete slab, since a significant number of structures utilize rebar grids for floor construction.

4.4 Sample Time

Sub-slab and soil gas samples should preferentially be collected multiple times over the course of a year or more to understand the temporal variability and its potential impact on cumulative exposures. However, such sampling frequency is often cost-prohibitive. Thus, samples are generally collected during the worst-case scenario or season. Soil gas samples should be collected during the hottest and driest time of the year (generally late summer and early fall) when volatilization is typically at its maximum rate and has had time to build up in the soil pore space. Sub-slab samples should either be collected during the same time as soil gas or in the middle of winter when the negative pressure inside a building from running a furnace should create maximum vapor concentrations just below the slab. It is important to note that temperature differences between soil gas and ambient air may also lead to condensation of heavier VOCs (e.g., Naphthalene) on the sample train itself, resulting in a low-bias sample. Thus, Naphthalene should be sampled during the summer season in soil gas and sub-slab locations. If soil gas and/or sub-slab samples are collected during the worst-case scenario time periods, then only one round of samples is usually sufficient to assess potential risks. However, soil gas and/or sub-slab samples collected outside of the worst-case scenario time periods will require additional samples to account for temporal variability.

In addition to time of year, residents are assumed to spend 24 hours a day in the residence, while industrial workers are assumed to spend eight (8) hours a day at the work location. Since soil gas and sub-slab concentrations will vary throughout the day, it is important to collect the samples over a time period that integrates conditions during these timeframes. Thus, residential buildings should be sampled for 24 hours to integrate conditions over a "typical" day, whereas commercial buildings should be sampled for 8 hours during normal business hours. Note that shorter time periods can be used but may also require additional samples to assess cumulative exposures.

5.0 EQUIPMENT APPARATUS

5.1 Soil Gas Wells

5.1.1 Slam Bar/Stainless Steel Hand Auger Method

- Slam bar or Stainless-Steel Hand Auger
- Soil gas probes (stainless steel screen, ¼-inch OD, 5-foot length)
- Flexible wire or cable
- "Quick Connect" fittings, if applicable
- Bentonite clay
- Vacuum box
- Pumps, capable of drawing approximately 3.0 L/min
- ¼-inch OD tubing (type of tubing contingent upon site and sample requirements), ~3-ft length
- Tedlar bags, 1.0-L, if applicable
- Summa canisters (plus shipping cases), if applicable
- Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)
- PID/FID for field air monitoring, if applicable
- Cooler(s)
- Metal detector or magnetometer, if applicable
- Portable GC instrument, if applicable
- Large plastic bags
- Silica sand
- Tubing cutter

5.1.2 Direct-Push (Geoprobe) Method

- Tubing: Polyethylene or Teflon
- Gas sampling cap
- Probe rods
- Tubing adaptor(s)
- Expendable point holder, threaded
- Expendable drive point(s)
- O-rings for expendable point holder
- O-rings for adaptor
- O-rings for probe rods
- O-rings for gas sampling cap
- Vacuum pumps
- PID/FID for field air monitoring
- Tape
- Tedlar bags, 1.0-L, if applicable
- Summa canisters (plus shipping cases), if applicable
- Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)
- Metal detector or magnetometer, if applicable
- Cooler(s)
- Large dark plastic bags
- Portable GC instrument, if applicable
- Silica sand
- Tubing cutter

5.2 Sub-Slab Probes

- PID/FID for field air monitoring, if applicable
- Modeling clay (VOC free to prevent cross contamination)
- Hammer Drill or Rotary Hammer
- Alternating current extension cord
- Alternating current generator, if AC power is not available on site
- Hammer or Rotary Hammer drill bits, ⅜” and 1” diameter
- Portable vacuum cleaner with HEPA filter
- 1 - ¾-inch open end wrench or 1-medium adjustable wrench
- 2 – 9/16-inch open end wrenches or 2-small adjustable wrenches
- Hex head wrench, ¼-inch
- Tubing cutter
- Disposable non-plastic cups, ~5 ounce
- Disposable non-plastic mixing device (e.g., craft stick, tongue depressor, etc.)
- Swagelok SS-400-7-4 Female Connector, ¼-inch National Pipe Thread (NPT) to ¼-inch Swagelok connector, or equivalent

- Swagelok SS-400-1-4 Male Connector, ¼-inch NPT to ¼-inch Swagelok connector, or equivalent
- ¼-inch NPT flush mount hex socket plug, Teflon-coated
- ¼-inch OD stainless steel tubing, pre-cleaned, instrument grade
- ¼-inch OD Teflon tubing
- Teflon thread tape
- ⅛-inch OD stainless steel rod, 12-inch to 24-inch length
- Swagelok Tee, optional (SS-400-3-4TMT or SS-400-3-4TTM), or equivalent

6.0 REAGENTS

Refer to the site-specific SAWP for the preservatives required for the specified analysis to be performed. The following reagents are generally used for soil gas sampling in a soil gas well:

- Calibration and spike gases
- Deionized water
- Methanol, High Performance Liquid Chromatography (HPLC) grade
- Ultra-zero grade compressed air
- Bentonite

The following reagents are generally used for soil gas sampling from sub-slab probes:

- Tap water, for mixing anchoring cement
- Anchoring cement
- Modeling clay/Bentonite

7.0 PROCEDURES

7.1 Soil Gas Well Installation

7.1.1 Slam Bar/Stainless Steel Hand Auger Method

1. Before digging/drilling the hole, a soil gas probe made from inert materials (e.g., stainless steel, copper, brass, PVC, or HDPE) is constructed. Example probe construction includes ¼-inch outer diameter (OD) stainless steel (USEPA Environmental Response Team 2001), and 1-inch PVC 0.010-slot well screen, with a screen length at least 1-ft long. A PVC busing fitted with a ¼-inch nylon hose bard is installed on the top of the probe to allow for connecting sample tubing, and a PVC cap is fitted on the bottom. All connections must be threaded or friction fit and no solvent or glue can be used to prevent false detections of VOCs.
2. A hole slightly deeper than the required depth is made using a piston slam bar or stainless-steel hand auger. Generally, the well should be approximately 5-ft deep to assess the soil gas in the typical basement zone. Soil gas wells can be deeper than 5-ft, especially if the near-source zone is much deeper, but

should not be less than 5-ft deep unless the presence of shallow groundwater prevents sampling soil gas at a depth of 5-ft or deeper. If shallow groundwater is present, consider the possibility of assessing soil gas via sub-slab samples, but if sub-slab samples would not allow adequate spatial cover to assess future buildings, then make the soil gas well as deep as possible. If depths deeper than 5-ft are required, use a piston slam bar with extensions.

3. Drive the slam bar rod or dig the hole using an auger to the desired depth. After the hole is made, the slam bar/hand auger is carefully withdrawn to prevent the collapse of the walls.
4. The soil gas probe is carefully inserted into the hole. The probe is inserted to full depth of the hole, then pulled up three to six inches. The probe is cleared by moving the cable up and down several times.
5. The annular space between the probe and the borehole should be filled with a silica sand pack from the bottom of the borehole to at least 6 inches above the top of the probe. A bentonite grout seal should be placed in the annual space between the sample tubing connected to the probe and the borehole above the sand pack to the surface, or the probe may have a steel manway installed.

7.1.2 Direct-Push Method

1. Direct-push sampling technology refers to soil gas samplers that are inserted into the ground without the use of slam bars, demolition hammers, or drilling rigs, such as a Geoprobe.
2. Sampling probes, consisting of 3-foot sections of flush-threaded, 1¼-inch hardened steel alloy steel rod tipped by an expendable steel point, are available from Direct-Push suppliers and are driven into the ground to the target depth (default depth is 5-ft, but may be deeper if specified in the SAWP). The probe tools are withdrawn to release the expendable tip and allow soil gas to flow into the tool’s tubing.
3. To ensure a representative soil gas sample, a discrete volume of gas is purged to rid the tubing of atmospheric air and allow the subsurface soil gas to enter the probe tubing. The volume of gas removed is determined by the volume of tubing used in the probe necessary to remove two times the volume of the ambient air in the tubing.
4. After allowing the system to return to atmospheric pressure, an aliquot of soil gas is withdrawn from the probe. Duplicate samples are collected as necessary and required in the site-specific SAWP.
5. If semi-permanent soil gas installations are required, the probe remains in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.2 Sub-Slab Probe

7.2.1 Assembly and Installation

Note that this assembly and installation is based on creating a sub-slab probe from scratch. Project Managers can use this method or alternately use a pre-manufactured vapor probe kit, such as Vapor Pin®, and follow their installation SOP to ease the process.

1. Drill a ⅜-inch diameter inner or pilot hole to a depth of 2 inches below the slab.
2. Using the ⅜-inch pilot hole as your center, drill a 1-inch diameter outer hole to a depth of 1⅜ inches. Using a pre-assembled probe for testing the depth may facilitate the process. Vacuum out any cuttings from the hole.
3. Verify that the ⅜-inch inner or pilot hole extends through the slab and a few inches into the sub-slab material and is clear of debris. Redrill the ⅜-inch hole as necessary. Vacuum out any cuttings from the hole.
4. Determine the length of stainless-steel tubing required to reach from the bottom of the outer hole, through the slab and into the open cavity below the slab. To avoid obstruction/clogging of the probe tube, ensure that it does not contact the sub-slab material. Using a tube cutter, cut the tubing to the desired length.
5. Attach the measured length (typically 8-12 inches) of ¼-inch OD stainless steel tubing to a female connecter (e.g., Swagelok SS-400-7-4, or equivalent) with the nut. Tighten the nut.
6. Insert the ¼-inch hex socket plug into the female connector. Tighten the plug. **Do not over tighten.** If excessive force is required to remove the plug during the sample set up phase, the probe may break loose from the anchoring cement. The sampling probe may be pre-assembled.
7. Place a small amount of clean modeling clay around the stainless-steel tubing adjacent to the nut, which connects the stainless-steel tubing to the female connector. Use a sufficient amount of modeling clay so that the completed probe will create a seal between the outer and inner holes, when placed in the outer hole. The clay seal will prevent any anchoring cement from flowing into the inner hole during the final step of probe installation.
8. Place the completed probe into the outer hole. The probe tubing should not contact the sub-slab material, and the top of the female connector should be flush with the surface of the slab and centered in the outer hole. If the top of the completed probe is not flush with the surface of the slab, due to the outer hole depth being greater than 1⅜ inches, additional modeling clay may be placed around the stainless-steel tubing adjacent to the nut that connects the stainless tubing to the female connector. Use a sufficient amount of clay to raise the probe until it is flush with the surface of the slab while ensuring that a portion of the clay will still contact and seal the inner hole.
9. Mix a small amount of the anchoring cement and use it to fill the space between the probe and the outside of the outer hole. Allow the cement to cure according to manufacturer's instructions before sampling.

7.2.2 Sampling Set-Up

1. Wrap one layer of Teflon thread tape onto the NPT end of the male connector (e.g., Swagelok SS-400-1-4, or equivalent).
2. Remove the ¼-inch hex socket plug from the female connector (e.g., Swagelok SS-400-7-4, or equivalent).
3. To ensure that the interior of the sampling probe has not been blocked by the collapse of the inner hole below the end of the stainless-steel tubing, a stainless-steel rod, ⅛-inch diameter, may be passed through the female connector and the stainless-steel tubing. The rod should pass freely to a depth greater than the length of the stainless-steel tubing, indicating an open space or loosely packed soil below the end of the stainless-steel tubing. Either condition should allow a soil gas sample to be collected. If the probe appears blocked, the stainless-steel rod may be used as a ramrod to attempt to open the probe. If the probe cannot be opened, it should be reinstalled or a new probe installed in an alternate location.
4. Screw and tighten the male connector into the female connector. **Do not over tighten.** Overtightening may cause the probe to break loose from the anchoring cement during this step or when the male connector is removed upon completion of the sampling event.
5. If a collocated sub-slab sample or split sample is desired, a stainless-steel tee (e.g., Swagelok SS-400-3-4TMT, SS-400-3-4TTM or equivalent) may be used in place of the male connector.
6. Attach a length of ¼-inch OD Teflon tubing to the male connector with a nut. The Teflon tubing is then connected to the sampling container or system to be used for the sample collection.
7. After sample collection, remove the male connector from the probe and reinstall the hex socket plug. It is recommended that the hex socket plug be wrapped with Teflon thread tape prior to re-installation. **Do not over tighten** the hex socket plug. If excessive force is required to remove the plug during the next sampling event the probe may break loose from the anchoring cement.

7.2.3 Repairing a Loose Probe

1. If the probe breaks loose from the anchoring cement while removing or installing the hex head plug or the male connector (e.g., Swagelok SS-400-14, or equivalent), lift the probe slightly above the surface of the concrete slab.
2. Hold the female connector (e.g., Swagelok SS-400-7-4, or equivalent) with the ¾-inch open wrench.
3. Complete the step being taken during which the probe broke loose, following the relevant instructions above, remembering not to overtighten the connections.
4. Push the probe back down into place and reapply the anchoring cement.
5. Modeling clay may be used as a temporary patch to seal around the probe until the anchoring cement can be reapplied.

7.3 Tedlar Bag Sampling

1. Sampling will take place at least 2 hours after construction to allow for equilibration, preferably 24 hours or more.
2. An amount of air equivalent to three times the volume of the soil gas well must be evacuated prior to sampling (Purge volume = $3\pi r^2 h$, where r is the radius of the inner probe and connecting tubing, and h is the entire length of the sampling train). Connect a vacuum pump, hand pump or soil gas syringe to the sample probe using a section of Teflon tubing. If using a vacuum pump, calculate the required length of time to purge the required volume, turn on the pump and adjust the flow rate to 3.0 L/minute. The calculated volume of air is evacuated from the hole for the specified length of time or extracted for the equivalent volume using a hand pump or soil gas syringe.
3. A leak test should also be performed by placing a shroud around the sample train and using a tracer gas (99.999% laboratory grade helium) to enrich the atmosphere within the shrouded sampling train. A vacuum should then be drawn on the sampling tubing at 150-160 mL/min rate and the vacuum exhaust monitored for helium using a helium detector that has been factory calibrated within the past year. Any leaks showing >10% of the ambient helium reading should be located and sealed before proceeding with sampling.
4. After evacuation and leak test, a PID/FID monitoring instrument is connected to the probe using a Teflon connector. Upon stabilization, the reading is recorded on soil gas data sheets.
5. Use the vacuum box and sampling train to collect the sample. The sampling train is designed to minimize the introduction or loss of contaminants due to adsorption and other factors. All parts used are either Teflon or stainless steel, and a vacuum is drawn directly to avoid contamination from the pumps.
6. Place the Tedlar bag inside the vacuum box, attach it to the sampling port and open the valve. The sample probe should be attached to the sampling port with Teflon tubing and a “Quick Connect” fitting.
7. Draw a vacuum around the outside of the bag, using a pump connected to the vacuum box evacuation port with Tygon tubing and a “Quick Connect” fitting. The negative pressure inside the box causes the bag to inflate, drawing the sample into the bag.
8. Break the vacuum by removing the Tygon line from the pump. Remove the bagged sample from the box and close the valve. Record the date, time, sample location ID, name of sampler and any other pertinent information on the sample bag label and on data sheets or in logbooks.
9. Bags should not be labeled directly with a marker or pen, nor should adhesive labels be affixed directly to the bags. Inks and adhesive may diffuse through the bag material and contaminate the sample. Labels should be tied to the metal eyelets provided on the bags.
10. Chain-of-custody sheets must accompany the samples to the laboratory.

7.4 Summa Canister Sampling

1. Sampling will take place at least 2 hours after construction to allow for equilibration, preferably 24 hours or more.
2. Before installing any Summa canister, be sure to conduct a shut-in or leak test on the Summa canister according to manufacturer specifications. Faulty connections have been known to cause failed sampling events that have to be repeated.
3. An amount of air equivalent to three times the volume of the soil gas well must be evacuated prior to sampling (Purge volume = $3\pi r^2 h$, where r is the radius of the inner probe and connecting tubing, and h is the entire length of the sampling train). Connect a vacuum pump to the sample probe using a section of Teflon tubing. Turn on the pump and adjust the flow rate to 3.0 L/minute. The calculated volume of air is evacuated from the hole by pulling a vacuum through the probe for the specified length of time.
4. A leak test should also be performed by placing a shroud around the sample train and using a tracer gas (99.999% laboratory grade helium) to enrich the atmosphere within the shrouded sampling train. A vacuum should then be drawn on the sampling tubing at 150-160 mL/min rate and the vacuum exhaust monitored for helium using a helium detector that has been factory calibrated within the past year. Any leaks showing >10% of the ambient helium reading should be located and sealed before proceeding with sampling.
5. After evacuation and leak test, a PID/FID monitoring instrument is connected to the probe using a Teflon connector. Upon stabilization, the reading is recorded on soil gas data sheets.
6. Attach a certified clean, evacuated 6-L Summa canister via the ¼-inch Teflon tubing. (Note that other sizes of Summa canisters are available and acceptable with WVDEP approval for specific conditions, but 6-L canisters are the default size.)
7. Open the valve on the Summa canister. The soil gas sample is drawn into the canister by pressure equilibration. The approximate sampling time for a 6-L canister is variable depending on the receptors of concern. Generally, the longer the sample time, the better. Residential buildings should be sampled for 24 hours, but a minimum of 8 hours during the most active portion of the day is acceptable. Industrial buildings should be sampled for 8 hours during typical business operations. Shorter sample durations are possible but additional sampling may be necessary to account for daily variability. Soil gas samples should be collected during the late summer/early fall and sub-slab samples in either late summer/early fall or middle of winter to account for worst-case scenarios. Otherwise, multiple rounds of samples will need to be collected to assess cumulative risks.
8. Sample number, sample location, date collected, sampler name and any other pertinent sample information must be recorded on a chain-of-custody form and on a blank tag attached to the canister.
9. Chain-of-custody sheets must accompany the samples to the laboratory.

8.0 CALCULATIONS

Calculations used to determine concentrations of individual components are beyond the scope of this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

9.1 Sample Probe Contamination

Sample probe contamination is checked between each sample by drawing ambient air through the probe using a vacuum pump and checking the response with a PID/FID. If readings are higher than background, replacement or decontamination is necessary. Sample probes may be decontaminated simply by drawing ambient air through the probe until the PID/FID reading is at background. Contamination can also be removed by decontaminating with alconox and deionized water, then air drying. For persistent contamination, use of a portable propane torch may be needed. Using a pair of pliers to hold the probe, run the torch up and down the length of the sample probe for approximately 1-2 minutes. Let the probe cool before handling. When using this method, make sure to wear gloves to prevent burns. Having more than one probe per sample team will reduce lag times between sample stations while probes are decontaminated.

9.2 Sample Train Contamination

The Teflon line forming the sample train from the probe to the Tedlar bag should be changed on a daily basis. If visible contamination (soil or water) is drawn into the sampling train, it must be changed immediately. When sampling in highly contaminated areas, the sampling train should be purged with ambient air, via a vacuum pump, for approximately 30 seconds between each sample. After purging, the sample train can be checked using a PID/FID to establish the cleanliness of the Teflon line.

9.3 PID/FID Calibration

The PID and/or FID must be calibrated at least once a day using appropriate calibration gases.

9.4 Trip Blanks

A trip blank detects any sample contamination during shipping and storage. With the exception of Summa canisters, the trip blank is prepared and added to the site samples after sampling has been completed and prior to shipment.

9.4.1 Tedlar Bags

Each cooler containing Tedlar bag samples must contain one Tedlar bag of ultra-zero grade air, acting as a trip blank for samples shipped to a laboratory. Chain-of-custody records must accompany each cooler of samples and should include the blank that is dedicated to that cooler.

9.4.2 Summa Canisters

Canister trip blanks are evacuated containers that are shipped to and from the site with the canisters used for air sampling.

9.5 Field Blanks

Field blanks detect sample contamination during the handling and shipping process associated with a specific sampling event.

9.5.1 Tedlar Bags

For each day of sampling, a Tedlar bag is filled with ultra-zero air at the beginning of the day and handled in the same manner as the samples.

9.5.2 Summa Canisters

For each day of sampling, a Summa canister is filled with ultra-zero air at the beginning of the day and handled in the same manner as the samples, including attachment of regulator valve and leak test.

9.6 Trip Standards

If Tedlar bags are used for sampling, each cooler containing samples should contain a Tedlar bag of standard gas to calibrate the analytical instruments. This trip standard will be used to determine any changes in concentrations of the target compounds during the course of the sampling day (e.g., migration through the sample bag, degradation, or adsorption). A fresh trip standard must be provided and placed in each cooler pending additional sample collection. Chain-of-custody records must accompany each cooler of samples and should include the trip standard that is dedicated to that cooler.

9.7 Lot Blanks

9.7.1 Tedlar Bags

Prior to use, one bag is removed from each lot of Tedlar bags to be used for sampling and checked for possible contamination as follows: Fill the test bag with ultra-zero grade air; withdraw a sample from the bag and analyze using a field portable GC or other field instrument to ensure sample container cleanliness prior to the start of the sampling effort.

9.7.2 Summa Canister Check

From each lot of four cleaned Summa canisters, one is used for a GC/MS certification check. If the canister passes certification, it is re-evacuated and all four canisters from that lot are available for sampling. If the chosen canister is contaminated, the entire lot of four Summa canisters must be re-cleaned and a single canister is re-analyzed by GC/MS for certification.

9.8 Duplicate Samples

A minimum of 5% of all samples should be collected in duplicate. The Project Manager will choose which samples to duplicate, typically in areas of highest concern. However, a duplicate may be taken only if after filling the first Tedlar bag and evacuating the well for 15 seconds, the second field monitoring device is within 20% of the first reading.

9.9 Spikes

A Tedlar bag spike and sorbent tube spike may be desirable in situations where high concentrations of contaminants other than the target compounds are found to exist (e.g., landfills). The additional level of QA/QC attained by this practice can be useful in determining the effects of interferences caused by these non-target compounds. Summa canisters containing samples are not spiked.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or Quality Assurance Program Plan (*QAPrP*) shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*. However, for each target compound to be considered valid, the concentration found in the sample must be greater than three times the level of that compound found in the appropriate blank (lot, field and trip) that accompanied that sample. Additional data to be verified/validated include but is not limited to location information, GPS coordinates, digital photographs and area sketches.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the hazards associated with well sampling:

- Exposure to unknown contaminants
- Lifting injuries associated with moving equipment, coolers with samples.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE

- Slips, trips, and fall hazards
- Biological hazards such as insects, snakes, spiders and poison ivy
- Below surface pipes and rebar

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known site contaminants of potential concern, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

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Indoor Air Sampling

SOP OER-0131

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ross Brittain	0.0	1/10/2021	Created new SOP and SOP ID#	Editorial, Technical
Ross Brittain	1.0	1/14/2025	Edited for grammar and clarifying timing issues	Editorial

INDOOR AIR SAMPLING

SOP OER-0131

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List of Acronyms and Abbreviations

DL	Detection Limit
FID	Flame Ionization Detector
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
GPS	Global Positioning System
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HPLC	High Performance Liquid Chromatography
IDW	Investigation Derived Wasted
L	Liter
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PID	Photoionization Detector
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
RL	Reporting Limit
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compound
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
USEPA	United States Environmental Protection Agency
WVDEP	West Virginia Department of Environmental Protection

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1.0 SCOPE AND APPLICATION

Vapor intrusion of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) and some vapor-phase metals (e.g., mercury) is often a leading risk pathway for contaminated sites, especially those with petroleum and/or halogenated compounds. Methods for identifying and tracing the movement of underground vapor-phase contaminants is critical to protecting human health. The purpose of this standard operating procedure (SOP) is to outline the methods and equipment used to sample ambient or indoor air. These procedures may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. Experience, objectives, site characteristics and chemical characteristics will dictate sampling strategy. Thus, alternate methods of collecting samples may be proposed for the site and the West Virginia Department of Environmental Protection (WVDEP) Office of Environmental Remediation (OER) will review the merits of such alternatives for potential approval. The procedures utilized at a site should be documented and included in the site investigation report.

2.0 SUMMARY OF METHOD

Air monitoring utilizes direct-reading instruments that provide instantaneous data on the levels of airborne contaminants. By comparison, air sampling is the combination of sampling and analytical techniques that require laboratory analysis and are therefore not immediate results but provide more accurate results with greater sensitivity. This air sampling will typically occur after some sort of screening determines the list of contaminants of potential concern in the air. Risks associated with airborne contaminants can be determined by comparing the air sampling results to health-based benchmarks, such as the USEPA Vapor Intrusion Screening Levels (VISL).

Generally, indoor air is sampled to assess the potential of vapor intrusion issues in existing buildings. However, indoor air should only be sampled after screening via groundwater or soil gas samples to determine if the indoor air might be contaminated because other spurious sources of indoor air contamination (e.g., aerosol sprays, gas cans, etc.) make it difficult to determine the sources of indoor air contamination. Additionally, indoor air samples of existing buildings do not effectively screen out future buildings on the site. Only groundwater and soil gas samples can screen potential future buildings for vapor intrusion. Ambient air samples are taken simultaneously with indoor air samples to assess the potential for other sources contributing to the indoor air contamination and, to a lesser degree, to determine if the subsurface sources of vapors may be contributing to ambient air contamination. The samples may be collected via Summa Canisters or Tedlar Bags. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.1 Tedlar Bags

Indoor air samples can be collected in 1.0 L Tedlar bags, which should be stored in the dark (e.g., opaque containers) and protected from damage during transit to the laboratory. However, Summa canisters are recommended for indoor air samples because Tedlar bags must be kept at ambient temperatures out of direct sunlight and analyzed within 48 hours of sample collection.

3.2 Summa Canisters

Summa canisters have a range of capacities, but 1.0 L and 6.0 L are the most common and they are certified clean by GC/MS before collecting samples in the field. The size of canister used depends on the predetermined sampling timeframe (e.g., 1 hour vs. 24 hour). Canisters are stored and shipped in travel cases and should be analyzed within 30 days of sample collection. The canister should be fitted with a regulator valve properly calibrated by the laboratory to allow a maximum flow rate of 200 mL/min.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Upwind sources can contribute to sample concentrations and natural sources can produce hydrogen sulfide and methane that contribute to air contamination. Additional sources from burning fossil fuels, vehicular traffic, petrochemical facilities, and emissions from smokestacks may also contribute to contaminant levels. Importantly, it has been found that lighter SVOCs, particularly Naphthalene, may have significant sample losses in cool conditions (Hayes et al. 2005), and differences in soil temperatures in the upper profile can lead to variations in soil gas concentrations by a factor of two for all VOCs (Luo et al. 2009, USEPA 2010, Hers et al. 2014, Johnson and Deeb 2014). Indoor air concentrations are often biased low due to indoor positive pressure during the cold months while heating a home and during the hot months while cooling a home (USEPA 2015). Accordingly, WVDEP recommends that vapors be sampled when the ambient temperature is at least 21°C (70°F). WVDEP may require additional samples be collected at a time when ambient temperature is at least 21°C to verify the data if indoor air is collected during periods of relatively low soil and ambient air temperatures, especially when concentrations are greater than one-half of benchmark values. Photoreactivity or reactions with non-related compounds of concern may be an issue. Some samples should not be exposed to light, particularly PAHs. Humidity, temperature and pressure also impact the air sampling methodology, collection efficiency and detection limit. The collection procedure thus becomes an integral part of the analytical method.

5.0 EQUIPMENT APPARATUS

The following sources of analytical methods are used for most environmental air sampling applications: Manual of Analytical Methods (NIOSH 2016), American Society for Testing and Materials (ASTM) Methods, USEPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air (USEPA 1999), OSHA Methods (OSHA 1990, 1991), and Air Sampling Instruments for Evaluation of Atmospheric Contaminants (ACGIH 2001). No single reference or method is best for all applications. The following equipment and materials may be required to conduct air sampling:

- Site logbook
- Clipboard
- Chain of custody forms
- Custody seals
- Air sampling worksheets
- Sample labels
- Small screwdriver set
- Aluminum foil
- Extension cords
- Multiple plug outlet
- Whirl-pak^{TM} bags or culture tubes
- Teflon tape
- Calibration devices
- Tygon and/or Teflon tubing
- Nitrile or non-powdered latex gloves
- Lint-free gloves
- Sampler container
- Camera
- Scribe printer with paper
- Protective equipment (e.g., splash goggles, etc.)
- Paper towels
- Five-gallon bucket
- Scrub brushes and bottle brushes
- Summa canisters and/or Tedlar bags
- Flow regulators properly calibrated for the specific sample collection duration, request at least one extra as a backup
- In-line filters, if needed
- PID/FID

6.0 REAGENTS

Refer to the site-specific SAWP for the preservatives required for the specified analysis to be performed. The following reagents are generally used for air sampling:

- Calibration and spike gases
- Deionized water
- Methanol, High Performance Liquid Chromatography (HPLC) grade
- Ultra-zero grade compressed air

7.0 PROCEDURES

7.1 Air Sampling Strategy

The goal of air sampling is to accurately assess the impact of a contaminant sources(s) in ambient indoor or outdoor air. This impact is expressed in terms of overall average and/or maximum air concentrations for the time period of concern and may be affected by the transport and release of pollutants from both on- and off-site sources. The location of these sources must be taken into account as they impact the selection of sampling locations. Unlike soil and groundwater concentrations, air concentrations at points of interest can easily vary by orders of magnitude over the period of concern and should be accounted for when designing the air sampling strategy.

Downwind outdoor air concentration is determined by the amount of material being released from the site into the air (the emission rate) and by the degree that the contamination is diluted as it is transported. Local meteorology and topography govern downwind dilution. Contaminant emission rates can also be heavily influenced by on-site meteorology and on-site activities. For indoor air sampling, the concentrations are generally governed by the emission rates into the room/building and the air exchange rate, which are impacted by HVAC systems, the type of subflooring, cracks in subflooring, meteorological conditions, soil porosity and the presence/absence of preferential pathways. All of these concerns must be incorporated into an air sampling strategy.

A sampling strategy can be simple or complex, depending on the sampling program objectives. Programs involving characterization of the pollutant contribution from a single point source tend to be simple, whereas sampling programs investigating fate and transport characteristics of components from diverse sources require a more complex sampling strategy. In addition, resource constraints may affect the complexity of the sampling design.

An optimal sampling strategy accounts for the following site parameters:

- Location of sources
- Analytes of concern
- Analytical Reporting Limit (RL) to be achieved
- Rate of release and transport of pollutants from sources
- Availability of space and utilities for operating sampling equipment
- Meteorological monitoring data
- Meteorological conditions in which sampling is to be conducted

The sampling strategy typically requires that the concentration of contaminants at the source or area of concern, as well as background contributions, be quantified. It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks, as well as various other types of quality assurance/quality control (QA/QC) samples, can be utilized to determine other sources. The impact of extraneous sources on sampling results can frequently be accounted for by placing an outdoor ambient air sampler upwind of the building being assessed. Indoor air samples may need to be placed in various lower-level rooms to account for potentially different points of entry, and in various levels to account for air circulation.

7.2 Sampling Objectives

The objectives of the sampling must be determined prior to developing the *QAPrP*. In addition, the assumptions associated with the sampling program must be defined. These assumptions include whether the sampling is to take place under "typical," "worst case," or "one-time" conditions. If the conditions present at the time of sampling are different from those assumed during the development of the sampling plan, the quality of the data collected may be affected. WVDEP generally recommends air sampling under the worst-case scenario to avoid costly frequent sampling over long time periods (typical scenario) or the potential for false negatives (one-time scenario). The following definitions have been established:

- Typical: routine daily sampling or routine scheduled sampling at pre-established locations.
- Worst case: sampling conducted during meteorological and/or site conditions that have the greatest potential to result in elevated air concentrations. To meet this definition the sampling must occur:
    - with negative pressure in the building
    - with low outdoor atmospheric pressure
    - with temperatures greater than 70°F on the sampling train
    - over an 8-hour period for commercial/industrial buildings
    - over a 24-hour period for residential or sensitive receptor (e.g., daycare and nursing homes) buildings
- One-time: only one chance is given to collect a sample without regard to time or conditions. Qualitative data acquired under these conditions are usually applicable only to the time period during which the data were collected and may not provide accurate information to be used in estimating the magnitude of an air impact during other periods or over a long-time interval.

The volume of sample to be collected is dependent upon an estimate of the contaminant concentration in the air, the sensitivity of the analytical method, and the standard or desired detection limit (DL) or RL. A sufficient amount of sample must be collected to achieve the desired DL without interference from other contaminants. Most importantly, the selected method must be able to detect the target compound(s).

7.3 Location and Number of Individual Sampling Points

Choose the number and location of sampling points according to the variability, or sensitivity, of the sampling and analytical methods being utilized, the variability of contaminant concentrations over time at the site (if known), the level of precision required, and cost limitations. In addition, determine the number of locations and placement of samplers by considering the local terrain, meteorological conditions, location of the site (with respect to other conflicting background sources), size of the site, and the number, size, and relative proximity of separate on-site emission sources and upwind sources. The following are several considerations for air sampler placement:

- Location of potential on-site emission sources, as identified from the review of site background information or from preliminary on-site inspections.
- Location of potential off-site emission sources upwind of the sampling location(s). Review local wind patterns to determine the location of off-site sources relative to wind direction.
- Vegetation, such as trees and shrubs, which stabilizes soil and hinders subsurface contaminants from becoming airborne. Indoor plants also scrub some contaminants from the air.
- Look for cracks in basements and floors, points of utility entry/exit (e.g., water, sewer and natural gas), and floor drains as potential pathways of vapor entry into the building. A particular point of entry of note is sewer drains that have been unused for a long time such that the drain traps designed to prevent sewer gases from backing into the building may have dried up and gases can freely flow. If all of the points of entry and cracks are in one room, then that may be the only room to sample, depending on air circulation patterns. Dirt basements and crawl spaces are especially likely points of entry to evaluate.
- HVAC systems can circulate contaminated air throughout the building. Determine the number of self-contained HVAC systems and prioritize sampling them based on proximity to vapor source areas, number of cracks and points of entry, and the location of human receptors.
- Extreme care should be taken to remove all potential sources of VOCs from a building before air sampling in order to prevent false positive results, such as indicating a vapor intrusion problem that was actually caused by an aerosol spray or cleaning agent. Sources of VOCs include gasoline cans, aerosol spray cans, paint, solvents, tobacco smoke, etc. Even empty cans can still be a source of VOCs and should be removed from the building. The building should be screened with a PID/FID to determine the location of any potential spurious sources. Once the

potentially spurious sources have been removed, including cessation of smoking indoors, the building should be allowed to equilibrate for at least 48 hours before sampling, longer (~72 hours) if the air exchange rate is low (<0.3 ACH). This care includes conducting indoor air sampling before the installation of sub-slab probes.
- Do not place sample canisters near primary-use doors or open windows.
- Sample locations should avoid fans and ask the occupants not to use any fans during sampling activities.
- The rooms to be sampled should also be kept predominantly closed for at least 24 hours prior to sampling to minimize dilution of the air contaminants.

The number of samples is variable, but each HVAC system and/or each room with a point of entry or obvious cracking should be sampled for indoor air quality, particularly in rooms with high occupancy or where people spend at least 8 hours of time.

7.4 Time, Duration and Frequency of Sampling Events

The time of day, duration and frequency of sampling events is governed by the effects of site activities and meteorology on emission and dispersion of the contaminants, the variable impacts of off-site sources, costs and logistical considerations. Generally, samples for OER may be collected as one-time and/or worst-case grab samples, but longer sampling periods are preferential to integrate a more accurate average concentration and dose. Integrated samples should be collected over at least a 2-hour period, preferentially 8-hours for commercial buildings and 24-hours for residents to meet the worst-case scenario definition. Outdoor ambient air samples will be collected at the same time as the indoor air samples and upwind of the building being sampled. If conditions during the time of indoor air sampling are shown to be under worst-case conditions (e.g., negative pressure in the building, low atmospheric pressure, temperatures greater than 70°F on the sampling train) then only one round of samples may be necessary, but more rounds of samples may be necessary to fully assess vapor intrusion if the sampling did not occur under worst-case conditions.

7.5 Chemical Considerations

The chemical characteristics of a contaminant (e.g., molecular weight, physical state, vapor pressure, aerodynamic size, temperature, reactive compounds and photodegradation) affect its behavior and can influence the method used to sample and analyze it.

7.6 Summa Canisters

Canisters at least 6.0-L in size should be used for integrated air samples. The canisters will need to be fitted with a calibrated flow controller to collect air at a fixed rate (e.g., 40 cc/min over 2 hours for a 6.0-L canister). The canister should be left under some vacuum at the end of the sampling period to ensure sufficient driving force collecting air at a steady rate, typically -3 to -5 inches of Hg. Samples collected under vacuum may need to be pressurized with the addition of inert gas prior to analysis. Alternately, equipment exists to actively pump air into a pressurized canister (up to 2 atmospheres) to collect a higher volume than the previous method. However, special care must be taken with pressurized equipment to make sure none of the components that contact the air sample prior to the canister become contaminated and compromise subsequent samples. Samplers should be flushed with zero air or clean nitrogen between samples.

1. Before installing any Summa canister, be sure to conduct a shut-in or leak test on the Summa canister according to manufacturer specifications. Faulty connections have been known to cause failed sampling events that have to be repeated.
2. Atmospheric conditions (e.g., temperature and humidity) and other critical sampling information (e.g., date and time) should be recorded on the sampling log prior to initiating sampling.
3. Place the sampling canisters at the breathing-zone height and be sure to photograph the canister in place. If canisters cannot be placed so that the intake is at the breathing-zone height, Summa Canister cane-shaped rain guards must be used so that the intake would be at the approximate breathing-zone height.
4. Remove the brass plug from the canister and connect the flow regulator (with in-line particulate filter and vacuum gauge, if needed) to the canister.
5. Tighten the flow regulator and canister connection using a wrench.
6. Open the valve on the Summa canister and record the starting vacuum. The sample is drawn into the canister by pressure equilibration. The appropriate sampling time for a canister is dependent on the unit of investigation. Generally, 20-60 minutes for a grab sample but 8 to 24 hours are more representative in integrated commercial and residential samples, respectively. Note that shorter time periods will usually mean having to collect additional samples to properly assess cumulative exposures.
7. Return to the sample location ~15 minutes before the end of the sample collection timeframe. Examine the flow regulator to ensure that some vacuum is left on the gauge (preferably 5 inches, but 2 to 10 inches of Hg on the regulator dial is acceptable).
8. Record the vacuum pressure and stop the sample collection by closing the flow regulator.
9. Remove the flow regulator using a wrench and re-install the brass plug on the canister, tightening the plug with a wrench.
10. Package the canister and flow regulator into the shipping container provided by the lab.

11. Sample number, sample location, date collected, sampler name and any other pertinent sample information must be recorded on a chain-of-custody form and on a blank tag attached to the canister.
12. Chain-of-custody sheets must accompany the samples to the laboratory.

7.7 Tedlar Bags

The use of Tedlar Bags is recommended only when the samples can be analyzed within a few hours, such as having a portable GC in the field. It has been shown that high concentrations of contaminants in contact with the Tedlar bag for more than 12 hours may react with the bag and be unrecoverable for analysis. If Tedlar bags are used, the results should be accompanied with documentation that the samples were analyzed within recommended holding times, and percent recovery data as an indication of matrix effects. The percent recovery can be determined by charging the Tedlar bag with a known gas (e.g., a calibration standard or Standard Reference Material), holding it for a similar time as samples and then analyzing it. For samples taken under extreme humidity or oily mist conditions, a partially filled Tedlar bag with known volume could be spiked with a known concentration and volume of a calibration standard or Standard Reference Material and analyzed along with an unspiked sample to calculate the percent recovery.

1. Assemble the sampling train (e.g, vacuum box).
2. A leak test should be performed by placing a shroud around the sample train and using a tracer gas (99.999% laboratory grade helium) to enrich the atmosphere within the shrouded sampling train. A vacuum should then be drawn on the sampling tubing at 150-160 mL/min rate and the vacuum exhaust monitored for helium using a helium leak detector that has been factory calibrated within the past year. Any leaks showing >10% of the ambient helium reading should be located and sealed before proceeding with sampling.
3. Atmospheric conditions (e.g., temperature and humidity) and other critical sampling information (e.g., date and time) should be recorded on the sampling log prior to initiating sampling.
4. Use the vacuum box and sampling train to collect the sample. The sampling train is designed to minimize the introduction or loss of contaminants due to adsorption and other factors. All parts used are either Teflon or stainless steel, and a vacuum is drawn directly to avoid contamination from the pumps.
5. Place the Tedlar bag inside the vacuum box, attach it to the sampling port and open the valve. The sample probe should be attached to the sampling port with Teflon tubing and a “Quick Connect” fitting.
6. Draw a vacuum around the outside of the bag, using a pump connected to the vacuum box evacuation port with Tygon tubing and a “Quick Connect” fitting. The negative pressure inside the box causes the bag to inflate, drawing the sample into the bag.

7. Break the vacuum by removing the Tygon line from the pump. Remove the bagged sample from the box and close the valve. Record the date, time, sample location ID, name of sampler and any other pertinent information on the sample bag label and on data sheets or in logbooks.
8. Bags should not be labeled directly with a marker or pen, nor should adhesive labels be affixed directly to the bags. Inks and adhesive may diffuse through the bag material and contaminate the sample. Labels should be tied to the metal eyelets provided on the bags.
9. Chain-of-custody sheets must accompany the samples to the laboratory.
10. Tedlar bag samples will require at least two rounds of samples to fully assess the site unless they can meet the 24-hour duration for residences or 8-hour duration for industrial sites representative of their daily exposure.

8.0 CALCULATIONS

Volume is obtained by multiplying the sample time by the average flow rate, making sure to use similar time units. Adjustments for temperature and pressure differences may be required. Results are usually provided in micrograms per cubic meter (µg/m^3).

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

9.1 General

Refer to the site-specific *QAPrP* for details on the QA/QC requirements. All data must be documented in approved field data sheets, in a logbook and/or recorded electronically. All instrumentation must be operated in accordance with operation instructions as supplied by the manufacturer, unless otherwise specified in the *QAPrP*. A training record indicating the level of competency for each field employee will be documented and maintained on file. A chain of custody record must be maintained from the time a sample is taken to the final deposition of the sample.

9.2 Sample Train Contamination

The Teflon line forming the sample train to the Tedlar bag or Summa canister should be changed on a daily basis. If visible contamination (soil or water) is drawn into the sampling train, it must be changed immediately. When sampling in highly contaminated areas, the sampling train should be purged with ambient air, via a vacuum pump, for approximately 30 seconds between each sample. After purging, the sample train can be checked using a PID/FID to establish the cleanliness of the Teflon line.

9.3 PID/FID Calibration

The PID and/or FID must be calibrated at least once a day using appropriate calibration gases.

9.4 Trip Blanks

A trip blank detects any sample contamination during shipping and storage. With the exception of Summa canisters, the trip blank is prepared and added to the site samples after sampling has been completed and prior to shipment.

9.4.1 Tedlar Bags

Each cooler containing Tedlar bag samples must contain one Tedlar bag of ultra-zero grade air, acting as a trip blank for samples shipped to a laboratory. Chain-of-custody records must accompany each cooler of samples and should include the blank that is dedicated to that cooler.

9.4.2 Summa Canisters

Canister trip blanks are evacuated containers that are shipped to and from the site with the canisters used for air sampling.

9.5 Field Blanks

Field blanks detect sample contamination during the handling and shipping process associated with a specific sampling event.

9.5.1 Tedlar Bags

For each day of sampling, a Tedlar bag is filled with ultra-zero air at the beginning of the day. This field blank is handled in the same manner as the samples.

9.5.2 Summa Canisters

For each day of sampling, a Summa canister is filled with ultra-zero air at the beginning of the day. This field blank is handled in the same manner as the samples.

9.6 Trip Standards

If Tedlar bags are used for sampling, each cooler containing samples should contain a Tedlar bag of standard gas to calibrate the analytical instruments. This trip standard will be used to determine any changes in concentrations of the target compounds during the course of the sampling day (e.g., migration through the sample bag, degradation, or adsorption). A fresh trip standard must be provided and placed in each cooler pending additional sample collection. Chain-of-custody records must accompany each cooler of samples and should include the trip standard that is dedicated to that cooler.

9.7 Lot Blanks

9.7.1 Tedlar Bags

Prior to use, one bag is removed from each lot of Tedlar bags to be used for sampling and checked for possible contamination as follows: Fill the test bag with ultra-zero grade air; withdraw a sample from the bag and analyze using a field portable GC or other field instrument to ensure sample container cleanliness prior to the start of the sampling effort.

9.7.2 Summa Canister

From each lot of four cleaned Summa canisters, one is used for a GC/MS certification check. If the canister passes certification, it is re-evacuated and all four canisters from that lot are available for sampling. If the chosen canister is contaminated, the entire lot of four Summa canisters must be re-cleaned and a single canister is re-analyzed by GC/MS for certification.

9.8 Duplicate Samples

A minimum of 5% of all indoor samples should be collected in duplicate. In choosing which samples to duplicate when using Tedlar bags, a duplicate may be taken only if after filling the first Tedlar bag and evacuating the well for 15 seconds, the second field monitoring device is within 20% of the first reading.

9.9 Spikes

A Tedlar bag spike may be desirable in situations where high concentrations of contaminants other than the target compounds are found to exist (e.g., landfills). The additional level of QA/QC attained by this practice can be useful in determining the effects of interferences caused by these non-target compounds. Summa canisters containing samples are not spiked.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*. However, for each target compound to be considered valid, the concentration found in the sample must be greater than three times the level of that compound found in the appropriate blank (lot, field and trip) that accompanied that sample. Additional data to be verified/validated include but is not limited to location information, GPS coordinates, digital photographs and area sketches.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous

Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the hazards associated with well sampling:

- Exposure to unknown contaminants, with particular attention to potentially explosive or flammable atmospheres.
- Lifting injuries associated with moving equipment, coolers with samples, etc.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE
- Slips, trips, and fall hazards
- Biohazards, such as snakes, biting insects and poison ivy

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

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Sediment Sampling

SOP OER-0132

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ross Brittain	0.0	1/10/2021	Created new SOP and SOP ID#	Editorial, Technical
Ross Brittain	1.0	1/15/2025	Edited to account for PFAS sampling methodology	Technical

SEDIMENT SAMPLING
SOP OER-0132

Table of Contents

List of Acronyms and Abbreviations

DI	Deionized Water
FID	Flame Ionization Detector
GPS	Global Positioning System
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HPLC	High Performance Liquid Chromatography
ID	Identification
IDW	Investigation Derived Waste
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PFAS	Per- and Polyfluoroalkyl Substances
PID	Photoionization Detector
RL	Reporting Limit
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compounds
PPE	Personal Protection Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Program Plans
VOC	Volatile Organic Compound
WVDEP	West Virginia Department of Environmental Protection

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1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to outline the methods and equipment used to collect representative sediment samples. Sediment is defined as organic and/or inorganic material that is broken down by the processes of weathering and erosion and deposited/transported by the action of water/air/ice. Some examples include weathered rock, naturally occurring organic material (e.g., peat) and secretions from organisms (e.g., calcite). These procedures may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. Experience, objectives, site characteristics and chemical characteristics will dictate sampling strategy. Thus, alternate methods of collecting samples may be proposed for the site and the West Virginia Department of Environmental Protection (WVDEP) will review the merits of such alternatives for potential approval. The procedures utilized at a site should be documented and included in the site investigation report. Generally, the biologically active zone (top 6") of sediment should be sampled to conduct human health and ecological risk assessments. However, deeper sediment samples may be necessary to characterize source areas for pore water contamination or historic releases that have been buried by more recent sediment.

2.0 SUMMARY OF METHOD

The use of the various sediment sampling techniques and equipment is dependent on project goals (e.g., receptors of concern) and site conditions, such as depth of the aqueous layer, sediment profile required, type of sample required, contaminants, sediment type and analyses required. Sediment can be collected using a hand-held device such as a scoop, trowel or auger, or using remotely activated devices such as an Ekman or Ponar dredge. Once collected, sediment is transferred from the sampling device to sample containers of appropriate size and construction for the analyses. Composite sampling can be used to analyze for inorganic compounds in sediments but should not be used for VOCs and SVOCs due to potential loss of vapors. Composite techniques should have multiple grabs placed into a container constructed of an inert material (e.g., stainless steel bowl or aluminum pan), homogenized and transferred to the sample container(s) appropriate for the analyses requested. VOC and SVOC samples should be transferred directly from the sampling device to the sample container(s). Cores may also be collected directly into an acetate or polyvinyl chloride (PVC) sleeve that serves as the sample container for undisturbed samples. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is generally not recommended, except for VOC samples. Preservation with sodium bisulfate for VOCs creates low pH conditions that may deteriorate certain target compounds, whereas samples preserved with methanol can only be analyzed with the medium-level method and thereby have elevated reporting limits (RLs). Cooling to less than or equal to 6°C but withing freezing is usually the best approach, supplemented by the appropriate holding time for the analyses requested. Wide-mouth glass containers with Teflon lined caps are utilized for sediment samples. The sample volume depends on the analytical requirements and should be specified in the site SAWP and *QAPrP*.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Sediments occur in a variety of environments such as streams, wetlands, rivers and lakes. It is common to find material that is too large to sample, such as cobble and gravel, in addition to clay, silt and organic material. The appropriate sampling equipment will be necessary for the type of sediment encountered at the site. A vessel will be required for areas deeper than wading depth, with appropriate safety measures taken while using the vessel. The material that sample containers are made of can interfere with the contaminants that a sample will be analyzed for (i.e., plastics absorb pesticides, metal devices may corrode, etc.). Contaminants are more likely to be concentrated in areas of fine particle size and high organic matter compared to coarse sediments with low organic matter. Thus, selection of sample location is important and should generally be located in zones of deposition where the fine particles will settle. Efforts must also be made to prevent the loss of light sediments during sampling due to current, agitation or other disturbances.

5.0 EQUIPMENT APPARATUS

The equipment required for sediment sampling is largely dependent on the type of contaminants and sediments to be sampled. The following equipment and materials may be required to conduct sediment sampling:

- Maps/navigational charts
- Personal protective equipment (PPE, certified PFAS-free if sampling PFAS)
- Compass
- Global positioning system (GPS) receiver
- Tape measure
- Survey stakes, flags, buoys and anchors
- Digital camera
- Bucket, plastic or stainless steel (stainless steel for PFAS sampling)
- Sample bottles (HDPE if sampling PFAS)
- Plastic sheeting (certified PFAS-free if sampling PFAS)
- Sampling gloves (unpowdered nitrile if sampling PFAS)
- Ziploc® baggies of various sizes (other brands of baggies can be used but must be certified PFAS-free if sampling PFAS)
- Logbook/data sheets
- Sample labels
- Chain of custody records
- Custody seals
- Cooler(s)
- Ice
- Decontamination equipment and supplies
- Scoops (plastic or stainless steel)

- Trowels (plastic or stainless steel)
- Bucket auger, with T-handle and extensions
- Tube auger, with T-handle and extensions
- Pipe wrenches
- En Core® or Terra Core™ samplers for VOCs
- Ekman™ dredge
- Ponar™ dredge
- Van Veen Sampler or Young-Modified Van Veen Sampler
- Rope or steel cable (PFAS-free rope, if sampling PFAS)
- Winch
- Power drill
- PID/FID
- Vessel
- Hacksaw
- Trash bags
- Coring device
- Acetate/polycarbonate/PVC sleeves
- Hook blade razor knife
- Hip and chest waders
- Over boots
- Stainless steel bowls for homogenizing
- Personal floatation device

6.0 REAGENTS

Refer to the site-specific SAWP for the preservatives required for the specified analysis to be performed. The following reagents are generally used for sampling:

- Calibration and spike gases
- Deionized water
- Methanol, High Performance Liquid Chromatography (HPLC) grade

7.0 PROCEDURES

7.1 Sample Collection

1. Determine the project objectives and extent of sampling area, and the type of equipment necessary to complete the sampling. Confirm that all equipment is in proper working order. Identify and mark all potential sampling locations with flags, stakes and/or buoys.
2. The selection of sampling device is dependent upon the physical characteristics of the sediment, the type of sample needed, analytical parameters required, amount of sediment, contaminants, depth of water above the sediment, and possible interferences introduced by the sampling device.

3. If analysis of sediment from a discrete depth or location is desired, sediment is transferred directly from the sampling device to a labeled sample container(s) of appropriate size and construction for the analyses requested. Transfer is accomplished with a stainless steel or plastic lab spoon or equivalent, or En Core®/Terra Core^{TM} sampler for VOCs.
4. If composite sampling techniques or multiple grabs are employed, equal portions of sediment from each location or collocation are deposited into a decontaminated stainless steel, plastic, aluminum pan or other appropriate container (e.g., Teflon). The sediment is homogenized thoroughly to obtain a mixture representative of the area sampled. The composite sediment sample is transferred to a labeled container(s) of appropriate size and construction for the analysis (es) requested. Transfer of sediment is accomplished with a stainless steel or plastic lab spoon or equivalent. Samples for VOC or SVOC analysis must be transferred directly from the sample collection device or pooled from multiple areas in the homogenization container prior to mixing. This is done to minimize the loss of contaminant due to volatilization during homogenization.
5. All non-dedicated sampling devices should be decontaminated prior to use, then wrapped in aluminum foil (foil must be certified PFAS-free if sampling for PFAS). The sampling device should remain wrapped until needed. Dedicated sampling devices should be used for each sample. Disposable sampling devices for sediment are generally impractical due to cost and the large number of sediment samples which may be required.
6. Once samples have been collected, follow these procedures:
    a. Transfer the sample(s) into suitable, labeled sample containers specific for the analysis to be performed.
    b. Preserve the sample, if appropriate, or use pre-preserved sample bottles. Do not overfill the sample bottles if they are pre-preserved.
    c. Cap the container securely, place in a resealable plastic bag, and cool to <6°C but without freezing, if required by the analytical method.
    d. Record all pertinent data in the logbook and/or field data sheets
    e. Generate a chain of custody record, place inside a plastic sleeve and tape to the top of the inside of the cooler.
    f. Attach custody seals to the cooler prior to shipment.

7.2 Sediment Sampling

Several techniques have been developed to sample sediment material, including scoops, bucket/tube augers, coring devices and mechanical grabs. Scoops cause the greatest degree of sediment disturbance. Cores and mechanical grabs cause the least disturbance. Recall that human health and ecological risk assessments require sampling the biologically active zone of sediment (0-6”), but deeper sediments may be needed to fully characterize a site. The main sampling procedures are discussed below.

7.2.1 Sampling Surface Sediment with a Scoop/Trowel

In shallow, slow-moving water, representative surficial sediment samples may be collected with plastic or stainless-steel scoops or trowels. Focus the study area in zones of deposition that are downgradient of observed or likely contaminant migration pathways.

1. Collect the desired thickness and volume of sediment from the marked sampling location causing minimal disturbance of the water-sediment interface with a scoop.
2. Place the sample into a homogenization container or a specified sampling bottle. (If sampling for VOCs/SVOCs, do not homogenize; transfer the sample directly into the container, starting with the VOC samples first).
3. Label the sample bottle and store in a cooler with ice at ≤6°C but without freezing.

7.2.2 Sampling Surface Sediment with a Bucket/Tube Auger

In shallow water, representative surficial sediment samples may be collected with a bucket or tube auger. Focus the study area in zones of deposition that are downgradient of observed or likely contaminant migration pathways. Bucket and tube augers are sampling devices that consist of a bucket or tube with a series of extensions and a handle in the shape of the letter “T” (commonly known as “T” handle).

1. Attach the bucket/tube auger to the required length of extensions and attach the "T" handle to the upper extension.
2. If the study objectives and characteristics of the sediment or water body warrant, an acetate sleeve may be inserted into the tube auger prior to sampling.
3. Insert the bucket/tube auger onto the sediment at a 90° vertical angle.
4. Begin sampling by rotating the auger into the sediment with downward pressure until the desired depth is reached.
5. Slowly retrieve the auger containing the sample. The auger should be examined to determine if significant amounts of sediment are lost due to the thin, wet nature of some sediments. If significant losses have occurred, an alternate method of sampling should be performed, such as coring.
6. Carefully decant the surface water contained in the auger.
7. Collect VOC samples first and then SVOC samples directly from the bucket/tube auger using methods discussed below.
8. Place the sediment sample in a container to homogenize, and then transfer the sediment sample into the appropriate sample bottle.
9. Label the sample bottle and store in a cooler with ice at ≤6°C but without freezing.

7.2.3 Sampling Deep Sediment with a Bucket/Tube Auger

In some instances, Bucket/Tube Augers may also be used to collect subsurface sediment samples in a dry creek bed. Typically, this method is not practical due to difficulties keeping boreholes open to desired depth.

1. Attach the auger bucket/tube to the required length of extensions and attach the "T" handle to the upper extension.
2. If using a tube auger, insert an acetate sleeve prior to sampling.
3. Insert the bucket/tube auger into the sediment at a 90° vertical angle.
4. Rotate the auger into the sediment with downward pressure until the desired depth is reached.
5. Begin augering while periodically removing any accumulated sediment (i.e. cuttings) from the auger bucket/tube. The cuttings should be temporarily stored on plastic sheeting at a distance of at least two (2) feet from the sampling area, to prevent cross-contamination.
6. After reaching the upper range of the desired depth, carefully retrieve the bucket/tube auger from the boring.
7. Advance the auger down the borehole carefully avoiding contact with the borehole sides to prevent cross-contamination. Gradually push down the auger into the sediment sampling location to reach the desired depth.
8. Retrieve the auger from the borehole.
9. Carefully decant the surface water contained in the auger.
10. Collect VOC samples first and then SVOC samples directly from the bucket/tube auger using methods discussed below.
11. Place the sediment sample in a homogenization container, homogenize, and then transfer into the appropriate sample bottle.
12. Label the sample bottle and store in a cooler with ice at ≤6°C but without freezing.
13. Dispose the cuttings in accordance with the site-specific *QAPrP*.

7.2.4 Surface Sediment Sampling with a Mechanical Dredge

The Ekman, Van Veen, and the Ponar™ dredges are recommended for sampling in deeper water (water that is too deep to use scoops or augers) or for when relatively large amounts of sediments are required. In general, dredges are devices with jaws that are forced shut by weights, level arms, springs, cables or cords. The Ekman™ dredge is mainly used to sample fine sediments (e.g. mud, silt, and other soft and unconsolidated materials) whereas the Ponar™ dredges can be used to sample a wider range of grain sizes (clay to small gravel). Listed below are the assembly and operation instructions for both devices.

Sampling using an Ekman™ Dredge

1. Attach a dredge head to the bracket on the base of the extension pole with machine bolts.

2. Engage the jaws in a way that they are in the open position by placing trip cables over the release studs. Ensure that the hinged doors on the top of the dredge open freely to grab a sample.
3. Lower the dredge above the sampling location and hold.
4. Using the extension pole, push the dredge head into the sediments to the desired depth.
5. Trigger the jaw by depressing the button on the upper end of the extension pole.
6. Raise the sampler and slowly decant the water contained in the device through the top opening of the sampler.
7. Open the dredge jaws and place the sediment into a container for homogenization or directly into appropriate sample containers.
8. Label the sample bottle and store in a cooler with ice at ≤6°C but without freezing.

Sampling using a Ponar™ or Van Veen Dredge

NOTE: Special care should be taken when using these types of dredges. The steel arms act in such a way as to cause significant pinch hazards.

1. Attach a nylon rope (at least ¼″) or a steel cable (at least ⅛″) to the ring located on top of the dredge.
2. Arrange the dredge with the jaws in the open position, setting the trip bar or spring pin so the sampler remains open when lifted from the top.
3. Slowly lower the sampler to just above the sediment surface and drop the sampler into the sediment.
4. Raise the dredge to the surface and slowly decant the water through the screens on top of the dredge.
5. Open the dredge jaws and place the sediment into a container for homogenization or directly into appropriate sample containers.
6. Label the sample container and store in a cooler with ice at ≤6°C but without freezing.

7.2.5 Sampling Sediment with a Coring Device

This method is ideal for collecting intact sediment core samples. By utilizing this technique, the original layering of the sediment deposited will be preserved. In general, core samplers are elongated tubes composed of an acetate sleeve, a "T" handle, a core catcher, drive hammer and a cutting shoe.

1. Assemble the coring device and insert an acetate sleeve into the sampling tube.
2. Insert the core catcher, if needed, into the lower end of the sampling tube with the convex surface positioned inside the acetate sleeve.
3. Screw the cutting shoe onto the lower end of the sampling tube, securing the acetate sleeve and core catcher.

4. Attach the sampling device to the required length of extensions; then attach the “T” handle or the drive hammer onto the upper extension.
5. Place the sampler 90° over the location to be sampled.
6. If the "T" handle is used, place downward pressure on the device until the desired depth is reached. After the desired depth is reached, slowly retrieve the sampler from the sediment. Some samplers may be equipped with a ball valve at the top of the core to aid in retrieving wetter samples. This valve should be closed before retrieving the sampler from the bottom.
7. Carefully remove the coring device from the water sampling location.
8. Unscrew the cutting shoe and remove the core catcher.
9. Slide the PVC sleeve out of the bottom of the sampler tube. Decant surface water, using care to retain the fine sediment fraction. The sample may be left in the PVC sleeve, collected directly from the sleeve, or placed in a container for homogenization prior to transferring to sample containers. Cores should always be stored in an upright position until the overlying water has been drained, the PVC cores cut to remove any overlying air spaces and capped on both ends. To drain the overlying water, the PVC core should be cut at various levels starting near the top of the core and proceeding to just above the top of the sediments. Water should be drained at a rate slow enough to minimize turbulence and disturbance to the sediment. Indicate on the PVC tube the orientation of the sediment core using a waterproof marker.
10. Label the sample and store in a cooler with ice at ≤6°C but without freezing.

7.2.6 Vibracore Sampling

When sampling in deep water or where significant sample volume or depth are required, Vibracoring techniques may be used. Use of the Vibracore obtains sediment samples by vibrating a metal core barrel into the sediment. Penetration success is dependent upon the lithology of the formation. Vibracores are generally composed of a stainless-steel tube, detachable metal-cutting nose, stainless steel core catcher and the Vibracore drilling head. In general, Vibracores are operated by a team of two or more people from a vessel or on a structure extending over the water surface. Vibracoring should be conducted in accordance with subcontractor’s SOPs and industry methodology standards. Vibracoring uses vibration to achieve penetration into the sediments. If undisturbed cores are required, alternate sampling methods should be evaluated.

1. After allowing the sediments in the core to settle, all standing water should be drained from the core by cutting small holes above the sediment line. Water should be drained slowly so as not to re-entrain fine sediments.

2. Put the core sleeve on the soil identification table.
3. Use a Vibracore™ sleeve cutting tool (electric sheet metal cutter) and cut the full length of the sleeve. Then position the cutting tool roughly 4 inches to the left or right of the first cut and cut the entire length of the sleeve again.
4. Separate the sample core into the pre-determined sampling intervals.
5. Collect VOC samples first, followed by SVOC samples, using a technique outlined in Soil Sampling Using Direct-Push Drilling SOP OER-0121. Screen the sample core with the appropriate air monitoring device using the techniques outlined in the PID/FID Field Screening SOP OER-0101 and record all readings in a site logbook. Then, transfer the remainder of the interval to a mixing bowl and homogenize.
6. Perform soil identification/description activities.
7. Transfer the samples into the appropriately labeled sample containers and then store in a cooler with ice to maintain a temperature of ≤6°C but without freezing.

7.2.7 Volatile Organic Compound Sampling

En Core® Sampling Method

The En Core® sampler is designed to collect sediment samples to be analyzed for VOC’s. The En Core® sampler is comprised of an inert composite polymer (coring body) and a stainless steel “T” handle. This method reduces the open-air handling of soil samples in the field, minimizing the loss of VOCs. The following procedures are used for collecting sediment samples using an En Core® sampler.

1. Assemble the coring body, plunger rod and “T” handle.
2. Turn the “T” handle with the T-up and the coring body down and push the sampler into the sediment until the coring body is completely full (o-ring on sampler seen in the bottom hole of the sampler for 5 grams, and the top hole of the sampler for 25 grams) with minimal disturbance of the sample. Remove the sampler from the sediment.
3. Cap the coring body while it is still on the “T” handle. Push the cap over the flat area of the ridge. Ensure that the cap is seated properly to seal the sampler. Push cap to lock arm in place. Rotate the cap 90 degrees ensuring the cap is locked.
4. Remove the capped sampler by depressing the locking lever on the “T” handle while twisting and pulling the sampler from the “T” handle.
5. Using the hole located on the En Core® “T” handle, insert the core plunger, twist and lock the plunger of the core body.
6. Attach the label to the coring body cap, place it back into the En Core® sample bag and seal the bag.

7. This process will be conducted a total of three times for each field sample, six times for a sample and a field duplicate and nine times for a sample that has been chosen for the Matrix Spike/Matrix Spike Duplicate (MS/MSD) as outlined in the *QAPrP*.
8. Store the sample in a cooler with ice at ≤6°C but without freezing.

Terra Core® Sampler Method

A Terra Core® sampler is a single-use device designed to collect sediment samples to be analyzed for VOCs. The Terra Core® sampler is made of an inert composite polymer and reduces the open-air handling of sediment samples in the field. The following procedures are used for collecting sediment samples using a Terra Core® sampler.

1. Assemble the Terra Core® sampler by inserting the plunger portion into the "T" handle. Snap the plunger into the sampler.
2. Push the Terra Core® sampler into the sediment, ensuring that the Terra Core® sampler is completely full with sediment. Remove sampler from the sediment.
3. Unclip the plunger, rotate 90° and push the sample out of the sampler into a pre-weighted 40-milliliter (mL) vial containing a stirring bar. Refer to the analytical method if preservation is required. Label sample and store on ice at ≤6°C but without freezing.
4. This process will be conducted 3 times for the collection of a sample, 6 times for a duplicate and 9 times for an MS/MSD as outlined in the *QAPrP*.

7.2.8 PFAS Considerations

Sampling sediment for PFAS should follow the general procedures detailed above but with the following adjustments to prevent cross contamination from the numerous sources of PFAS in the environment and everyday life.

1. All sampling components must be PFAS-free. This includes shovels, trowels and scoops that must not be coated.

2. Glass components should not be used for collecting PFAS samples because several PFAS are known to adsorb to the glassware when in contact with the glass for extended periods of time.

3. Similarly, LDPE and PTFE containers should not be used due to either adsorption of PFAS onto or leaching of PFAS from the container materials.

4. Per the OER *QAPrP*, PFAS sampling containers must be 500 mL certified PFAS-free HDPE bottles sealed using a HDPE or polyethylene cap with no liner.

5. Due to the abundance of PFAS in food packaging, all food and beverage should be kept in a designated location far away (>50 feet) from the wells to be sampled, and after eating, the workers hands must be washed with PFAS-free soap for decontamination before returning to sampling activities.
6. Avoid use of cosmetics, moisturizers, hand cream, perfume, deodorant/antiperspirant, sunscreen, insect repellent or similar products that have not been determined to be PFAS-free on the day of sampling.
7. Sampling materials should not come into contact with carpeting or upholstery in buildings or vehicles (including boats) before, during or after the sampling process.
8. Do not use chemical ice packs to cool the samples.
9. Do not use foil as a layer between stacked sample bottles.
10. PFAS sampling of sediment currently can only be done using EPA Method 1633.
11. At least one sediment sample, preferably in a known/likely PFAS source area, should be analyzed for Total Organic Fluorine (TOF) or Total Oxidizable Precursor (TOP) analysis to assess how much of the potential PFAS compounds are accounted for using Method 1633.
12. Clothing
    a. *Permitted*:
        - 100% cotton preferred, but synthetic, polyurethane, PVC, rubber, neoprene, powderless nitrile gloves, uncoated Tyvek® clothing, wax-coated fabrics are acceptable
        - Clothing should be previously laundered (preferably at least six times) without fabric softeners
        - Boots can be either polyurethane, PVC or PFAS-free boot covers

    b. *Banned*:
        - New or unwashed clothing, or clothing washed with fabric softeners
        - Clothing treated with fabric protection, water-resistant, stain-resistant or insect-resistant chemicals
        - Any clothing or boots made of Gore-Tex™ or other known PFAS-containing or water-resistant materials.
13. PPE
    a. *Permitted*:

- Powderless nitrile gloves (Sampling personnel must wash their hands with PFAS-free soap and water before putting on any gloves.)
- HDPE hard hats, or hard hat covers/liners made of cotton or other natural fabrics
- Safety glasses made with HDPE
- Life jackets made of polyethylene foam and nylon shell fabric
- Waders made of Neoprene or other PFAS-free materials
- PFAS-free sunscreen (examples include Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 50, Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, and Neutrogena® Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30)
- PFAS-free insect repellent (examples include OFF® Deep Woods and Sawyer® Permethrin)

b. *Banned*:

- Gore-Tex™ gloves, waders or safety equipment, or any other PPE made with PFAS-containing materials
- Note that further research is needed on the potential use of Latex and leather gloves.

14. Field Materials

a. *Permitted*:

- Aluminum, polypropylene or Masonite clipboards
- Rite in the Rain® notebooks
- Loose paper (non-waterproof and non-recycled)
- Ballpoint pens and pencils

b. *Banned*:

- All PFAS-coated materials
- Post-It® Notes and other adhesive paper products
- Sharpie markers (there is not a consensus on PFAS in Sharpie markers, but they should not be used unless that are certified PFAS-free)
- Coated paper towels
- Aluminum foil should not be used since it is often coated with PFAS, but if a certified PFAS-free foil can be found then it can be used

15. Decontamination

a. *Permitted*:

- Alconox®, Liquinox® or Citranox®

- Dry decontaminated equipment using cotton cloth or untreated paper towels, or air dry on a PFAS-free surface
- Polyethylene or PVC brush to remove particulates

b. *Banned*:

- Decon 90®
- Dawn dish detergent
- PFAS treated paper products

When in doubt, assume that the product contains PFAS and should not be used!

8.0 CALCULATIONS

This section is not applicable to the SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on field data sheets and/or within the field logbook.
- All instrumentation should be operated and calibrated in accordance with the manufacturer's instructions unless specified otherwise in the site-specific SAWP.
- The collection of an equipment rinsate blank is recommended to evaluate potential for cross-contamination.
- The collection of duplicate samples will likely be required for the project. Refer to the site-specific SAWP and/or *QAPrP* for further information on collection of duplicate samples.
- Trip blanks are required for each cooler with samples for volatile organic compounds analysis.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the hazards associated with sediment sampling:

- Exposure to unknown contaminants, with particular attention to potentially explosive or flammable atmospheres.
- Lifting injuries associated with moving equipment, coolers with samples, and retrieving sampling devices.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE.
- Slips, trips, and fall hazards.
- Water hazards, such as drowning.
- Biohazards, such as snakes, biting insects and poison ivy.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

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Surface Water Sampling

SOP OER-0133

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ross Brittain	0.0	1/10/2021	Created new SOP and SOP ID#	Editorial, Technical
Ross Brittain	1.0	1/15/2025	Edited to account for PFAS sampling methodology	Technical

SURFACE WATER SAMPLING

SOP OER-0133

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List of Acronyms and Abbreviations

DO	Dissolved Oxygen
GPS	Global Positioning System
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	High Density Polyethylene
HPLC	High Performance Liquid Chromatography
IDW	Investigation Derived Waste
LDPE	Low Density Polyethylene
OER	Office of Environmental Remediation
ORP	Oxidization Reduction Potential
OSHA	Occupational Safety and Health Administration
PE	Polyethylene
PFAS	Per- and Polyfluoroalkyl Substances
PTFE	Polytetrafluoroethylene
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
PPE	Personal Protection Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Program Plans
VOC	Volatile Organic Compound
WVDEP	West Virginia Department of Environmental Protection

Disclaimer: Any mention in this SOP of any products or services does not constitute or imply the endorsement, recommendation or favoring by WVDEP or any of its employees or contractors acting on its behalf.

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to outline the methods and equipment used to collect representative surface water samples from streams, rivers, lakes, ponds, lagoons and surface impoundments, including from depth and the surface of the water. These procedures may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. Experience, objectives, site characteristics and chemical characteristics will dictate sampling strategy. Thus, alternate methods of collecting samples may be proposed for the site and the West Virginia Department of Environmental Protection (WVDEP) will review the merits of such alternatives for potential approval. The procedures utilized at a site should be documented and included in the site investigation report.

2.0 SUMMARY OF METHOD

The conditions for sampling surface water will vary widely due to water depths, velocity, sampling intervals, etc.; therefore, there is no universal sampling procedure. Collecting representative surface water samples can generally be accomplished by using either a Kemmerer bottle, a dip sampler or sampling directly into the container. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The amount of sample collected, chemical preservation, storage requirements and the proper sample container type (i.e., glass or plastic) are dependent upon the matrix sampled and analysis performed. Refer to the relevant WVDEP *QAPrP* for details of the appropriate sample containers, amounts, etc. based on the analysis performed. Whenever possible, dedicated sampling devices should be used. However, if re-usable (non-dedicated) equipment is used, it will need to be decontaminated between samples following SOP OER-0100. The sample volume depends on the analytical requirements and should be specified in the site *QAPrP*. Additional QA/QC samples will need to be collected as specified in the site *QAPrP*. Once samples have been collected the following general procedures should be followed:

- Transfer the sample(s) into suitable, labeled sample containers specific for the analysis to be performed.
- If appropriate, preserve the sample, or use pre-preserved sample bottles. Do not overfill bottles if they are pre-preserved.
- Cap the container securely, place in a resealable plastic bag, and cool to <6°C.
- Record all pertinent data in the site logbook and/or on field data sheets.
- Complete the chain of custody record.
- Attach custody seals to cooler prior to shipment

- Decontaminate all non-dedicated sampling equipment prior to the collection of additional samples.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Cross contamination can be eliminated or minimized through the use of dedicated or disposable sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Selection of samplers constructed of glass, stainless steel, HDPE, LDPE, PVC or PTFE should be based upon the suspected contaminants and the analyses to be performed (refer to the relevant WVDEP *QAPrP*). Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed or non-representative area. Following proper decontamination procedures, minimizing disturbance of the sample site (e.g., working from downstream to upstream sample locations), and careful selection of sampling location will eliminate most problems. Proper timing for the collection of samples must be taken into consideration for low or fast-flowing streams or rivers (e.g., drought vs. flood conditions). Dip samplers may collect floating debris which may skew sample results.

5.0 EQUIPMENT APPARATUS

The following equipment and materials may be required to conduct surface water sampling, depending on the sampling and analytical methods:

- Kemmerer bottles
- Line and messengers
- Dip sampler
- Peristaltic pump
- Tygon tubing (some Tygon tubing is known to contain PFAS so be sure to use the certified PFAS-free tubing for PFAS sampling)
- Polyethylene (PE) or PTFE tubing (PTFE cannot be used for PFAS sampling)
- 0.45 micron (µm) filters
- Sample bottles
- Gloves (unpowdered nitrile gloves if sampling PFAS)
- Preservation reagents
- pH paper
- Ziploc® baggies of various sizes (other brands of baggies can be used but must be certified PFAS-free if sampling PFAS)
- Ice
- Coolers
- Inert packing material
- Sample labels
- Printer
- Chain of custody records
- Custody seals
- Field data sheets

- Decontamination equipment/supplies
- Maps/plot plan
- Personal protective equipment (PPE, certified PFAS-free if sampling PFAS)
- Compass
- Tape measure
- Survey stakes, flags, or buoys and anchors
- Vessel
- Global Positioning System (GPS) unit
- Camera
- Logbook/waterproof pen
- Paper towels (untreated if sampling PFAS)
- Water quality meter (e.g., pH, DO, conductivity, salinity, temperature)

6.0 REAGENTS

Refer to the site-specific SAWP for the preservatives required for the specified analysis to be performed. The following reagents are generally used for sampling:

- Calibration and spike gases
- Deionized water
- Methanol, High Performance Liquid Chromatography (HPLC) grade

7.0 PROCEDURES

7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the type and amount of equipment and supplies needed.
2. Obtain the necessary sampling and monitoring equipment.
3. Decontaminate or pre-clean equipment and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Use stakes, flags, or buoys to identify and mark all sampling locations identified by GPS data. If required, the proposed locations may be adjusted based on site access, property boundaries, and obstructions.
6. Field Rinsing - Once field work has begun, and before samples are collected, the sample wetted portions of most of the collection and processing equipment require a field rinse with native water. Field rinsing helps to condition, or equilibrate, sampling equipment to the sample environment. Rinsing also serves to ensure that all cleaning-solution residues have been removed. Note – Do not field rinse pre-preserved bottles or when collecting volatile organic compounds (VOCs).

7.2 Representative Sampling Considerations

In order to collect a representative sample, the hydrology and characteristics of a stream, river, pond, lake or impoundment should be determined prior to sampling. This will aid in determining the presence of separate phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths. Location of sampling will depend on project goals and conditions. For example, in a stream or river the sample should be collected at a location where the velocity is sufficient to prevent deposition of solids and should have relatively uniform flow. In moving water, the sampler must always stand downstream of the collected sample. Care must be taken to avoid introducing re-suspended sediment into the sample, particularly in small stagnant ponds. Recent storm events may dilute contamination or bring contaminants from upstream sources and should be taken into consideration when collecting samples. In addition, present or recent storm events will alter water quality data. Storm event data should be recorded in logbooks to help evaluate the data.

In-stream Monitoring Procedures:

All samples will be collected for the specific pollutants of concern and using accepted QA/QC procedures. Surface water samples will be collected during low to normal flow conditions as follows:

Transect Locations:
One transect 25′ from the upstream property line and one transect located 25′ from the downstream property line. However, note that at least three upstream samples are recommended to fully assess the background conditions, especially if more heterogeneous sediment samples are going to be collocated with surface water samples. The number and location of transects along the reach of stream adjacent to the site is site-specific, depending upon information gleaned during the site characterization process and the site conceptual model, with regard to groundwater delineation and flow direction. At a minimum, one transect will be located in the reach of stream where groundwater is projected to discharge for each 75’ of plume width. Individual samples are to be collected from mid-depth in streams less than 1.5-feet deep, and in the lower 1′ of the water column for all streams deeper than 1.5-feet. During development of the stream characterization component of the SAWP, refer to the VRP Guidance Manual for specific requirements, and coordination with the OER Project Manager is encouraged.

Sample Locations per Transect:
1. For a stream less than 30′ in width, one sample collected at the approximate mid- channel location.
2. For streams between 30′ and 60′ in width, two samples collected at locations equally spaced between mid-channel and the shoreline.
3. For streams between 60′ and 100′ in width, 3 samples collected at locations equally spaced between mid-channel and the shoreline.

4. For streams greater than 100′ in width, 4 samples at locations equally spaced between the lesser of 75 ′ from the shoreline, or mid-channel and the shoreline.

In-pond/impoundment Monitoring Procedures:

All samples will be collected for the specific pollutants of concern and using accepted QA/QC procedures. Surface water samples will be collected during low to normal pool conditions. The number and location of samples in any pond/impoundment is dependent on the size of the impoundment and potential number of hotspots. At a minimum, one sample will be located in the pond/impoundment for every 500 ft^2, and in known/likely hotspots for conservative risk estimates. Ponds less than 500 ft^2 in size should have at least two samples. Recall that a minimum of eight (8) samples must be collected per medium to calculate an Exposure Point Concentration using a 95% UCL. Ponds/impoundments with more than eight samples may locate their samples randomly for good representation. Individual samples are to be collected from mid-depth in ponds/impoundments less than 1.5-feet deep, and in the lower 1′ of the water column for all ponds/impoundments deeper than 1.5-feet. During development of the pond/impoundment characterization component of the SAWP, coordination with the OER Project Manager is encouraged.

7.2.1 Water Quality Data

Water quality data, including pH, conductivity, oxidation reduction potential (ORP), salinity and dissolved oxygen (DO) may be collected in ponds, lakes and impoundments to determine if stratification is present. Measurement intervals will depend on many factors (i.e. total depth, location access, site conditions, etc.). A determination will be made prior to collecting any water quality data as to depth(s) and frequency of measurements. These measurement intervals should be as consistent as possible throughout the sampling event. Depth intervals should be documented in the site *QAPrP*; any changes should be documented in a field logbook.

7.2.2 Sampling Methods

Factors that contribute to the selection of a sampling method are:

- Width, depth, flow and accessibility of the location being sampled
- Whether the sample will be collected onshore or offshore

Kemmerer bottles may be used in most situations where site access is from a boat or structure, such as a bridge or pier, and where samples at specific depths are required.

Dip samplers are useful in situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access to the sample point is not feasible.

The **direct method** may be utilized to collect water samples from streams, rivers, lakes, and other surface waters directly into the sample container(s).

Note that all VOC samples must completely fill their sample containers with no headspace.

7.3 Sample Collection

7.3.1 Kemmerer Bottle

Sampling procedures for a Kemmerer Bottle are as follows:

1. Use a properly decontaminated Kemmerer bottle. Set the sampling device so that the upper and lower stoppers are pulled away from the body, allowing the surface water to enter tube.
2. Lower the pre-set sampling device to the predetermined depth. Avoid disturbance of the bottom.
3. When the Kemmerer bottle is at the required depth, send the weighted messenger down the suspension line to close the sampling device.
4. Retrieve the sampler and discharge the first 10-20 milliliters (mL) from the drain to clear potential contamination from the valve. Fill sample containers for VOC samples first as these samples should not be composited. This procedure may be repeated if additional sample volume is needed to fulfill analytical requirements. Subsequent grabs may be composited or transferred directly to appropriate sample containers.

7.3.2 Dip Sampler

Sampling procedures for a Dip Sampler are as follows:

1. If necessary, assemble the device in accordance with the manufacturer's instructions.
2. Extend the device to the sample location and collect the sample by dipping the sampler into the water.
3. Retrieve the sampler and transfer the sample to the appropriate sample container(s).

7.3.3 Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples directly into the sample container(s). Health and safety considerations must be addressed when sampling lagoons or other impoundments where specific conditions may exist that warrant the use of additional safety equipment. These issues must be addressed in the site-specific Health and Safety Plan (HASP). Using adequate protective clothing for wading or boats, access the sampling station from a downstream location, walking upstream so as to not disturb sediments and suspending them into the water column. Collect water quality information for the sampling location and record in the site logbook or field data sheets. For shallow stream stations, collect the sample under the water surface while pointing the sample container upstream; the container must be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface while avoiding surface debris and boat wake. Pre-preserved sample bottles cannot be used for this sampling method. Surface water samples may also be collected directly by using a peristaltic pump with PE or PTFE lined tubing. This method is also used when collecting filtered samples.

7.3.4 PFAS Considerations

Sampling surface water for PFAS should follow the general procedures detailed above but with the following adjustments to prevent cross contamination from the numerous sources of PFAS in the environment and everyday life.

1. All sampling components must be PFAS-free.
2. Glass components should not be used for collecting aqueous PFAS samples because several PFAS are known to adsorb to the glassware when in contact with the glass for extended periods of time.
3. Similarly, LDPE and PTFE containers should not be used due to either adsorption of PFAS onto or leaching of PFAS from the container materials.
4. Per the OER *QAPrP*, PFAS sampling containers must be 500 mL certified PFAS-free HDPE bottles sealed using a HDPE or polyethylene cap with no liner.
5. Due to the abundance of PFAS in food packaging, all food and beverage should be kept in a designated location far away (>50 feet) from the wells to be sampled, and after eating, the workers hands must be washed with PFAS-free soap for decontamination before returning to sampling activities.
6. Avoid use of cosmetics, moisturizers, hand cream, perfume, deodorant/antiperspirant, sunscreen, insect repellent or similar products that have not been determined to be PFAS-free on the day of sampling.

7. Sampling materials should not come into contact with carpeting or upholstery in buildings or vehicles (including boats) before, during or after the sampling process.
8. Ensure that the equipment does not have any known sources of potential cross-contamination, such as Teflon fittings or tubing. If the equipment does contain such materials, then PFAS-free replacement equipment must be found for collecting PFAS samples.
9. Do not use chemical ice packs to cool the samples.
10. Do not use foil as a layer between stacked sample bottles.
11. PFAS sampling of surface water can be done using either EPA Method 537.1 for drinking water or Method 1633. Method 1633 has more analytes and is therefore the preferred method to use.
12. At least one round of surface water PFAS samples should be analyzed for Adsorbable Organic Fluoride (AOF), Total Organic Fluorine (TOF) or Total Oxidizable Precursor (TOP) analysis to assess how much of the potential PFAS compounds are accounted for using either Method 537.1 or Method 1633.
13. Clothing
    a. *Permitted*:
        - 100% cotton preferred, but synthetic, polyurethane, PVC, rubber, neoprene, powderless nitrile gloves, uncoated Tyvek® clothing, wax-coated fabrics are acceptable
        - Clothing should be previously laundered (preferably at least six times) without fabric softeners
        - Boots can be either polyurethane, PVC or PFAS-free boot covers
    b. *Banned*:
        - New or unwashed clothing, or clothing washed with fabric softeners
        - Clothing treated with fabric protection, water-resistant, stain-resistant or insect-resistant chemicals
        - Any clothing or boots made of Gore-Tex™ or other known PFAS-containing or water-resistant materials.
14. PPE
    a. *Permitted*:
        - Powderless nitrile gloves (Sampling personnel must wash their hands with PFAS-free soap and water before putting on any gloves.)

- HDPE hard hats, or hard hat covers/liners made of cotton or other natural fabrics
- Safety glasses made with HDPE
- Life jackets made of polyethylene foam and nylon shell fabric
- Waders made of Neoprene or other PFAS-free materials
- PFAS-free sunscreen (examples include Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 50, Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, and Neutrogena® Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30)
- PFAS-free insect repellent (examples include OFF® Deep Woods and Sawyer® Permethrin)

b. *Banned*:

- Gore-Tex™ gloves, waders or safety equipment, or any other PPE made with PFAS-containing materials
- Note that further research is needed on the potential use of Latex and leather gloves.

15. Field Materials

a. *Permitted*:

- Aluminum, polypropylene or Masonite clipboards
- Rite in the Rain® notebooks
- Loose paper (non-waterproof and non-recycled)
- Ballpoint pens and pencils

b. *Banned*:

- All PFAS-coated materials
- Post-It® Notes and other adhesive paper products
- Sharpie markers (there is not a consensus on PFAS in Sharpie markers, but they should not be used unless that are certified PFAS-free)
- Coated paper towels
- Aluminum foil should not be used since it is often coated with PFAS, but if a certified PFAS-free foil can be found then it can be used

16. Decontamination

a. *Permitted*:

- Alconox®, Liquinox® or Citranox®
- Dry decontaminated equipment using cotton cloth or untreated paper towels, or air dry on a PFAS-free surface
- Polyethylene or PVC brush to remove particulates

b. *Banned*:

- Decon 90®
- Dawn dish detergent
- PFAS treated paper products

When in doubt, assume that the product contains PFAS and should not be used!

8.0 CALCULATIONS

This section is not applicable to the SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

There are no specific QA/QC activities that apply to just surface water, but the following general quality assurance procedures apply:

- All data must be documented on field data sheets and/or within the field logbook.
- All instrumentation should be operated and calibrated in accordance with the manufacturer's instructions unless specified otherwise in the site-specific SAWP.
- The collection of an equipment rinsate blank is recommended to evaluate potential for cross-contamination.
- The collection of duplicate samples will likely be required for the project. Refer to the site-specific SAWP and/or *QAPrP* for further information on collection of duplicate samples.
- Trip blanks are required for each cooler with samples for volatile organic compounds analysis.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the hazards associated with surface water sampling:

- Exposure to unknown contaminants, with particular attention to potentially explosive or flammable atmospheres.
- Lifting injuries associated with moving equipment, coolers with samples.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE.
- Slips, trips, and fall hazards.
- Water hazards, such as drowning.
- When sampling lagoons or surface impoundments containing known or suspected hazardous substances, adequate health and safety and boating precautions must be taken to ensure personnel safety.
- Biohazards, such as snakes, biting insects and poison ivy.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

Sampling Precautions and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS), Interstate Technology Regulatory Council (ITRC), 2023. https://pfas-1.itrcweb.org/wp-content/uploads/2023/10/Sampling_and_Lab_PFAS_Fact-Sheet_Sept2023_final.pdf

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SPLP and TCLP Sampling

SOP OER-0134

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ross Brittain	0.0	1/10/2021	Created new SOP and SOP ID#	Editorial, Technical
Ross Brittain	1.0	1/15/2025	Edited to account for PFAS sampling methodology	Technical

SPLP AND TCLP SAMPLING

SOP OER-0134

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List of Acronyms and Abbreviations

FID	Flame Ionization Detector
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDW	Investigation Derived Waste
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PFAS	Per- and Polyfluoroalkyl Substances
PID	Photoionization Detector
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leaching Procedure
SVOC	Semi-Volatile Organic Compounds
PPE	Personal Protection Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Program Plans
TCLP	Toxicity Characteristic Leaching Procedure
VOC	Volatile Organic Compound
WVDEP	West Virginia Department of Environmental Protection

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1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to outline the methods and equipment used to collect representative soil samples that will be used to measure the potential for leaching to groundwater via either the Synthetic Precipitation Leaching Procedure (SPLP) or the Toxicity Characteristic Leaching Procedure (TCLP). SPLP determines the mobility of both organic and inorganic analytes present in leachate from soils that are exposed to acidic rainfall ($pH = 5$). TCLP is designed to determine the mobility of both organic and inorganic analytes in leachate as water passes through landfill waste but can also be used to determine leachability from soil in more acidic conditions. This SOP only discusses the collection of samples to be analyzed using SPLP (Method 1312) and/or TCLP (Method 1311) laboratory methods. The laboratory procedures for SPLP/TCLP analyses are determined by the SOPs within the respective laboratories and outside the scope of this SOP. These procedures may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure, as long as the changes would not significantly impact the representativeness of the results. Experience, objectives, site characteristics and chemical characteristics will dictate sampling strategy. Thus, alternate methods of collecting samples may be proposed for the site and the West Virginia Department of Environmental Management (WVDEP) will review the merits of such alternatives for potential approval. The procedures utilized at a site should be documented and included in the site investigation report.

2.0 SUMMARY OF METHOD

SPLP and TCLP are both used as a way to screen contaminated soils for the potential of leaching into groundwater. These methods can be used in place of screening via Migration to Groundwater screening levels, such as those in the VRP Guidance Manual, or collecting groundwater samples. However, if the results of SPLP or TCLP indicate the potential exceedance of groundwater standards, such as the Groundwater De Minimis Standards, then groundwater wells will need to be installed to verify the contamination of the groundwater. Generally, SPLP should be used to determine the leaching capability of contaminated soils. TCLP should only be used where more acidic conditions are known or expected to exist, such as a landfill or abandoned mine land.

For both the SPLP and TCLP analyses, a soil sample is collected and then extracted with an amount of extraction fluid equal to 20 times the weight of the solid phase. The extraction fluid used in SPLP is a function of the region of the country where the sample site is located. In WV the extraction fluid has been pre-determined for the SPLP method to be SPLP Extraction Fluid #1 for sites east of the Mississippi River, in which 60:40 H_2SO_4/HNO_3 is added to reagent water until the pH is 4.20 ± 0.05. The extraction fluid used in TCLP is a function of the alkalinity of the soil/waste. If the pH is <5.0, TCLP Extraction Fluid #1 is used. TCLP Extraction Fluid #1 is created by adding 5.7 mL of glacial acetic acid to 500 mL of reagent water, then adding 64.3 mL of 1N NaOH and diluting the mixture to a volume of 1L with the resulting TCLP Extraction Fluid having a pH of 4.93 ± 0.05. If the pH is >5.0, 3.5 mL 1N HCl is added but if the pH goes below 5.0 TCLP Extraction Fluid #1 is added. If the pH remains >5.0, then TCLP Extraction Fluid #2 is used to get the pH below 5.0. TCLP Extraction Fluid #2 is created by diluting 5.7 mL of glacial acetic acid with reagent water to a volume of 1L with a resulting pH of 2.88 ± 0.05. Following extraction, the liquid extract is separated from the solid phase by filtration through a 0.6 to 0.8 µm glass fiber filter. The liquid extract is then analyzed using appropriate aqueous methods for the analytes of interest to determine the concentrations of potential contaminants in the leachate. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Soil samples should be collected in wide-mouth glass containers with Teflon-lined caps and refrigerated at ≤6°C but without freezing. If precipitation occurs, the entire sample, including precipitate, should be extracted. All extracts must be stored at ≤6°C until analyzed within the proper holding times for the analytes. Extracts for metallic analytes must be acidified with nitric acid to a pH less than 2.0, unless precipitation occurs.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Potential interferences that may be encountered are inherent to the analytical methods used for the extracts.

5.0 EQUIPMENT APPARATUS

The following equipment and materials may be required to conduct soil sampling for either SPLP or TCLP analysis, depending on the sampling and analytical methods. Refer to the SAWP to determine specific needs for any given project:

- Photoionization detector (PID) and/or flame ionization detector (FID)
- Logbook
- Field data sheets and samples labels
- Chain of custody records and seals
- Sample and shipping containers
- Pails, tubs, or buckets (certified PFAS-free if sampling PFAS)
- Plastic sheeting (certified PFAS-free if sampling PFAS)
- Packing materials and Ziploc® plastic bags (other brands of baggies can be used but must be certified PFAS-free if sampling PFAS)
- Decontamination solutions (i.e., tap water, non-phosphate soap, distilled water)
- Brushes
- Stakes and flagging
- Sampling gloves (unpowdered nitrile if sampling for PFAS)
- Shovel (uncoated if sampling for PFAS)
- Spatula, scoops, and/or trowels
- Continuous flight (screw) auger
- Bucket auger
- Post hole auger
- Split spoons
- Drilling rig equipment (points, drive head, drop hammer, puller jack and grip, extension rods, T-handle, thin wall tube sampler, etc.)

- Backhoe
- Drums for storage of investigation derived waste
- Personal protective equipment (PPE, certified PFAS-free if sampling PFAS)

6.0 REAGENTS

Refer to the site-specific SAWP for the preservatives required for the specified analysis to be performed. The following reagents are generally used for sampling:

- Calibration and spike gases
- Deionized water

7.0 PROCEDURES

7.1 SPLP vs TCLP

First determine if the samples will be analyzed using SPLP or TCLP procedures in the SAWP. SPLP should be used to determine the leaching capability of the majority of contaminated soils. TCLP should only be used where more acidic conditions are known or expected to exist, such as a landfill.

7.2 Sampling Considerations

In order to screen the potential of groundwater contamination via leaching from contaminated soils, potential source areas should be identified at the site, with SPLP/TCLP analyses of soils from each of the potential source areas. The soil samples should come from these hotspots to screen the worst-case scenario for leaching to groundwater. These source areas can either be identified beforehand with historical soil data, they can be determined in the field while collecting soil samples for conventional soil analytical methods (e.g., screening), or they can be determined in the laboratory.

Option 1: Using Historical Soil Data

If adequate historical soil data exists to determine the contamination hot spots, then select at least one sample location for each hotspot. There should be a minimum of three SPLP/TCLP sample locations to adequately assess the potential for contaminant leaching to groundwater. However, more than three samples may be needed, depending on the number of hotspots, number of contaminants of concern and the size of the site/hotspots. The depth of the soil samples for SPLP/TCLP should be based on the depth of the highest concentrations of the contaminants of concern. If multiple contaminants of concern are present in the soils, then choose locations/depths that capture the greatest range of high concentrations of as many contaminants as possible to assess potential interactive effects. Additional sample locations may need to be determined in order to assess the maximum concentrations of different contaminants. The determination of the sample locations and depths should be discussed with the WVDEP Project Manager in the development stages of the SAWP to expedite the process.

Option 2: Using Real-time Soil Data

In this case, since the concentrations of contaminants are not known ahead of time, a SPLP/TCLP sample will need to be collected from each soil boring and sent to the laboratory for analysis. While collecting soils for conventional analytical analyses, the soils can be screened in the field following the procedures outlined in *Soil Sampling* SOP OER-0120, *Soil Sampling Using Direct-Push Drilling* SOP OER-0121, *PID/FID Field Screening* SOP OER-0101, and *XRF Field Screening* SOP OER-0102 to determine the likely hotspots within each soil boring. Then a sample(s) will be collected from the depth(s) of the boring where there is obvious staining, odors, relatively high XRF readings for the metals of potential concern and/or the highest PID/FID readings.

Option 3: Using Laboratory Data

This option requires collecting extra surface and subsurface soil samples for SPLP/TCLP analyses from each boring while in the process of collecting conventional soil samples following the procedures outlined in *Soil Sampling* SOP OER-0120, *Soil Sampling Using Direct-Push Drilling* SOP OER-0121, *PID/FID Field Screening* SOP OER-0101, and *XRF Field Screening* SOP OER-0102. Once the conventional soil analyses have been completed in the laboratory, the choice of which samples to run for SPLP/TCLP analysis can be made based on where the known hotspots are located as in Option 1 above. The remaining soils that will not be used for SPLP/TCLP analysis will likely need to be disposed of as Investigation Derived Waste. This option requires collecting far more soil samples than necessary but allows for determining a more limited set of soil samples to analyze for SPLP/TCLP than Option 2 when there is no historical soil data.

7.3 Sample Collection

Once the sample locations have been determined, the soil samples should be collected following the procedures outlined in Soil Sampling SOP OER-0120 according to the requirements of the analytes to be processed. Note that SPLP/TCLP can also be run on sediments, in which case the sediments should be collected following the procedures outlined in Sediment Sampling SOP OER-132. The specific requirements for collecting SPLP/TCLP soil samples should be found in the SAWP, but the following are the general requirements for different analytes:

- **VOCs**: At least 25 g of soil (preferably 50 g) with no headspace in an amber glass jar, cooled to ≤6°C but without freezing and extracted within 14 days

- **SVOCs**: At least 300 g of soil (preferably 500 g) with no headspace in a glass jar, cooled to ≤6°C but without freezing and extracted within 14 days
- **Pesticides**: At least 300 g of soil (preferably 500 g) in a glass jar, cooled to ≤6°C but without freezing and extracted within 14 days
- **Metals**: At least 100 g in a glass jar, cooled to ≤6°C but without freezing and extracted within 180 days
- **Mercury**: At least 100g in a glass jar, cooled to ≤6°C extracted within 28 days.
- **PFAS**: At least 300 g of soil (preferably 500 g) in a HDPE jar, cooled to ≤6°C but without freezing and extracted within 14 days

7.4 Interpreting SPLP/TCLP results

If the SPLP/TCLP sample results are below the relevant groundwater standards, then no further assessment of groundwater is needed due to the releases in question. However, if the SPLP/TCLP sample results are above the relevant groundwater standards then further assessment of groundwater will be required. The further assessment can take one of two paths:

1. Consult your WVDEP Project Manager about determining a site-specific dilution factor from the leachate to the groundwater and rescreen the results.
2. Collect groundwater samples for analyses and screen the concentrations against the relevant groundwater standards.

7.5 PFAS Considerations

Sampling soils for PFAS should follow the general procedures detailed above for SPLP/TCLP analysis but with the following adjustments to prevent cross contamination from the numerous sources of PFAS in the environment and everyday life.

a) All sampling components must be PFAS-free. This includes shovels, trowels and scoops that must not be coated.

b) Glass components should not be used for collecting PFAS samples because several PFAS are known to adsorb to the glassware when in contact with the glass for extended periods of time.

c) Similarly, LDPE and PTFE containers should not be used due to either adsorption of PFAS onto or leaching of PFAS from the container materials.

d) Per the OER *QAPrP*, PFAS sampling containers must be 500 mL certified PFAS-free HDPE bottles sealed using a HDPE or polyethylene cap with no liner.

e) Due to the abundance of PFAS in food packaging, all food and beverage should be kept in a designated location far away (>50 feet) from the wells to be sampled, and after eating, the workers hands must be washed with PFAS-free soap for decontamination before returning to sampling activities.

f) Avoid use of cosmetics, moisturizers, hand cream, perfume, deodorant/antiperspirant, sunscreen, insect repellent or similar products that have not been determined to be PFAS-free on the day of sampling.

g) Sampling materials should not come into contact with carpeting or upholstery in buildings or vehicles before, during or after the sampling process.

h) Do not use chemical ice packs to cool the samples.

i) Do not use foil as a layer between stacked sample bottles.

j) Clothing

   1. *Permitted*:
      - 100% cotton preferred, but synthetic, polyurethane, PVC, rubber, neoprene, powderless nitrile gloves, uncoated Tyvek® clothing, wax-coated fabrics are acceptable
      - Clothing should be previously laundered (preferably at least six times) without fabric softeners
      - Boots can be either polyurethane, PVC or PFAS-free boot covers
   2. *Banned*:
      - New or unwashed clothing, or clothing washed with fabric softeners
      - Clothing treated with fabric protection, water-resistant, stain-resistant or insect-resistant chemicals
      - Any clothing or boots made of Gore-Tex™ or other known PFAS-containing or water-resistant materials.

k) PPE

   1. *Permitted*:
      - Powderless nitrile gloves (Sampling personnel must wash their hands with PFAS-free soap and water before putting on any gloves.)
      - HDPE hard hats, or hard hat covers/liners made of cotton or other natural fabrics
      - Safety glasses made with HDPE
      - Life jackets made of polyethylene foam and nylon shell fabric
      - Waders made of Neoprene or other PFAS-free materials
      - PFAS-free sunscreen (examples include Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 50, Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, and Neutrogena® Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30)

  - PFAS-free insect repellent (examples include OFF® Deep Woods and Sawyer® Permethrin)

2. *Banned*:
   - Gore-Tex^{TM} gloves, waders or safety equipment, or any other PPE made with PFAS-containing materials
   - Note that further research is needed on the potential use of Latex and leather gloves.

l) Field Materials

1. *Permitted*:
   - Aluminum, polypropylene or Masonite clipboards
   - Rite in the Rain® notebooks
   - Loose paper (non-waterproof and non-recycled)
   - Ballpoint pens and pencils
2. *Banned*:
   - All PFAS-coated materials
   - Post-It® Notes and other adhesive paper products
   - Sharpie markers (there is not a consensus on PFAS in Sharpie markers, but they should not be used unless that are certified PFAS-free)
   - Coated paper towels
   - Aluminum foil should not be used since it is often coated with PFAS, but if a certified PFAS-free foil can be found then it can be used

m) Decontamination

1. *Permitted*:
   - Alconox®, Liquinox® or Citranox®
   - Dry decontaminated equipment using cotton cloth or untreated paper towels, or air dry on a PFAS-free surface
   - Polyethylene or PVC brush to remove particulates
2. *Banned*:
   - Decon 90®
   - Dawn dish detergent
   - PFAS treated paper products

When in doubt, assume that the product contains PFAS and should not be used!

8.0 CALCULATIONS

This section is not applicable to the SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

There are no specific QA/QC activities that apply to collecting SPLP/TCLP samples in the field, but the following general quality assurance procedures apply:

- All data must be documented on field data sheets and/or within the field logbook.
- All instrumentation should be operated and calibrated in accordance with the manufacturer's instructions unless specified otherwise in the site-specific SAWP.
- The collection of an equipment rinsate blank is recommended to evaluate potential for cross-contamination.
- The collection of duplicate samples will likely be required for the project. Refer to the site-specific SAWP and/or *QAPrP* for further information on collection of duplicate samples.
- Trip blanks are required for each cooler with samples for volatile organic compounds analysis.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered to when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the hazards associated with soil sampling:

- Exposure to unknown contaminants, with particular attention to potentially explosive or flammable atmospheres.
- Lifting injuries associated with moving equipment and lifting coolers with samples.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE.
- Slips, trips, and fall hazards.
- Biohazards, such as snakes, biting insects and poison ivy.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions, as well as known contaminants, as required by the Hazard Communication Standard requirements set forth in the OSHA regulations. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

American Society of Testing and Materials (ASTM). 1995. *Annual Book of ASTM Standards, Designation D4972 - 95a: Standard Test Method for pH of Soils*.

Sampling Precautions and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS), Interstate Technology Regulatory Council (ITRC), 2023. https://pfas-1.itrcweb.org/wp-content/uploads/2023/10/Sampling_and_Lab_PFAS_Fact-Sheet_Sept2023_final.pdf.

United States Environmental Protection Agency, Office of Solid Waste and Emergency Response. 1996. *Test Methods for Evaluating Solid Waste, SW-846, 3rd ed., Method 1311: Toxicity Characteristic Leaching Procedure*, Revision 0, July 1992

United States Environmental Protection Agency, Office of Solid Waste and Emergency Response. 1996. *Test Methods for Evaluating Solid Waste*, *SW-846, 3rd ed., Method 1312*.

Passive Diffusion Bag (PDB) Sampling

SOP OER-0135

Prepared for:
West Virginia Department of Environmental Protection
Division of Land Restoration
Office of Environmental Remediation

Author	Revision No.	Effective Date	Description of Changes	Type of Change
Ross Brittain	0.0	1/10/2021	Created new SOP and SOP ID#	Editorial, Technical
Ross Brittain	1.0	1/15/2025	Edited to account for PFAS sampling methodology	Technical

PASSIVE DIFFUSION BAG (PDB) SAMPLING
SOP OER-0135

Table of Contents

List of Acronyms and Abbreviations

bTOC	below Top of Casing
CoC	Contaminants of Concern
DI	Deionized Water
DQO	Data Quality Objectives
ft	Feet/foot
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
ID	Identification
IDW	Investigation Derived Waste
ITRC	Interstate Technology and Regulatory Council
MTBE	Methyl Tert-Butyl Ether
OER	Office of Environmental Remediation
OSHA	Occupational Safety and Health Administration
PFAS	Per- and Polyfluoroalkyl Substances
SAP	Sampling and Analysis Plan
SAWP	Site Assessment Work Plan
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
TOC	Top of Casing
PDB	Passive Diffusion Bag
PPE	Personal Protection Equipment
QA/QC	Quality Assurance/Quality Control
QAPrP	Quality Assurance Program Plans
VOC	Volatile Organic Compound
WVDEP	West Virginia Department of Environmental Protection

Disclaimer: Any mention in this SOP of any products or services does not constitute or imply the endorsement, recommendation or favoring by WVDEP or any of its employees or contractors acting on its behalf.

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to outline the methods and equipment used to collect representative groundwater samples using Passive Diffusion Bags (PDB). This SOP should be used in conjunction with the *Groundwater Well Sampling Procedures* SOP OER-0110. The laboratory procedures for specific analyses are determined by the SOPs within the respective laboratories and outside the scope of this SOP. These procedures may be varied or changed as required, dependent upon site conditions, equipment limitations and/or limitations imposed by the procedure. Experience, objectives, site characteristics and chemical characteristics will dictate sampling strategy. Thus, alternate methods of collecting samples may be proposed for the site and the West Virginia Department of Environmental Protection (WVDEP) Office of Environmental Remediation (OER) will review the merits of such alternatives for potential approval. The procedures utilized at a site should be documented and included in the site assessment report.

2.0 SUMMARY OF METHOD

Diffusion sampling is based on the underlying principle that there is constant, mostly horizontal flow from the aquifer through the saturated screened interval and that this flow, along with molecular diffusion, causes water within the saturated well screen to have the equivalent contaminants and concentrations as the surrounding aquifer. Diffusion sampling devices consist of one or more semipermeable membranes formed into a tubular shape, sealed at the bottom and filled with laboratory-grade deionized (DI) water. The top is typically manufactured with a nozzle for filling the sampler with the DI water. However, some diffusion samples are pre-filled with DI water by the manufacturer and sealed at both ends. The PDB sample is then suspended in the saturated screen zone of the monitoring well using a suspension tether assembly and left in place for chemical equilibration to occur. When the PDB is installed, a concentration gradient will exist between the contaminants outside the PDB and the DI water inside. The semipermeable membrane will allow certain molecules to pass through the membrane without restriction, so that during the residence time, the concentration gradient causes molecules to flow in or out of the sampler until equilibrium is achieved. The PDB is removed from the well after enough time to achieve equilibrium and the water within the sampler is transferred to the appropriate laboratory container and analyzed by standard laboratory methods. Consult the manufacturer to determine the appropriate sampler membranes suitable for the compounds of interest as well as recommended equilibration time. Specific details for sampling at any location should be found in the Sampling and Analysis Plan (SAP) or Site Assessment Work Plan (SAWP, hereafter both are referred to as SAWP).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The type of sample container, the preservative, holding time, and filtering requirements are all dependent upon the type of analysis to be performed. This information should be clearly set forth in the SAWP for the site. The sampler should consult the SAWP for all pertinent information relating to the proper sample preservation, type of containers, handling, and storage procedures for their project. A pair of clean, new, non-powdered disposable gloves shall be worn each time a different location is sampled to prevent cross-contamination. Samples should be collected directly from the PDB into appropriate laboratory cleaned containers, without making contact with the sampling device. Samples shall be appropriately preserved, labeled, and placed in a cooler to be maintained at ≤6ºC, but without freezing the sample, in accordance with the SAWP requirements. The samples should be shipped with adequate packing and cooling to ensure that they arrive at the laboratory intact and still cold. Refer to Table 2 of the WVDEP OER Quality Assurance Program Plan (*QAPrP*) for information on sample containers, preservation, and holding times for common contaminants

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The goal is to obtain a representative sample of the groundwater. Proper field sampling techniques need to be utilized in order to ensure that a representative sample is collected and the sampler does not compromise the sample through their actions. Analysis can be compromised by field personnel in three primary ways: taking an unrepresentative sample, by incorrectly handling the sample, or by improperly labeling the sample. There are a variety of ways to introduce contaminants into a sample; that is why it is very important to follow sampling protocols. Potential interferences that may be encountered are inherent to the analytical methods used for the extracts. Water flow around and through the PDB samplers are critical for representative sampling such that low-permeability formations are inappropriate for using PDB samplers. Accordingly, aquifers with hydraulic conductivity less than 1E-06 cm/s should generally not be sampled using PDBs. If the well screen is less permeable than the aquifer or sandpack under nonpumping conditions, then the water may also divert around the PDB and not equilibrate appropriately. Fluctuation of groundwater levels can also influence the effectiveness of the samplers by changing the dynamics of a contaminant plume. Any high precipitation events or periods of drought should be noted for the duration of time the samplers are deployed and sampling should be avoided during extreme events with adequate time for the aquifer to equilibrate to normal conditions prior to sampling. Additionally, there are several chemicals that have poor correlation with known groundwater concentrations using PDB samplers, such as Acetone, Methyl Tertiary Butyl Ether (MTBE), Methyl Isobutyl Ketone (MIBK) and Styrene. Be sure to check with the PDB manufacturer to ensure that the site's chemicals of concern can be representatively sampled using PDB methods.

5.0 EQUIPMENT APPARATUS

The following equipment and materials may be required to conduct PDB groundwater sampling, depending on the sampling and analytical methods. Refer to the SAWP to determine specific needs for any given project:

- Field data sheets and samples labels;
- Chain of custody records and seals;
- Sample and shipping containers;
- Pails, tubs, or buckets; (certified PFAS-free if sampling PFAS)
- Personal protective equipment (PPE, certified PFAS-free if sampling PFAS);
- Site-Specific Health and Safety Plan (HASP);
- Job Hazard Assessment;
- Air monitoring equipment, if required in the HASP;

- Site Access: agreements, photo identification, property owner contacts, keys, tools, etc.;
- Site Documentation: Site map with sampling locations, list of wells to be sampled, field;
- Logbook, Monitoring Well Sampling Forms, Well Construction Diagrams, etc.;
- Water level indicator and other instrumentation as required to meet site Data Quality Objectives (DQOs);
- Decontamination supplies;
- Laboratory-supplied containers with proper preservation;
- Coolers/shipping containers, ice and packing media;
- Deionized water travel blanks provided in sampler membrane materials when pre-filled samplers are used.

6.0 REAGENTS

Refer to the site-specific SAWP for the preservatives required for the specified analysis to be performed. The following reagents may be used for PDB sampling:

- Deionized water

7.0 PROCEDURES

7.1 PDB Sampler Depth

One or more passive diffusion samplers are suspended at predetermined depths in the saturated screen to intercept groundwater flow and produce a representative sample of the contaminants and their concentrations at that depth. If it is known that the aquifer adjacent to the saturated screen is somewhat homogeneous and the contaminants are not stratified, then a single sampler can be used to represent the entire saturated screen length. In the absence of those conditions or other knowledge about the well and contaminants, a single sampler should not be used to represent a vertical interval of more than about five feet. Wells having longer saturated screens or unknown stratification may be profiled using several samplers at intervals across the screen length for sampling specific intervals or to determine future placement of one or more samplers. Diffusion sampler depth setting is typically referred to by the mid-point of the sampler. This ability to characterize aquifer stratification is a key advantage of the PDB method in assessing site contamination and potential risks and remedies.

7.2 Considerations

A. Select the sampler type for sampling the contaminants of concern (COC). Single membrane passive diffusion bag samplers are only viable for volatile organic compounds (VOCs). Multi-membrane samplers will provide reliable samples for virtually any COC, however, verify specific COCs with the manufacturer.

B. Select the sampler size to fit the well diameter, saturated screen and sample volume requirements. If adequate sample volume may be difficult to acquire, ask the laboratory for the Minimum Volume Requirements to meet the site Data Quality Objectives. In most cases the laboratory will be able to perform the analyses with significantly reduced sample volume.
C. If there is any question regarding the integrity of the sample when collected, a new PDB should be deployed at that time so that a new sample could be provided to the laboratory two or three weeks later if the laboratory data are questionable.

7.3 PDB Samplers filled with Deionized Water

Some laboratories provide laboratory-grade water for the user to fill empty samplers before deployment and some laboratories may provide PDBs pre-filled with laboratory-grade water. If samplers are purchased empty, consult the manufacturer's filling instructions. A Fill Water Travel blank, constructed from the sampler membrane materials and the same lot of DI water used to fill the samplers, should be ordered or produced and accompany the samplers from the point of filling to the project site. A spare sampler may also be used to contain a travel blank.

Because diffusion samplers will equilibrate with the surrounding groundwater, low concentrations of diffusible compounds that may be in the sampler or fill water prior to installation will equilibrate with the surrounding groundwater. There are several compounds, including acetone, methyl tert-butyl ether (MTBE) and butanone compounds, that may not equilibrate when using a single membrane polyethylene diffusion sampler for VOCs. In these cases, and for general data quality reporting, a certificate of analysis of the lot of water used to fill the samplers and a fill/travel blank representing any compounds that enter the sampler during transportation and storage and are in the sampler at the time of deployment is required. Travel blanks should be sampled at the project site during the deployment process. Typically, one sampler per site per round of deployment is used.

7.4 PDB Sampler Residence Time Requirements

The required sampler residence time requirement is dependent on two phases; the well must first stabilize and return to its natural flow conditions after being disrupted by the installation of the sampler, followed by the sampler contents coming into chemical equilibrium with the surrounding groundwater. Site specific aquifer characteristics may influence the optimum residence time, but it is generally accepted that two weeks (14 days) is the minimum residence time to cover installation and equilibration when sampling for VOCs and three weeks (21 days) when sampling for metals, inorganics and other compounds. There has not been shown a maximum residence time, as the diffusion process maintains a dynamic equilibrium, keeping the sampler at the same concentrations as the surrounding groundwater even as changes in the aquifer occur. However, extended sampler residence time can lead to a loss in sampler bag integrity that should be considered when designing any sampling strategies and can also be influenced by seasonal differences in concentrations in surrounding groundwater.

For cost savings and logistics, samplers can be installed during one event and left in place until the next sampling event and then removed, sampled and replaced for the next event. EonProduct Samplers have been used successfully in this manner with sampling intervals longer than one year, but the Interstate Technology and Regulatory Council (ITRC) indicates potential losses of bag integrity as residence times approach one year. Sample strategies with residence times greater than three months should be prepared for potential losses and are not recommended. Because the diffusion process requires some time and occurs at differing rates for each compound, the acquired sample will represent the chemistry of the past few days in residence, to about one week prior to removal of the sampler from the well. If significant seasonal effects are potential at your site, the PDB sampler removal timing will need to be adjusted accordingly.

7.5 PDB Sampler Installation Assembly

Dedicated sampler suspension tether assemblies can be made to order by the PDB supplier, are re-usable, and reduce the time and effort required to measure and construct these cleanly in the field. Because the assemblies are a one-time investment, with only the disposable samplers requiring replacement, it is recommended that dedicated PDB assemblies (tethers, reels, and weights) be purchased ready-made from the supplier to ensure compatibility.

A. To ensure that project deadlines are met, contact the sampler and tether-assemblies supplier as far in advance as possible, preferably at least two weeks before the planned PDB deployment date. If this is the first use of diffusion samplers in any well, deploy the samplers in the wells at least two to three weeks (depending on sampler type and contaminants of interest) before the planned sampling date.
B. To order pre-made PDB assemblies, provide the supplier with the following information:
    a. Well identification (ID)
    b. Well diameter
    c. Total depth of well at the time of installment (feet below top of casing (ft bTOC))
    d. Screened interval (ft bTOC)
    e. Number of samplers per well and desired sampling depths of each
    f. Ship-to address and purchase order number (project number)

C. Each standard dedicated diffusion sampling assembly, as provided by the supplier, should include the following:
   a. Diffusion sampler bag (disposable)
      i. select prefilled with Lab grade DI water by manufacturer, or
      ii. unfilled for filling by the lab or
      iii. for filling by the sampling team
   b. Stainless steel weights with split ring connectors
   c. Tether made of braided polypropylene rope on a plastic reel (certified PFAS-free if sampling for PFAS)
   d. Embedded stainless steel connection rings at sampler depths-2 per sampler
   e. Aluminum tag with well ID inscribed
   f. Snap connectors
   g. Cable ties
   h. Well caps (optional: prepared with rings from which to suspend tethers in the well)
   i. Discharge tubes (disposable)
   j. DI water (for unfilled samplers)
   k. DI water travel-blank (for prefilled samplers, minimum one per shipment)
   l. DI water certificate of analysis for water used to fill the samplers

7.6 Filling and Transporting PDB Samplers

A. All sampler bags should be filled at a single time to save time and minimize the potential for contamination, before mobilizing to the various wells for deployment. Care should also be taken to prevent contamination of the water inside the bag by placing and storing the bags on/in clean surfaces, such as clean plastic sheeting. However, if phthalates are part of the contaminants of potential concern at the site, then plastic sheeting may cross-contaminate the PDB sample and should not be used for bags intended to sample phthalates. In that case, a clean stainless-steel surface would be appropriate.
B. Wear disposable, powder-free latex or nitrile gloves to prevent cross-contamination.
C. If the samplers are not pre-filled, fill the sampler with laboratory-grade DI water and follow the manufacturer's instructions for filling the samplers so that the sample bag is expanded to its maximum capacity. Remove visible air pockets.
D. Filled sample bags should be placed in a clean poly bag and the poly bags placed in a clean cooler with a tight-fitting lid, for transportation to and on the site to reduce potential contamination.
E. From the point the samplers are filled with DI Water, the travel blank should travel with the samplers at all times. The project manager should decide at which location on-site the blank should be placed during sampling activities.

7.7 Installing Suspension Tethers and PDB Samplers

If the suspension tether has already been installed and is in use in the well, go to Section 7.8. *Retrieving and Sampling PDB Samplers* for information on removing installed samplers before installing new samplers. If the suspension tether is new and hasn't been previously installed, follow the manufacturer's directions to;

A. Unpackage the spooled tether. The weights should be attached to the ring on the leading end of the rope. If not, find the correct weight and attach.
B. Find the Well ID Tag located on the spooled tether. Match the ID tag to the well ID.
C. Place the weighted leading end of the suspension tether into the well and slowly lower until a small diameter (~0.50-in) stainless steel ring is located on the tether. A second ring should be located further up the rope at a distance slightly more than the length of the sampler.
D. Use a Zip-Tie to attach the bottom ring or loop on the sampler to the lower of the two rings embedded in the tether. Use a Zip-Tie to attach the loop near the top of the sampler to the upper stainless-steel ring on the tether. Repeat the sampler attachment process for each set of rings on the tether if more than one sampler is used in the well. Optionally trim the excess Zip-Tie. (Do NOT hold the sampler over the well before attaching zip-ties to prevent accidental loss down the well.)
E. Once all the samplers are securely attached to the tether rings continue to lower the tether into the well until the black snap connector is located on the tether. It is usually clipped to the spool.
F. Hold the tether or otherwise secure it so that it cannot slip free down the well and move the snap connector from the spool to the ring on the underside of the well cap.
G. If there is extra tether rope past the snap connector, place the rope in the well so it hangs alongside the tether. The excess can be zip-tied to the tether if preferred. The extra length allows for field lowering the assembly if the well depth or sampler location is deeper than reported. When the well cap is installed, the stainless-steel weight will typically be resting on the well bottom, and the sampler will be in the desired position within the screened interval.
H. More than one sample bag may be deployed in-line along a single tether assembly to allow samples to be collected from discrete depths within the screened interval. In wells larger than two inches, samplers may be placed side by side to obtain more volume if duplicates are needed and the volume of the selected sampler is not adequate. A heavier weight will be needed to hold multiple sample bags in place.
I. If the well has become silted such that the actual total depth is less than the total depth when the well was installed, the portion of the pre-made tether between the weight and the sample bag can be shortened by creating several small loops and securing them with a cable tie. DO NOT cut the tether to shorten it, because the full length will be needed if the well is redeveloped and restored to its original depth.

J. Record the water level and the date, time, and depth of sampler installations in the field notebook. Note any occurrences during deployment.

7.8 Retrieving and Sampling PDB Samplers

A. To avoid loss of analytes, do not retrieve the PDB unless you are ready to sample it immediately. Samples should be decanted into laboratory containers immediately upon retrieval.
B. Remove the sample bag from the well by reeling the tether onto the dedicated reel. Secure the rope and/or reel so that the weighted tether and samplers do not spool back down the well. This can be done by tying off the rope to the casing or hanging some types of spools on the top of the casing or using a tripod assembly over the well. Small leaks do not interfere with the results provided there is adequate sample volume. Users should make efforts to protect themselves from contact with contaminated samples and spray.
C. Remove the sampler from the tether by carefully using a small snipping tool to cut the zip-ties that hold the sampler to the rings on the tether. Be careful to not let anything touch the area of the sample bag where you intend to insert the discharge tube.
D. Open one end of the plastic wrapper containing the discharge tube and, leaving this wrapper on the tube, puncture the upper part of the sample bag (similar to inserting a straw into a juice-box). It may help to hold the sampler at the upper nozzle area to reduce squeezing.
E. Remove the plastic wrapper from the discharge tube and let the straw purge for a second or two and then fill the laboratory-supplied containers in the usual manner, manipulating the sample bag to start and stop flow as needed.
F. If VOCs and other compounds are collected from the same sampler, fill the VOC containers first, being sure to leave no headspace in the containers.
G. Collect field duplicates as needed by filling a second set of laboratory-supplied containers immediately after collecting the first set.
H. Prepare and ship all samples as usual to meet standard lab requirements.
I. Dispose of the remaining water in the PDB as investigation derived waste (IDW) or as directed by the project manager.
J. At the project manager’s discretion, new sample bags for the next sampling event may be deployed at this time to avoid an additional mobilization.

7.9 Decontamination and Disposal

A. If new sample bags are not deployed during the sampling event the dedicated suspension tether assemblies may be left in the well or, if the project manager does not want to leave the dedicated tether assemblies in the well, reel the entire assembly onto the dedicated reel (having marked the reel with the well ID using an engraver or marker) and secure the tether with cable ties. At the project manager’s discretion, segregate secured assemblies in plastic bags by level of contamination. It may be desirable to rinse the tethers with DI water to prevent potential recontamination of the well water. The potential for carry-over effects of cleaning agents, such as Alconox, has not been explored. Therefore, the use of cleaning agents is discouraged until research shows they have no significant impacts on groundwater contaminant concentrations. ONLY use a tether in the well originally designated for that specific tether.

B. Dispose of the spent PDB in the same manner as other disposable items such as latex gloves, tubing, etc., or as directed by the project manager.

7.10 PFAS Considerations

Sampling groundwater for PFAS using PDB samplers should follow the general procedures detailed above but with the following adjustments to prevent cross contamination from the numerous sources of PFAS in the environment and everyday life.

A. All sampling components must be PFAS-free.

B. Glass components should not be used for collecting aqueous PFAS samples because several PFAS are known to adsorb to the glassware when in contact with the glass for extended periods of time.

C. Similarly, LDPE and PTFE containers should not be used due to either adsorption of PFAS onto or leaching of PFAS from the container materials.

D. Per the OER QAPrP, PFAS sampling containers must be 500 mL certified PFAS-free HDPE bottles sealed using a HDPE or polyethylene cap with no liner.

E. Due to the abundance of PFAS in food packaging, all food and beverage should be kept in a designated location far away (>50 feet) from the wells to be sampled, and after eating, the workers hands must be washed with PFAS-free soap for decontamination before returning to sampling activities.

F. Avoid use of cosmetics, moisturizers, hand cream, perfume, deodorant/antiperspirant, sunscreen, insect repellent or similar products that have not been determined to be PFAS-free on the day of sampling.

G. Sampling materials should not come into contact with carpeting or upholstery in buildings or vehicles before, during or after the sampling process.

H. Ensure that the well does not have any known sources of potential cross-contamination, such as Teflon fittings or PFAS-containing grout. If the well does contain such materials, then another well may need to be installed for collecting PFAS samples.

I. Do not use chemical ice packs to cool the samples.

J. Do not use foil as a layer between stacked sample bottles.

K. PFAS sampling of groundwater can be done using either EPA Method 537.1 for drinking water or Method 1633. Method 1633 has more analytes and is therefore the preferred method to use.

L. At least one round of groundwater PFAS samples should be analyzed for Adsorbable Organic Fluoride (AOF), Total Organic Fluorine (TOF) or Total Oxidizable Precursor (TOP) analysis to assess how much of the potential PFAS compounds are accounted for using either Method 537.1 or Method 1633.

M. Clothing

1. *Permitted*:
   - 100% cotton preferred, but synthetic, polyurethane, PVC, rubber, neoprene, powderless nitrile gloves, uncoated Tyvek® clothing, wax-coated fabrics are acceptable
   - Clothing should be previously laundered (preferably at least six times) without fabric softeners
   - Boots can be either polyurethane, PVC or PFAS-free boot covers
2. *Banned*:
   - New or unwashed clothing, or clothing washed with fabric softeners
   - Clothing treated with fabric protection, water-resistant, stain-resistant or insect-resistant chemicals
   - Any clothing or boots made of Gore-Tex™ or other known PFAS-containing or water-resistant materials.

N. PPE

1. *Permitted*:
   - Powderless nitrile gloves (Sampling personnel must wash their hands with PFAS-free soap and water before putting on any gloves.)
   - HDPE hard hats, or hard hat covers/liners made of cotton or other natural fabrics
   - Safety glasses made with HDPE
   - Life jackets made of polyethylene foam and nylon shell fabric
   - Waders made of Neoprene or other PFAS-free materials
   - PFAS-free sunscreen (examples include Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 50, Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, and Neutrogena® Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30)
   - PFAS-free insect repellent (examples include OFF® Deep Woods and Sawyer® Permethrin)
2. *Banned*:
   - Gore-Tex™ gloves, waders or safety equipment, or any other PPE made with PFAS-containing materials

- Note that further research is needed on the potential use of Latex and leather gloves.

O. Field Materials

1. *Permitted*:

   - Aluminum, polypropylene or Masonite clipboards
   - Rite in the Rain® notebooks
   - Loose paper (non-waterproof and non-recycled)
   - Ballpoint pens and pencils

2. *Banned*:

   - All PFAS-coated materials
   - Post-It® Notes and other adhesive paper products
   - Sharpie markers (there is not a consensus on PFAS in Sharpie markers, but they should not be used unless that are certified PFAS-free)
   - Coated paper towels
   - Aluminum foil should not be used since it is often coated with PFAS, but if a certified PFAS-free foil can be found then it can be used

P. Decontamination

1. *Permitted*:

   - Alconox®, Liquinox® or Citranox®
   - Dry decontaminated equipment using cotton cloth or untreated paper towels, or air dry on a PFAS-free surface
   - Polyethylene or PVC brush to remove particulates

2. *Banned*:

   - Decon 90®
   - Dawn dish detergent
   - PFAS treated paper products

When in doubt, assume that the product contains PFAS and should not be used!

8.0 CALCULATIONS

This section is not applicable to the SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

There are no specific QA/QC activities that apply to collecting PDB samples in the field, but the following general quality assurance procedures apply:

- All data must be documented on field data sheets and/or within the field logbook.

- All instrumentation should be operated and calibrated in accordance with the manufacturer's instructions unless specified otherwise in the site-specific SAWP.
- The collection of an equipment rinsate blank is recommended to evaluate the potential for cross-contamination by rinsing the dedicated tethers and reels before they are lowered into a well for a new round of sampling.
- The collection of duplicate samples will likely be required for the project. Refer to the site-specific SAWP and/or *QAPrP* for further information on collection of duplicate samples.
- Trip blanks are required for each cooler with samples for volatile organic compounds analysis as well as one trip blank PDB for each day of sampling.

Refer to the site-specific SAWP and/or *QAPrP* for specific quality assurance/quality control measures that may be applicable for the given project.

10.0 DATA VALIDATION

Data validation requirements set forth in the site-specific SAWP or *QAPrP* shall be adhered to for any given project. Results of quality control samples will be evaluated for contaminants. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives as set forth in the site-specific SAWP and/or *QAPrP*.

11.0 HEALTH AND SAFETY

OSHA regulations should be adhered to when working with potentially hazardous materials. Personnel performing environmental work at OER sites should have their 40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) with 8 Hour refreshers as appropriate. Some level of Personal Protective Equipment (PPE) is generally required for all sampling and decontamination activities. The appropriate level of PPE for these activities may be found in the site-specific SAWP and/or the Site Health and Safety Plan (HASP). Personnel should adhere to the safety requirements outlined in the site-specific plans. The following is a summary of just some of the hazards associated with groundwater sampling:

- Exposure to unknown contaminants, with particular attention to potentially explosive or flammable atmospheres.
- Lifting injuries associated with moving equipment, coolers with samples, and pulling bags out of the monitoring wells.
- Heat/cold stress as a result of exposure to extreme temperatures and the use of PPE.
- Slips, trips, and fall hazards.
- Biological hazards such as insects, snakes, spiders and poison ivy.

Safety data sheets (SDS) should be readily available on-site for all decontamination solvents or solutions as required by the Hazard Communication Standard requirements set forth in the OSHA regulations, as well as each of the contaminants of potential concern that may be in the water samples. Investigation derived waste (IDW) generated from decontamination activities requires proper handling, storage, and disposal. Refer to the site-specific SAWP for IDW procedures.

12.0 REFERENCES

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