

<p>Sampling Method/Media: Well-Volume Purging and Sampling / Groundwater</p>	<p>Title: Standard Operating Procedure for Well-Volume Purging and Groundwater Sample Collection</p>
<p>Revision No: Original Revision Date: 24 November, 2020</p>	<p>Reference No: SOP-E2-05 Parent Document: BC Field Sampling Manual – Part E2</p>
<p>1. Introduction and Scope</p> <p>This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the collection of representative groundwater samples. The procedure is designed to ensure the sampling techniques selected are based on Site conditions and project objectives in order to provide representative groundwater geochemical data. For long term monitoring programs where consistency is of key importance for trend analysis, the sampling process should be evaluated on a per well basis.</p> <p>This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on well-volume purging and sampling is provided in Part E2 – Groundwater, which must be used in conjunction with the information provided in this SOP. Further guidance regarding groundwater is provided in the Water Sustainability Act (WSA) and the Groundwater Protection Regulation (GPR) which are available at:</p> <p>https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/laws-rules/groundwater-protection-regulation.</p> <p>The Environmental Management Act (EMA), the Contaminated Sites Regulation (CSR) and associated guidance documents provide information specific to groundwater monitoring wells installed to investigate and remediate contaminated sites; these documents are available at:</p> <p>https://www2.gov.bc.ca/gov/content/environment/air-land-water/site-remediation/contaminated-sites.</p> <p>Groundwater sampling and monitoring conducted for regulatory purposes within the provincial jurisdiction of BC must be carried out with consideration to the WSA, the GPR, the EMA, and the CSR, all as applicable, Part E2 of the BC Field Sampling Manual, and this document.</p>	
<p>2. Document Control</p> <p>This Standard Operating Procedure (SOP) is a controlled document. Document control provides a measure of assurance that the specifications and guidance it provides are based on current information that has been scrutinized by a qualified reviewer/s. Controlled documents are reviewed within a five year life cycle. Please ensure that the revision date listed in the header of this document does not exceed five years.</p>	
<p>3. Principle of the Sampling Method</p> <p>The objective of well purging is to remove standing water that has been in contact with the well casing and atmosphere, and to obtain water that is geochemically representative of the formation water. Obtaining relevant groundwater geochemical data is crucial for proper characterization, evaluation and delineation of potential contamination plumes. This SOP describes purging methods and various well sampling methodologies and equipment that can be used to collect representative groundwater samples.</p>	
<p>4. Quality Control</p> <ul style="list-style-type: none"> ▪ Ensure that all instruments are functioning and properly calibrated before starting and that all required information is recorded in the field. 	

- Use only clean purging/sampling equipment or equipment dedicated to the monitoring well.
- Never introduce foreign materials or liquids into a monitoring well.
- Purged water may contain regulated contaminants. Ensure that water collection and disposal requirements are based on known or potential contaminants before commencing work. If on-site disposal is deemed appropriate dispose the purged liquid well away from the sampling location.

5. Recommended Equipment and Materials

Field equipment should include the following:

- Metal detector to locate flush-to-ground wells, if the site is unpaved or if there is a potential for the well to be covered ice or snow,
- Water level and/or interface probe,
- Instrumentation to measure pH, conductivity, temperature, dissolved oxygen, redox potential, and turbidity,
- Organic Vapour Monitor (OVM) and span gas,
- Syringe or turkey baster to remove water from casings,
- Cleaning solutions and spray bottles,
- Decontamination equipment,
- Sample labels,
- Indelible felt pen (VOC-free),
- Field book/field forms,
- Waste container(s) (drums, totes, plastic buckets with lids for on-site transport from well to drums/totes),
- In-line 0.45 micron filters (or alternate where appropriate) if required,
- Laboratory-supplied sample collection bottles,
- Coolers,
- General tools,
- Repair tools; and,
- Site map.

Several purging and sampling techniques are available. Depending on the technique, necessary equipment may include:

- Disposable or stainless steel bailers and rope/cord,
- Inertial hand pump consisting of a plastic foot valve (i.e., Waterra®, Solinst®, or similar) and low or high density polyethylene (LDPE/HDPE) tubing to match the foot valve (commonly 5/8" [1.59 cm] outside diameter); and,
- Peristaltic pump, or other approved pump or water collection device, flexible LDPE/HDPE tubing (one per sample location), two polyethylene fittings of compatible diameter for end of the tubing (for peristaltic pump).

NOTE: Low-flow purge and sampling and no-purge sampling are not discussed in this SOP. Please refer to SOP E2-06 for low-flow sampling procedures.

6. Purging and Sampling Considerations

- Standard purging techniques can generate large volumes of purge water. If the well contains known or potential contaminants the purge water will have to be treated on site or stored for proper treatment/disposal. If purge volumes are large, significant cost savings may be possible by using a low-flow purge method.
- Bailers are not preferred for purging, as they act as slugs which develop the well rather than removing purge water. Bailers may also increase turbidity and result in a loss of volatiles.

7. Procedures

Confirm the most appropriate purge and sampling technique based on well conditions (i.e., completion details, water level, depth of well, etc.) and analyte specific sampling requirements. Use the following table as a guide for selecting the most appropriate sampling method for your project.

Well-Volume Purge and Sampling		
Sampling Method	Pros	Cons
<ul style="list-style-type: none"> ○ Disposable bailers, ○ Inertial hand pump, ○ Submersible pump, ○ Gear-drive pump, ○ Bladder pump, ○ Double valve Pump; or, ○ Piston pump. 	<ul style="list-style-type: none"> ▪ Obtain consistent high quality samples. ▪ Commonly used and well known to regulators. 	<ul style="list-style-type: none"> ▪ May introduce turbidity and aerate the water column affecting water quality results. ▪ The use of inertial hand pumps may exacerbate volatilization and can result in samples being biased low for volatile and semi-volatile organic chemicals. ▪ Produces more purge water than low-flow techniques. ▪ Excessive purging rates may mobilize non-representative constituents. ▪ Not practicable in low-permeability units.
<ul style="list-style-type: none"> ○ Peristaltic pump 	<ul style="list-style-type: none"> ▪ Provides flexibility in how samples can be collected (e.g., varying flow rates, etc.). ▪ Utilized where low turbidity samples are desired. 	<ul style="list-style-type: none"> ▪ Not suitable for sampling volatile chemicals. ▪ Produces more purge water than low-flow. ▪ Not practicable in low-permeability units.
Low-Flow Purge and Sampling		
Sampling Method	Pros	Cons
<ul style="list-style-type: none"> ○ Peristaltic pump; or, ○ Submersible pump. 	<ul style="list-style-type: none"> ▪ Preferred method for obtaining high quality groundwater samples. ▪ Reduces costs associated with water disposal. 	<ul style="list-style-type: none"> ▪ Not practicable in low-permeability units, where unstable drawdown at flow rates less than 0.1 L/min are recorded. ▪ Not practical when ambient air temperatures are below -5°C. ▪ Not suitable for sampling volatile chemicals.
No Purge and Sampling		
Sampling Method	Pros	Cons
<ul style="list-style-type: none"> ○ Grab Sampler (e.g., Hydrasleeve™) 	<ul style="list-style-type: none"> ▪ Utilized for discrete sampling where purging is not required. ▪ Ideal for deep, low-yielding, or remote wells. ▪ Purging may create unnatural flow gradients and turbidity. ▪ Reduces costs associated with water disposal. 	<ul style="list-style-type: none"> ▪ Currently limited regulatory acceptance. ▪ Limited sample volumes. ▪ Biologic activity in the well can result in negative and positive biases. ▪ Analytical results represent time-averaged concentrations. ▪ Not appropriate for sensitive parameters (i.e., DO, ORP). ▪ Wells with > 3 m long screens can result in depth specific variation in geochemistry, therefore for trend analysis consistency, accurate sampler placement depth is required.

Purging

- 1) Open the well case or road box. If water is present inside a road box, use a syringe to remove as much of the water as possible. Remove the monitoring well cap and lock if present. If pressure has built up in the well, record this finding in field notes. A temporary extension can be added to a flushmount well to ensure that surface water does not flow into the well pipe. Place the lid and or cap in a clean, secure location to prevent loss or damage.
- 2) Measure the following parameters, as required:
 - a. If a well is known to contain or is suspected to contain volatile contaminants, collect well headspace vapour concentrations using an OVM. This measurement is taken immediately after opening the well.
 - b. static water level.
 - c. thickness of light or dense non-aqueous phase liquids (LNAPL or DNAPL) if present. If LNAPL or DNAPL is present or detected, do not purge or sample the well unless NAPL was anticipated and the monitoring plans provide specific instructions for purging and sampling NAPLs.

- 3) Calculate and record the minimum purge volume using the following equations. Calculate purge volumes as follows:

a. Water level is ≤ 2m above the well screen

If the water level is within or close to the top of the well screen, it is recommended that three (3) well volumes be purged. A well volume is defined as the volume of standing water within the well pipe, less the water in the sand pack. The equation for this is as follows:

$$V_p = 3 * V_w$$

Where: V_p = minimum purge volume (L)
 V_w = water volume in well pipe (excluding water in the sand pack)
 $= \pi/4 * (h_b - h_s) * d_w^2 * 1000$
 h_b = depth to base of well (m)
 h_s = depth to static water level in well (m)
 d_w = inside diameter of well pipe (m)

b. Water level is ≥ 2m above the well screen

If the water level is more than or equal to 2 m above the well screen, it is recommended that one full well casing be removed (i.e., standing water within the well) and only two times the volume within the well screen.

$$V_p = (2 * V_w) + (1 * V_B) * 1000$$

Where: V_p = minimum purge volume (L)
 V_w = water volume in well pipe (excluding water in the sand pack)
 V_B = well casing volume

Reference for Volumes		
Standard Monitoring Well Pipe Diameter		Volume (L) per Metre (m) of Standing Water
(inches)	(metres)	
1.25	0.03	0.8
1.5	0.04	1.1
2	0.05	2.0
4	0.10	7.9

- 4) Insert a purging tool (Waterra® foot valve and HDPE tubing, bailer, pump) just below the surface of the water and remove the first well volume by slow, steady purging taking care to minimize agitation of the water surface. Avoid purging from the bottom of the well, because this will disturb and suspend accumulated sediments. Purge rates should not exceed 4 L/min and should not result in a significant drawdown; ideally

steady state drawdown is reached. Avoid “drying” the well.

- 5) Measure and record indicator parameters including temperature, pH, specific conductance, dissolved oxygen, etc. If possible, measure and record turbidity. Record qualitative observations including clarity, odour, and sheens, if obvious.
- 6) The well is considered stabilized and ready for sample collection when the desired purge volume has been removed and the water quality parameters shown in the following table have stabilized for three consecutive readings:

Parameter	Stabilization Criterion
Temperature	+/- 0.2°C *
pH	+/- 0.1 pH units*
Conductivity	+/- 3% of the reading
Dissolved Oxygen	+/- 10% of the reading, or +/- 0.2 mg/L whichever is greater*
Turbidity	± 10%
Redox Potential (ORP or eH)	+/- 10 mV*

* these values represent the common instrumentation accuracy; replace these values with your instruments' accuracy ratings.

Note: If field parameters do not stabilize after removing the minimum purge volumes, continue purging the well in increments of ½ well volumes and collect field measurements each time a ½ well volume has been purged until stable conditions are obtained. For wells with water levels ≥ 2 m above the screen, increments should be 1/2 screen volume.

- 7) If the well has been completed in a low-yielding formation and the desired V_p cannot be reasonably achieved, purge the well dry and allow the well to recover to at least 50% of its pre-purged water level before sampling. In very low-yielding formations such as clay or unfractured bedrock, this procedure may result in next-day sampling. Alternatively, consider using no purge or low flow sampling if authorized and accepted by the regulatory agency.

Note: All attempts should be made to avoid purging a well dry. This is particularly important in wells where adequate recharge occurs since this may have a deleterious effect on volatiles and cause large non-natural flow gradients. Purging a well dry may encourage mineral precipitation (worsening flow rates), and / or result in non-representative samples. Where appropriate use low-flow sampling techniques or, if allowable, no-purge sampling techniques.

- 8) For low yielding wells, record measurements of field parameters during sampling in order to monitor groundwater conditions at the time of sampling.
- 9) Once the well has been purged and water quality parameters have stabilized, the well is ready to be sampled.

Note: LNAPL may not immediately enter a well after purging. Groundwater wells should be left to recover for a minimum of 24 hours prior to sampling or measuring LNAPL thickness.

Sampling

- 10) Sample volumes, sample container types, preservation requirements and hold times should be confirmed with the testing laboratory for each parameter. Ensure that logistics are in place to accommodate transport requirements for the parameter with the shortest hold time.
- 11) Obtain certified-clean sample containers from the laboratory that will be performing the analyses. It is recommended that extra sample containers and supplies be brought to the field to accommodate an unplanned change of scope and to accommodate any errors that may occur in the field.
- 12) Confirm appropriate preservation chemical and dosage, if required. Check to determine if the laboratory supplied containers have been pre-charged with the appropriate preservative; Do not add preservatives to samples collected in pre-charged sample containers.

13) Confirm sampling priority and order. If yield is insufficient, prioritize the most important analytical parameters based on the project's scope of work. If sediment load is elevated in water samples, collect samples for analytical parameters not sensitive to sediment mobilization first. In some cases, it might be necessary to wait for sediments suspended during purging to settle out before collecting samples that may be affected by suspended solids.

Samples should be collected in the following order:

- a. Volatile organics,
- b. Samples requiring field filtering (e.g. dissolved metals),
- c. Semi-volatile organics,
- d. Non-volatile organics,
- e. Total metals,
- f. Nutrients; and,
- g. Other general chemistry parameters.

The following instructions provide sampling techniques that are grouped by parameter type:

14) Volatile Organics:

- a. This sampling procedure is appropriate for VOCs, including benzene, toluene, ethylbenzene, and xylenes (BTEX), chlorinated solvents and trihalomethanes (THMs), and petroleum hydrocarbons (PHC) F1.
- b. Samples are typically collected in pairs or triplicates of 40 mL to 60 mL purge and trap vials. Some laboratories may require additional sampling containers.
- c. Depending on the laboratory, the vials may be pre-loaded with a preservative. Potential preservatives include copper sulphate or sodium bisulphate crystals or liquid, or hydrochloric acid to minimize biological degradation of organics. Sodium thiosulphate may be used to minimize the formation of chlorinated organic compounds by free chlorine, which may be a concern when sampling treated drinking water.
- d. Fill the and cap the vials in a controlled manner as quickly as possible. To minimize turbulence and air entrapment, pour the sample against the inside wall of the slightly inclined vial in a controlled and steady flow. Due to the volatility of these compounds, agitation and or exposure to air results in volatilization which in turn results in a sample with a VOC concentration that is biased low. Up to 80% of volatiles can be lost during sample collection.
- e. If a sample must be obtained by submersion, fill a clean sample container and use this container to fill the sample vials. To minimize turbulence and air entrapment, pour the sample against the inside wall of the slightly inclined vial in a controlled and steady flow.
- f. Ensure that the vials are filled to the rim of the container to eliminate all air. A dome or convex meniscus should be present. Do not overfill the vial as this may result in a loss of preservative. A slight loss of sample may occur when the cap is applied.
- g. When capped, the Teflon[®] liner or septum should be in contact with the sample. Assess air trapped in the vial by turning the vial upside down and examine for air bubbles. If an air bubble covers the bottom of the vial (> approximately 2 mL of air volume), the sample may be compromised, and another should be collected using a fresh container.
- h. Inspect the sample for a non-aqueous layer, if a layer exists, it may not be suitable for analysis.

15) Extractable (Semi- and Non-Volatile) Organics:

- a. This sampling procedure is appropriate for PHCs F2 to F4, extractable petroleum hydrocarbons (EPH), mineral oil and grease, polycyclic aromatic hydrocarbons (PAHs), and semi-volatile organics, such as Base Neutral Acid (BNA) Extractables, polychlorinated biphenyls (PCB), pesticides, and herbicides herein referred to Extractable Organics.
- b. Samples are typically collected in amber glass containers.
- c. For some extractable organics, a chemical preservative is not required; however, others may be preserved with sodium bisulphate, sulphuric acid, or hydrochloric acid to reduce the pH of the sample to

less than 2.

- d. Choose a sampling method that minimizes sediment mobilization and turbidity. Extractable organics have low solubility in water and are generally hydrophobic; therefore, elevated sediment loads in water can create a strong positive bias in analytical results. If the sample is turbid, ensure that it is marked on the chain-of-custody and/or determine whether the sample should be submitted.
- e. Extractable organics are relatively stable; therefore, containers do not need to be filled to the top. Fill to approximately 50 mL short of capacity to allow laboratories to complete sample extraction in the container.
- f. Samples collected under reducing conditions may form red flocs of iron precipitate during sample collection due to exposure with atmospheric oxygen; these do not create a sampling bias.

16) Dissolved Metals:

- a. This sampling procedure is appropriate for dissolved metals, including mercury, hexavalent chromium, hydride-forming metals, and dissolved organic carbon (DOC).
- b. Samples are typically collected in HDPE, Teflon®, or glass containers. The type of container is dependant on the type of dissolved metals analysis (i.e. speciated, low, ultra-trace) required. Ensure the testing laboratory is aware of the type/s of dissolved metals analyses required when ordering your sampling supplies.
- c. If reducing conditions are present, the oxidation of certain dissolved metals can be rapid and result in the precipitation of metal oxides or hydroxides. As such, samples collected for dissolved metals analysis must be field filtered and preserved as quickly as possible.
- d. Samples collected for dissolved parameters should be filtered in the field using an in-line 0.45 micron filter immediately following collection and always prior to the addition of preservatives.
- e. Water samples are generally preserved with nitric acid for analysis of a full metals suite, hydrochloric acid or bromine chloride for mercury analysis, and a buffer solution such as sodium hydroxide for hexavalent chromium. Check with the laboratory to ensure that the proper preservative is utilized.
- f. Various methods are available for field filtering however dedicated, individually wrapped disposable field filters are preferred. If water is highly turbid, multiple filters may be required per well. Samplers should watch for break-through conditions and replace filters as needed. The most common method is to connect an inline filter to the discharge hosing of a peristaltic pump, Waterra® tubing or disposable bailer. When using a bailer, gravity or hand-pump pressure is required to drive the sample though the filter cartridge. If using a grab sampler (e.g. HydraSleeve™) or bailer, the sample can be filtered using a syringe with a disposable filter attached. Samplers should be aware that filters may contain trace concentrations of metals that can add to the metals in the sample; this is especially important when sampling 'clean' water sources. An equipment (filter) blank should be submitted with regular samples if this is a concern.
- g. Condition the filter by allowing or pushing 10 mL or more of the sample water through the filter. If the filter and or filter apparatus becomes wet during conditioning shake off the standing liquid before filling sample container/s.
- h. Pre-charged sample containers can be filled with the filtered water and capped. Sample containers that are not pre-charged should be filled to the base of the container's neck leaving room to add preservative.
- i. For sample containers that are not pre-charged with preservative, preserve the sample immediately after filtration to reduce the pH of the sample water to a pH of < 2.
- j. If a precipitate appears upon acidification, the laboratory may need to digest the sample and analyse for total metals. If precipitation occurs ensure it is recorded on the chain-of-custody form and confirm whether it should be analysed or stored until a decision can be made.

17) Total Metals:

- a. This sampling procedure is appropriate for total metals. Field filtering not required for a sample collected for the analysis of a total metal's suite of parameters. For the analysis of a specific metal or speciated metal, field filtering may be required and should be confirmed with the testing laboratory.
- b. Samples are typically collected in HDPE, PTFE, Teflon®, or glass containers and multiple sample containers may be required.
- c. Samples for total metals are not field filtered. Water is transferred into the sample container and preserved. Hydrochloric acid or bromine chloride is used for mercury, a buffer solution (sodium hydroxide) for hexavalent chromium, and nitric acid for all other metals or for a full metals suite. Check with the laboratory to confirm whether the containers have been pre-charged with preservatives or if preservatives must be added following collection.
- d. For sample containers that are not pre-charged with preservative fill the container to the base of the neck leaving room to add preservative.
- e. Preserve sample immediately after collection to reduce the sample to a pH < 2.

18) Nutrients and General Chemistry Parameters:

- a. This sampling procedure is appropriate for non-volatile and non-metallic water quality parameters, such as anions, alkalinity, chloride, hardness, nitrate and nitrite, sulphate, etc. This category of parameters covers groups of tests requiring different sample container types and sizes. Some test groups will require preservation while others do not. It is important to establish these requirements with the testing laboratory during pre-trip preparations.
- b. Samples are typically collected directly into HDPE or amber glass containers of various size. The container type will depend on the analyses required. Confirm the correct sample container type and size with the testing laboratory.
- c. Samples collected for the analysis of general water quality parameters do not require filtration or preservation.
- d. Samples collected for total nutrients should be collected in a laboratory supplied amber glass container and preserved with sulphuric acid.
- e. Samples collected for dissolved nutrients must be field filtered and collected in a laboratory supplied amber glass container. Samples collected for most dissolved nutrient parameters require preservation with sulphuric acid.

19) Chain of Custody and Shipping:

- a. Complete a sample submission and chain-of-custody form. Be sure to specify the analytical detection limit desired. For some parameters low level analyses may be required to achieve the detection limits necessary for comparison to provincial or federal water quality criteria, or for long term trend analysis. Ensure that sample shipments are arranged to arrive at the laboratory within the hold times prescribed for each test being conducted and at the temperature prescribed by the Province.

ENV maintains a table listing required sample containers, storage temperatures, preservation requirements and hold times on their website at:

<https://www2.gov.bc.ca/assets/gov/environment/research-monitoring-and-reporting/monitoring/emre/summary-of-sample-preservation-and-hold-time-requirements.pdf>.

- a. Place samples in a cooler chilled with ice (double-bagged) for transport to the laboratory. It is important that cooling begin as soon as possible following sample collection, particularly for organic analyses. Coolers should be maintained at a temperature below 10°C throughout storage and delivery.
- b. Dispose of all wastes (liquids, used gloves, and materials) in an appropriate manner. Note that tubing can be retained/stored for later sampling of the same well. **Leave the site in a tidy condition.**

7. References

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